Conservation Economics
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Module 12
Case studies
Lecture 1
Economics of Protected Areas

Namaste! Today, we begin with the 12th module which is case studies. This module will have 3 lectures Economics of Protected Areas, economics of environmental disasters part I and part II. Let us begin with the economics of protected areas.

Protected areas are defined under section 24 A of the wildlife protection act 1972. Protected areas means, a national park, a sanctuary, a conservation reserve or a community reserve notified under sections 18, 35, 36A and 36C of the Act. So, the protected area is a national park, a sanctuary, a conservation reserve or a community reserve.

And we have a number of wildlife that are found in the protected areas. What is wildlife? Wildlife is defined in the Wildlife Protection Act 1972 as: wildlife includes any animal, aquatic or land vegetation which forms part of any habitat. What we are saying here, is that if you have any animal or any plant that forms part of any habitat then we will say that it's a wildlife.

And the dictionary definition of wildlife is: wild animals collectively or the native fauna and sometimes flora of a region, which means that it is saying that the native fauna which is the native animals and the native flora which is the native plants. So, those animals and those plants that are found natively or which are indigenous to an area, if we look at a collection of those we will call it wildlife.

Wildlife are divided into these nine threat categories by the international union for the conservation of nature and natural resources. So, we have a red list of different organisms which tells us what the level of threat is. For certain organisms whether plants or animals the level of threat is so large that if we do not protect those animals and plants, then in a short while it is very likely that these plants and animals will become extinct.

On the other hand there are certain plants and animals that are not that threatening so, in that case we may not protect them to such a high extent. Or let us say that it is not an urgency to protect them right away. So, these threat categories are extinct. If an organism is extinct it means that there is nothing much that you can do about it. This organism just does not exist anymore.

Things such as the dinosaurs or the dodo bird are currently extinct, they are no longer found in this world. Certain other organisms are extinct in the wild, which means that we may have a few specimens of these organisms in a zoo, but if you look out in the wild conditions, we do not have any of these organisms left. Then we have critically endangered organisms, endangered

vulnerable, near threatened and least concerned.

An organism that is in the least concern such as the common dog or the cow, we do not need to provide them with the level of protection that is urgently required for say a critically endangered species such as the tiger. Then for a number of organisms we do not have the data.

We categorize them as data deficient. And, then we also have certain organisms that have not yet been evaluated and we call them not evaluated. So, there are several species that are in need of conservation, and the higher a species is on this list the more is the amount of conservation that it urgently needs.

This list gives us an idea of how we prioritize things. You will remember it is a principle of economics that there are tradeoffs involved in a number of things, well we would ideally want to conserve each and every of these organisms, but then our time is limited and our resources are limited. If we have to spend our time and resources, we should prioritize those species that require a greater amount of conservation and those species for which we can actually do something.

A scientific way of looking at which species to conserve looks at whether or not they are keystone species. Now, keystone species play critical ecological roles which means that they have an importance that is much greater than their numerical abundance in an ecosystem. So, things such as off season fruit bearing trees are keystone species.

What we mean by a keystone species is that the impact that these organisms have on an ecosystem is much greater than their numerical abundance, so, if there is a forest that is completely dry, and this forest is having a scarcity of food. But, then if you have a tree that can provide food to different animals and birds, then this tree would act as a keystone species.

Because, even though you have a single tree that is providing the food, it is able to support a large variety of plants and animals and keystone species include species such as the ficus trees, banyan trees, peepal trees. So, these are those trees that provide food in the off season, and also their leaves and their branches are all edible and they are large in size. So, if you have a look at a banyan tree; a banyan tree would be supporting say hundreds of organisms from small insects to reptiles to birds.

These sorts of species are known as keystone species; another keystone species is the tiger. Because, if you have a tiger in an area then the tiger regulates the number of herbivores that are there so, the herbivore population is not able to cross a threshold. Because, if there are too many herbivores then it is possible that they will eat up all the vegetation in the area, and the whole ecosystem would collapse. Species that are keystone species need to be given a greater priority when we talk about conservation.

Other species are known as umbrella species; these are species with large home ranges. So, what happens in the case of these species is that they have such large home range requirements, that if you make it a point to conserve these species or the other species in the large home range will automatically get conserved. So, here we have species such as the elephant or again the tiger.

An Amur tiger has a home range of around 800 square kilometers, in India we have tigers that have home ranges of roughly 80 square kilometers. So, if you are conserving the tigers, for each tiger roughly 80 square kilometers of area automatically gets conserved, all the different

organisms that live in that 80 square kilometers are automatically afforded protection, because we are conserving the tigers or species such as the elephants.

