NPTEL

NPTEL ONLINE COURSE

Ecology and Environment

The need to study ecology

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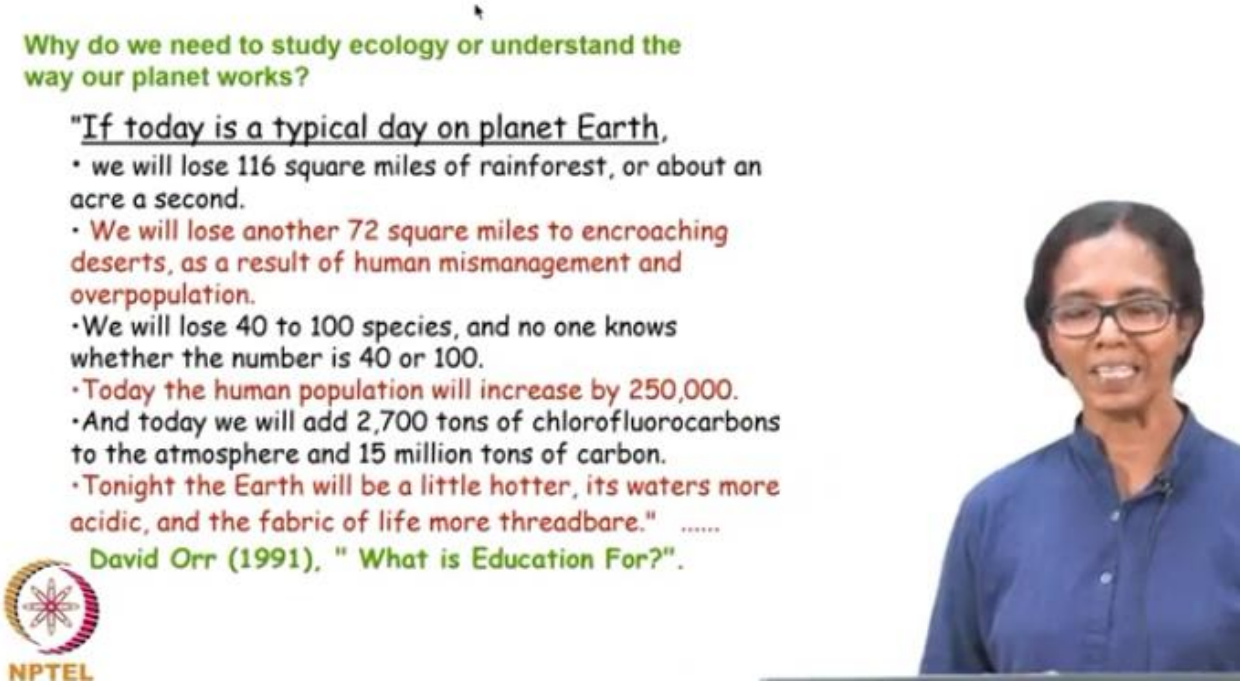
This lecture is on Ecology, basically in 3 to 4 hours I am trying to summarize something, what is known as the science of the universe.



The question is why do we need to study ecology or to understand how the way our planet works? So that is a question that we are asking here. This course is majorly aimed at students who are not studying ecology as a stream, or they are not continuing biology. So, mostly aimed at science and engineering students who may not have studied like us who have graduated in technology without studying ecology.

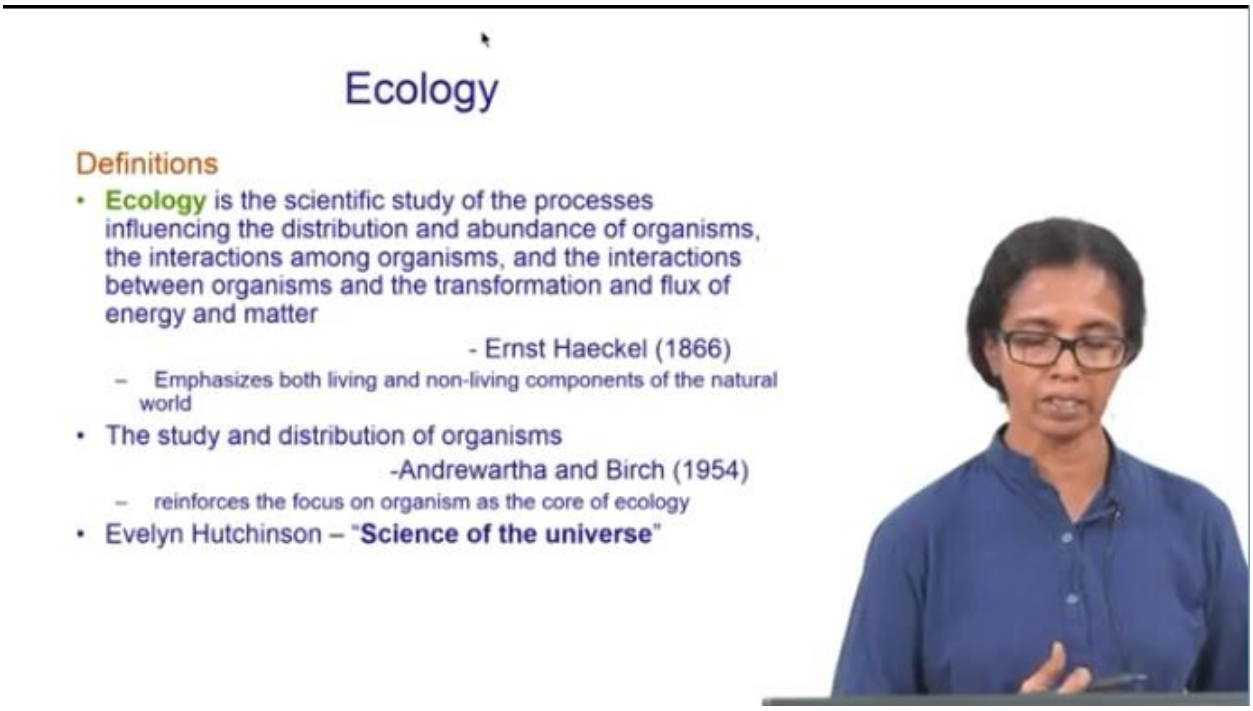
Why do we need to understand ecology? So, I will just like any other course, some motivation to do this ecology. So, I quote from Professor David Orr, this was written in 1991, he asked this

question in this lecture, what is education for? I am quoting from him. If today is