They also have large ranges. So, the species that have very large home ranges act like an umbrella to provide protection to a large number of species, just because these umbrella species get protected. So, again they should get priority when we are talking about conservation.

And the third is flagship species. Flagship species are well known charismatic species that have captured the public's heart and won their support and funds for conservation. Examples include the giant panda, the humpback whale, and the gorilla.

When we talk about flagship species these are those species that attract people. It is possible that a few of these species are beautiful species such as the peacock. So, peacocks are a flagship species because they are beautiful. People want to see peacocks or you could have species that are very majestic such as the tiger. So, a tiger becomes a flagship species because people are in awe of seeing a tiger. Or you could have species that have religious significance such as the elephants.

Now, these species that are the flagship species, they occupy a space in the hearts of people. And so, when you want to conserve these species it is easy to get funds and it is easy to get public support. So, those species that the public likes should also be given a higher priority in conservation. So, these are the flagship species.

Now, when we do conservation we try to look for those species that make all these three definitions. So, if there is a species that is a keystone species which means that it has a very large role in the ecosystem. It is an umbrella species which means that it requires a large home range, which would automatically give protection to a large number of other species. And, if it is also a flagship species which means that people want to conserve this species, they are and it is easy to get funds and public support, nothing like it.

We always look for those species that are at the conference of all three of these. A good example is the tiger. Because a tiger is a keystone species it's a flagship species and it is also an umbrella species. So, by protecting tigers or by allocating funds for the conservation of tigers, we are able to achieve a lot of our goods of conservation.

Now, in this context it is prudent to rememorize. Why are these species threatened, why are we doing this conservation at all, why are we setting up these protected areas? So, we had seen earlier that there are a number of factors that lead a species to extinction.

So, there are factors that act at large population sizes and there are factors that act at smaller population sizes. And, we can summarize these factors with the acronym HIPPO: habitat loss, invasive species, pollution, human overpopulation and over harvesting are the factors that have been driving species towards extinction. And, when we are talking about protected areas, they protect the animals and plants that are inside from these five things.

When we want to protect species against these factors of extinction there are two modes that are there with us. We can either take the species out from the natural environment, and give them a very high level of protection, say in a zoo.

What happens in a zoo is that you bring the animals from the natural environment, you keep them in controlled conditions, where they get sufficient amounts of food, sufficient amounts of

water and a very good veterinary care. That is one way. The other way is that you can protect these species when they are out there in their natural environment.

That brings us to two modes of conserving wildlife, we can go for an ex situ conservation, which is conservation which is off the site that is conservation outside the natural habitat. Such as in the case of zoos or aquariums, or we can have in situ conservation which is conservation on the site which means that conservation done that is within the natural habitat such as a national park.

How do these work? In the case of ex situ conservation, it is required for critically endangered species, because it provides urgent intervention so, in the case of critically endangered species. Because the numbers are so low, we need to give them a very high level of intervention and very intensive management which may not be possible in the wild conditions.

So, ex situ conservation is probably the only way out, to conserve those species that are critically endangered. So, in the case of ex situ conservation we designate areas with suitable conditions and we create facilities. So, in the case of ex situ conservation an area will be selected to make a zoo.

And, then we will create the facilities for a zoo. That is we will surround this area with say a wall, we will provide means of bringing in water means of bringing in food. We will create facilities such as a veterinarians office, say an operation theater and things like that, and once these are done the species are moved into these designated areas for their survival and breeding. And, in a number of cases we also do ex situ breeding of these animals, the captive breeding of animals.

So, what will be done is that these animals that are critically endangered, they are brought into these zoos and they are allowed to breed and when the population goes up. Then, it is also possible that we can later release them into their natural habitats. So, that is ex situ conservation.

It has a number of advantages, it allows better control of variables such as climate, diseases, diet and so on. Because it is a small area the intervention is much more intensive and so, it is much easier to provide them with standardized conditions. It provides opportunity for close observation to better understand the species and the proximate causes of its extinction. So, it provides us with an opportunity to understand the behavior of animals.

Suppose in a zoo environment you get to know that this animal avoids breeding, if it is exposed to too much sunlight. Then, probably when we release these animals back into the natural environment, we will make sure that we release them into an area that has a very good canopy cover.

Such kinds of observations are extremely indispensable, when we want to conserve the organisms. And, then they also permit intensive interventions such as in vitro fertilization, embryo transfer and so on. So, we can provide all sorts of modern scientific advancements and medicines to these organisms.

However, it also has certain disadvantages, because we are taking the animal out of its natural habitat and we are conserving those few animals, but in this process we are not conserving the habitat. It is possible that you remove all of the critically endangered species individuals from the natural environment, bring them to a zoo, do a captive breeding, but in the meantime their natural habitat gets destroyed completely.

That would defeat the purpose. So, this is one disadvantage. It can be planned for only a few species at a time because it is very expensive. We are doing an intensive intervention. So, the costs go up and when the costs go up, then it is difficult to do it for a very large number of species or a very large number of individuals.

Some wild behaviours may get lost because we are not keeping the organisms in a wild setting and so, it is possible that while a few of these organisms are able to survive and breed. But, they will lose out on their natural behaviours like, where to look for food or how to hunt. So, this is another disadvantage: captive bred and raised individuals may then find it difficult when they are reintroduced.

Because they are now completely dependent on human intervention, they do not know how to hunt for food. In that case once you try to release them back into the environment it is possible that they will just not be able to cope with the conditions. Then, it may increase the chances of inbreeding if it is not planned properly, if the spread books are not maintained properly, it is possible that brothers and sisters or parents and offspring might breed with one another.

In that case the number of recessive disorders will go up and then finally, it is also costly. Now, throughout this course we have observed that price or cost act as very good indicators about different activities. So, if it is costly and money is one input that you are able to provide, then you will have to also look at the trade off. Can this money be better spent in protecting the habitat than in setting up a zoo.

So, these kinds of questions need to be answered. Examples of ex situ conservation include zoos, aquaria, captive breeding facilities, botanical gardens, bambuseta, arboreta, seed banks cryopreservation facilities, such as tissue culture sperm bank ova banks and so on.

In all of these what we are doing is that we are taking the organism, or its body parts away from the natural setting. And keeping them in a very scientifically managed facility provides a very intensive intervention, with the hope that probably some day in the future, we will be able to release them back into the environment once the numbers have gone.

So, this is ex situ conservation the other mode of conservation is in situ conservation which is conservation on the site. In this, areas in the natural habitat are designated as reserves, national parks or protected areas. And, in these ecological monitoring and interventions, such as active management are done and legislations are required to maintain these areas after test protected areas.

What we do in the case of in situ conservation is that first of all, we designate a place as an in situ conservation facility, such as a national park or a wildlife sanctuary or any other modes of protected areas. Now, different countries may be using different terms, but you get the idea. So, the first step is to use legislation to designate an area as a protected area, or as an in situ conservation area.

Once we have done this designation, then laws will be used to ensure that people do not enter into this area or to regulate the movement of people into this area. And, also we do active interventions: that is active management such as control of forest fires or control of invasive species or provisioning of water. So, all different kinds of active management are also done in these areas.

It provides several distinctive advantages the species continue to live, in their natural environment which means that the natural behaviours are maintained in these areas. Then, this is less disruptive and more importantly it is less costly, because the only cost that is involved is doing a legislation, to designate these areas as protected areas.

And probably do a bit of protection, a bit of habitat planning, we do not have to set up facilities such as veterinarians office or an ot or cages for individual organisms, you do not have to bring in food from outside to feed these organisms and so on. So, it is much less costly as compared to an ex situ conservation facility.

Then, protection of the natural habitat provides protection to other species as well. So, if you are trying to conserve tigers by creating a tiger reserve, then not only is the tiger protected. But, the other species that live in the forest also get protection automatically. Whereas, if you are trying to conserve tigers using ex situ conservation facilities, you would have brought the tiger outside, you would have conserved the tiger, but when its habitat gets destroyed then the other species will also be in peril.

And so, a distinctive advantage of in situ conservation is that it provides protection to other species as well. Then, even in the case of ex situ conservation the animal will need to be released somewhere in some point of time. Once you have done the captive breeding in the case of ex situ conservation you have now a large number of animals. So, they will have to be released back into the environment.

If you only did ex situ conservation you only maintained these individuals in the zoos, and their natural habitats got destroyed in that case where would you release these organisms. So, in situ conservation is also important together with ex situ conservation, because it keeps certain portions of the habitats of these organisms intact so that you can release them there later on. These provide suitable areas for such releases and they also double as places for scientific studies and public awareness and things such as tourism.

The disadvantages include requirement of very large areas, because in the case of in situ conservation, what we are doing is that we are designating very large areas as protracted areas. So, the area requirement or the land size requirement is much greater. In the case of ex situ conservation such as a zoo, you can keep animals at a much greater density.

But, in the case of in situ conservation such as a tiger reserve or say a national park you will have to keep these animals, in the natural settings in which case it will require a much greater area. There is less intensive protection and management, because the areas may be encroached upon or the animals needed poached. Why? Because these areas are so large that it is not possible for you to man all of this area at all times. So, it is possible that a poacher might get into a national park and kill a few of your animals.

Which is very difficult in the case of an ex situ conservation facility, because we have erected huge walls. And, also because in the case of an intensive intervention, it is very easy to keep an eye on each and every animal, probably you could even make use of CCTV cameras. But, in the case of in situ conservation this becomes difficult because the area is so huge. Then, there are always the threats of diseases and disasters, because it is a large area you are not able to manage everything at all points of time.

And, a large establishment is required in each case; establishment in terms of people who are going to man the area establishment in terms of vehicles, because these are large areas. So, you have to go to two different areas to observe these animals to protect these animals. In that case you might even require say forest rest houses in certain locations. A large amount of establishment may also be required in the case of in situ conservation.

Now, when we say that we are going to do an in situ conservation, there are certain traditional ways of creating the protected areas. How did the kings of the bygone eras used to make a protected area? One option was to look for beautiful areas. So, if an area is a beautiful area the king would say ok, these are such beautiful areas let us make them into a national park. Lush green mountains, lakes, beaches - they used to be converted into protected areas for the enjoyment of the king.

In certain cases certain high species diversity areas used to be converted into protected areas, such as the silent valley national park in Kerala or in certain cases those areas that harbor unique animals endemic organisms that are found nowhere else would be converted into protected areas. Such as the Gir National Park in Gujarat that is the only home of Asiatic lands in India. But, in a number of cases these become a bit too haphazard and based on the whims and fancies of the reserve creator.

So, with time we have shifted from these traditional ways of creating protected areas, to the scientific ways of creating predicted areas. In the scientific way we look for those areas that are high in species richness, species endemism and that have a moderate level of threat to the species.

What is species richness? Species richness refers to those areas where you have more number of species per unit area. So, if we look at say things like global mammalian richness. There are certain areas that have a large number of species per unit area and there are certain areas that have a smaller number of species per unit area.

So, we can look at global mammalian richness, or we can look at amphibian richness, then we can also look at the number of species that are under threat. So, there are certain areas such as in Southeast Asia that have a much greater level of threat than say an area in North America. Then, we can also have a look at different categories of species such as the number of amphibian species in death threat.

What we do is that we look for those areas that have high species richness, which means these areas have a large number of organisms. And, if you create a protected area in one of these locations, then we will be able to afford protection to a very large number of species. Because these are the areas with high species richness, we look for those areas that have a high degree of endemism. So, if an organism is only found in one area, you will have to provide protection in that area.

Because, if you do not do that, that species will become extinct very soon and we look at those areas that have a high degree of threat, or at least a moderate degree of threat. Because, if we have an area that does not have any threat, say an island that nobody ever goes to. So, in that case, because our time, money and resources are limited, then it is much more prudent to make a protected area probably in a threatened region than this Island.

Because, even if you did not convert this Island into a protected area, the species would have remained fine there would not have been any difference or there is no impact of making a protected area in such a location. So, we look for these three criteria and those areas, which have all these three high degrees of richness, endemism and threat we call them as biodiversity hotspots.

These are the biodiversity hotspots in the world and in our country areas such as the Western Ghats are a biodiversity hotspot. Because we have a very large number of species that live in these areas, there is a very good amount of species richness. We have a number of species that are only found in the Western Ghats such as a number of the amphibian species. So, there is a very great amount of species endemism.

And the Western Ghats are also threatened because people want to cut these forests and convert them into certain other uses. In that case these areas also have a high degree of threat. So, these areas that are the biodiversity hotspots, they need to be afforded greater amounts of protection.

And, in this case we should also have a look at the threat triage that we have. So, if there is an area that has a very high degree of threat, then probably it is already a lost cause. Because by that time you would be able to convert this area into a protected area, maybe set up mechanisms for the protection of this area, set up mechanisms to do habitat management, by that time, because of the high level of threat probably, it would already been taken over on the other hand if you have a location that has a very low degree of threat. There too it does not make any difference whether you make a protected area or not. Because, the animals or the organisms in this area would remain fine, whether you make a protected area or not there is absolutely no threat in those areas.

So, the areas which have a very high degree of threat or the areas which have a very low degree of threat, they are not that preferred. But, those areas that have a medium degree of threat are more preferred because, in those cases we will be able to put in a much greater impact by converting those areas into protected areas.

So, we need to keep in mind that threat triage is built and we should also keep in mind the gap analysis. The gap analysis approach tries to identify holes in the existing network of protected areas, that are primarily in locations that are or were historically uninhabitable for humans due to their heights, prevalence of diseases, or other reasons.

And creating some protected areas in human dominated areas may fill the gap allowing a different set of species to thrive. Now, what we are saying here is that in the case of the existing network of protected areas, people normally went for those areas traditionally that were not of much use.

So, you would hardly find a protected area in or near a town or a city, you would only find protected areas in those mountains that were very difficult to reach or those areas that were infested with mosquitoes and malaria, because of which people did not want to go to those areas. So, the rulers used to convert those areas into protected areas.

Now, because we have inherited such protected areas. So, a number of protected areas today are in those locations that are not built within reach. Whereas, those areas which were which could be dominated by humans, such as the plane areas. They were completely converted into agricultural lands. Now, gap analysis says that because we created our earlier protected areas in

the mountains, we are able to protect the mountainous species, but we did not create any protected areas in the plane areas. So, if we have a chance let us at least create a few protected areas in the planes or those locations that are human dominated. Because, once we do that we will also be able to provide protection to the species that live in plane areas or those areas that have become human dominated.

So, that is gap analysis. You take a map, mark out all the protected areas and look for the gaps, and those gaps are the areas where you should be making them protected areas, that is the gap analysis and whenever we are making a protected area. Whenever we have the chance to make a protected area, there are certain principles of reserve design that should be kept in mind. Whenever, we are making a protected area go for a larger size. So, big is better than small.

Why because a bigger size means more number of habitats, which means a higher species diversity that you will be able to afford protection too. If you make a very small protected area, then you will be able to provide protection to less number of species and less number of habitats. But, if you are able to construct a large size reserve, then you will be able to provide protection to a large number of species that live in the diverse habitats that you have converted into the protected area.

Second thing is that they are more secure and easier to manage per unit area. Why are they more secure? Because, in larger areas we have larger populations, if you have larger populations then they are less susceptible to extinction. Because, you will only have those factors of extinction working there that work at the larger population sizes, but the factors of extinction that work at smaller scales the stochastic factors will not work in these larger areas.

So, the populations are inherently more secure from extinction, then in the protected areas you need to protect the perimeter. Because, the perimeter is where people can get into whereas, the species get protected in the area. Now, as you increase the size of a protected area the ratio of perimeter to the area of of this reserve, it reduces which means that it becomes much more cost effective to provide protection to this reserve.

So, the larger the size of the reserve it has the smaller perimeter per unit area, which makes protection more cost effective. Then, these are also less vulnerable to catastrophes, because smaller catastrophes will not impact the whole area.

Another principle is that one big is better than several small of the same total area, which means that if you have an option of making one big reserve, or four smaller reserves, or five smaller reserves, and the total area is the same in both the cases you should probably go for the largest sized one not a number of smaller ones. Why?

Because, these smaller ones will not be able to support those species with large home ranges. So, they will be only able to support those species that have smaller home ranges. Whereas, this large area will be able to support those species that have smaller home ranges, but also those species that have larger home ranges. So, one big is better than several small of the same total area.

But, then if you cannot make one big one if you only have the option of smaller ones, then go for those smaller reserves that are close together. Because they minimize the isolation, what happens is if you have these reserves that are close by the animals may go from one area to the next area.

And in that case it may be able to support at least some of those species that have higher home ranges. So, closer species minimize isolation. So, they should be preferred; those reserves that are very far from each other should be less preferred.

Then, you should go for a cluster approach, if the species are together in the form of a cluster it is more preferred than a linear arrangement. Because, in the case of a clustered approach the species from this reserve can go to this reserve, and it can also go to this reserve, the species in this reserve can go to this reserve, but also to this reserve.

So, the amount of movements increases whereas, if you have the results that are lined up in a linear fashion, then the organism says this reserve can only go to this reserve. So, the movements are more restrictive in a linear fashion. And, if possible go for a circular looking reserve, because circular reserves have less biotic pressure which means that the influence of humans that are there in the periphery say if it reaches to this distance. So, at least this area in the center will be protected. So, the core area of the reserve will be protected.

Whereas, if you have a reserve that is linear in structure, in that case the influence of the humans in this place will probably go to more than half the area of this reserve. And, in that case everywhere you will find an influence of humans and so, the level of protection in a linear reserve will be much lesser.

But, then we also have a number of linear reserves and we have already observed that in the case of the Mudumalai Tiger Reserve, if you make a 10 kilometer buffer from the habitations, you will find that the whole of the reserve is completely covered with these buffer areas. So, the circular reserves need to be promoted more than linear reserves such as these.

And if nothing else happens at least maintain the connections, because through these connections we can ensure that the organisms have free movement. And, in that case some species that have larger home range requirements, they will still get some level of protection.

But, if we have these reserves in the form of Islands what will happen is that in the absence of movement, we will find a large amount of inbreeding in each of these different reserves. And once that happens the level of protection goes down.

Now, we routinely make use of these approaches whenever we are making new protected areas. So, for instance in the state of Madhya Pradesh when we were looking for new sanctuaries we looked at biodiversity intactness. Now, the biodiversity intactness index tells us the level of biodiversity that remains in different areas.

So, if you look at this map, these sections that are darker in color have more biodiversity, these areas that have a lighter color have actually lost their biodiversity over several years. Whenever we are making a protected area we should ensure that there is a high level of species richness or biodiversity. So, these areas which are dark in color need to be selected.

Then, through a gap analysis we can look at those areas where you already have the reserves. And make results in those areas that are away from these and when we try to maintain the connections what we do is that suppose you consider this reserve and this reserve. So, here you have the Madhav National Park and here you have the Panna Tiger Reserve.

Now, we know that tigers take this route when they go from Madhav to Panna and in that case if you make a reserve here in the center. Then, probably it will be much more effective than, say,

creating a reserve here, where the animals do not move. So, in this case we are making use of gap analysis, we are making use of gap analysis to understand where we should be making these reserves.

So, we try to maintain the connections. We try to enhance the connection and we try to do it in a way where we can get the larger size areas and in those locations where we do not have the sanctuaries, but we do have transit paths of animals. Now, in the case of Madhya Pradesh, the tiger is the most important animal in terms of conservation, because it is a keystone, flagship as well as umbrella species. And so, when we are focusing on tigers, we should look at the routes that the tiger takes when it moves from one location to another location. So, this is what was done to identify the locations where we can have newer sanctuaries.

Now, once we have looked at what a protected area is, how do we make a protected area and what is the importance of a protected area. Let us now have a look at the economic analysis of protected areas. When we make a protected area what is the benefit that we can provide to people so which brings us to the ecosystem services from protected areas. Now, ecosystem services are the services that are provided by a well functioning ecosystem in these protected areas.

Ecosystem services are defined as the benefits that people obtain from ecosystems, again a cost benefit approach. If you want to make a protected area you will have to convince people that it is going to be of benefit to the people. So, we have to do a computation of the benefits that we can provide to people whenever we are making a protected area. So, this is bringing us to the culmination of conservation economics and you can get an idea of how to do conservation.

It is important to make use of economics to tell people that this project is going to be economically beneficial to the people. Especially because we are living in a democracy, so it is very important to convince the politicians and the policy makers if you want to do conservation. And, if you do good conservation you are going to provide benefits to the people of your state or your country. This is why a study of ecosystem services becomes very important.

Now, ecosystem services are divided into provisioning services in which case the ecosystem provides something in the form of materials, such as food or medicines. So, if you have a well functioning ecosystem, you can get hold of certain medicinal plants or you can get hold of certain amounts of food from this area. So, this is known as a provisioning service.

Now, this provisioning does not just mean that you should allow people to get into the protected area and approve these medicinal plants. But what it is saying is that if you maintain your area as a protected area, then a number of these species will also come out in the form of say seeds and through which you will be able to get these resources for the people who are living in the vicinity. So, provisioning services include things like food and medicines.

We also have several regulating services such as the regulation of local climate, the biological control of pest populations and so on. So, it has been seen that in areas that are close to the protected areas the level of insect infestation is much lesser, because the protected areas harbor a large number and variety of birds. There will also be a large number of insectivorous birds, and these birds will provide protection to the farmlands that are near the protected area.

So, this is an example of a biological control over the pest. The farmers that live in the vicinity do not have to spend that much amount of money on purchasing insecticides. So, this is a

regulating service another regulating service is the regulation of the local climate or the microclimate. So, the areas that are close to the protected areas have a more amiable climate, it does not become that hot in summers it does not become that cold in winters. So, that is a regulating service in the form of climate regulation.

Then, these ecosystems also provide supporting services in the form of soil formation and nutrient cycling; they also provide several cultural services, such as recreation, educational uses and religious uses. So, these are different services that a well functioning ecosystem provides to people. We have provisioning services, regulating services, supporting services and cultural services.

And to do a valuation of these services we can make use of economic models. Now, if you remember, a model is a simplified depiction of reality, but the best thing about a model is that it allows us to do computations in a simplified manner. One such model is the InVEST model, investors integrated valuation of ecosystem services and tradeoffs an integrated valuation.

So, you are incorporating a number of variables to do an integrated valuation; valuation of ecosystem services and also of the tradeoffs that you need to make, tradeoff in terms of say if you have 100 rupees. If you spend these hundred rupees into the functioning of a protected area do you get say 105 rupees out of it or do you lose 5 rupees and you only get 95 rupees in return.

That is a tradeoff. You have certain amounts of funds every government has certain amounts of funds. And, if the government uses them in construction or maintenance of a protected area, then probably those points cannot be used in other locations, say for health care or for education sector, or for setting up of a new industry or for laying of new roads.

So, there is always a tradeoff. The InVEST model helps us to understand that if we are putting 100 rupees into the functioning of the ecosystem services. Because of making a protected area or protecting a protected area, what is the return that we get out of it. So, that is something that this model also tells us. So, this is a GIS based suite. GIS is geographical information system.

So, in the case of GIS we make use of the information about where different things are located, where the water sources are located, are they located close to the villages or are they located in the interior of the protected areas, which would mean that they are far away from the villages. So, these are the kinds of information that we make use of: where does the river flow, where are the hills, where are the mountains, where are the planes.

And, we make use of all such information because we are using the geographical information. So, this is a GIS based suite of open source software models for mapping and doing valuation of ecosystem services. It performs computations using spatially explicit data and models. So, the data and the models that we use are also based on where different things are located, they are spatially explicit.

And, the final results can be in the form of biophysical information such as the tonnes of carbon that were sequestered, or we can get the results in the form of economic information that is what is the value of that amount of sequestered carbon. So, you can ask this model to give you a result of that; that so much amount of tonnes of carbon dioxide were sequestered by this protected area in this year, or it can give you what is the market value of that amount of sequestered carbon. Similarly in the case of water resources, similarly in the case of other services such as the

probating or the supporting services.

So, let us now have a look at what kinds of services we model here? The first thing or the first ecosystem service that the protected area gives you is employment generation. Because, there will be a large number of gypsy drivers that get employment, there will be a large number of guides that get employment, there will be portals that are set up because tourists are coming to this area.

Now, when the tourists come they will require n number of services, and all of these provide employment to people. Now, what is the amount of employment that the protection that the protected area generates? Is, given as the sum of the number of man days into the wage rate. So, how many man days of employment were generated, what was the rate at which these people got paid?

So, we do a multiplication of both of these and you sum them up for all the people who are getting employment, because of the protected area. So, this is giving us a value of the employment generation. Fishing benefits; which is the sum of production into the market prices. Now, in some protected areas we do permit fishing, especially in the buffer areas.

If there is a buffer area and it is getting water from the protected area or it is a part of the protected area, and it is also getting benefited or protected, because of the activities in the protected areas, what is the amount of fish caught and what is the market price of that fish. So, when you do a sum over the production into market prices you get the fishing benefits. We compute the fuel wood benefits again production into market prices, fodder benefits, production into market prices.

So, we are doing all these different kinds of valuations. Timber benefits: how much is the amount of timber that can be extracted especially in the buffer areas. Where do we permit extraction? We do production into market prices. Bamboo benefits: production into market prices. Non timber forest produce: this includes things such as honey, lac, medicinal plants and so on.

So, in the case of non timber forest produce, you also have a market for honey, you have a market for lac, you have a market for the medicinal plants that you get out of the forest. So, here again we can do production into market prices the sum of all the NTFPs that you are getting in this area.

Gene pool benefits such as the resilience of ecosystems and avenues for future use of biological compounds, or other products computed using the benefit transfer method. Now, what we are saying here is that if you conserve an area as a protected area, you are making the ecosystems more resilient.

Which means that if there is a release of pollutants into this area your ecosystem will not collapse that easily, then an ecosystem that was not given this protection. Because, as we had seen in the case of large infrequent disturbances, if a biological community is already disturbed or is already half disturbed and you give it a single disturbance and it will collapse.

But, when you are maintaining a system as a protected area you maintain the organisms in this ecosystem in the best possible state. And so, they are much more resilient to any impacts or any disturbances such as say, because of the release of pollutants or because of an oil spill or because

of a forest fire. So, we get genepool benefits in terms of resilience of ecosystems.
You also have avenues for future use of biological compounds and their products, which means that if we have a new disease that comes up. Then, we will have to look for medicines; we will have to look for those compounds that can help us fight those diseases. Now, a number of plants and animals have certain compounds that are known as metabolic compounds.
Now, these compounds can play a role in protecting us against diseases, a good example is the quinine that we get from the bark of cinchona trees. Now, quinine is something that the plant manufactures not because it is an anti malarial, but because it provides a certain degree of protection to the plant, other animals do not eat that plant insects are less able to invade into this plant. But, then because this plant produces quinine and if humans get malaria, they can make use of this bark to extract quinine to work as an antimalarial drug.
And a number of medicines such as artemisinin are also derived from different plant products. Now, if we have a large amount of biodiversity, there is a greater chance that we will have access to one or more of such compounds in the future when we need them. So, these are genepool benefits: the benefits that you are getting, because you are maintaining a good genepool and a good biodiversity.
Now, these kinds of benefits are computed using benefits transfer method, which is a method to estimate the economic values for ecosystem services, by transferring available information from studies already completed in another location and or context. What this means is that suppose in a protected area in some other country or in some other part of your country calculation has been made; to make evaluation of the kinds of benefits that we get to make an economic evaluation of the benefits that we get, we can make use of such studies to incorporate the results of the analysis that was done there into our protected area. That is known as a benefits transfer method. We can compute the valuation of these genepool benefits using the benefits transfer method. You do not have to do a valuation at each and every protected area, but in certain protected areas you can do a more intensive valuation and you can make use of those results in your protected area of study.
Then, we can find out carbon sequestration benefits which is the amount of carbon that has been sequestered multiplied by the market prices, or we can even make use of the social cost of sequestering this carbon.
Carbon storage benefits which is again total storage into the social cost of carbon. What is the social cost? The cost of impacts that is caused by the emission of carbon dioxide. So, what we are asking is if we did not sequester this amount of carbon, if we did not store this amount of carbon then this carbon would have been released into the environment. It would happen there in the atmosphere, it would have played a role in global warming and in climate change.
Now, because of climate change, because of global warming, there are a number of extreme climatic events. We are seeing more floods, more droughts, and things like that. Now, what is the social cost, what is the cost that people are suffering, because of that amount of carbon that is there in the atmosphere? That is the social cost of carbon.
We can do carbon storage benefits as total storage of carbon multiplied by the social cost of carbon. We can look at water provisioning benefits. What is the amount of clean water? That is given by this protected area multiplied with the market prices. We can look at what are

purification benefits, which is the water that is purified by a protected area multiplied by the average cost of treating water.

Or we can look at soil conservation and sediment retention benefits. The amount of erosion that was avoided by this protected area multiplied by the cost of damage that was avoided, we can look at nutrient retention benefits.

The amount of nutrients that were retained multiplied by the cost of artificial fertilizers, that would have been required if you were not retaining these nutrients. Biological control of pests computed using benefits transfer method, moderation of extreme, events benefits, pollination benefits, nursery for various species benefits.

Habitat for various species benefits, cultural heritage benefits, recreation benefits, air quality benefits, water assimilation that is being done by the protected areas, what is the benefit because of that. What is the benefit from regulation of climate? We can use it; we can have a look at all these different ecosystem services that are being provided by the protected area and do an economic valuation of that.

Now, what sorts of results are obtained? So, if we look at the valuation of Panna Tiger Reserve, we are getting flow benefits of around rupees 70 billion in a year of which direct benefits are 0.78 billion, indirect benefits are 53 billion option benefits are 15.65 billion stock benefits, critical ecosystem services kinds of services.

So, in total what we are getting is that we are having an investment multiplier. So, we can add up all of these different benefits and then we can figure out what the investment multiplier is. Now, what is an investment multiplier? An investment multiplier asked the question that if the government, or if the public spend 1 rupee into the protected area what is the return that they get out of it.

So, suppose the government invests 1 rupee in the health care sector, then people are more healthier if they are healthier then there is an increase in the economic output. What is that level of economic output? What is the bang for the buck that we are getting and what are the benefits that we get? So, for any investment we can look at the investment multiplier. And here we are observing that the investment multiplier, in the case of Panna Tiger Reserve, is as high as 1939.36.

Now, this is especially because if you have a protected area, there are hardly any costs involved, because you only have to maintain that area's minimal level of protection and minimal level of habitat interventions. But, then nature does everything else for you. So, it is a very good investment multiplier meaning that it is a very good investment opportunity for any economy.

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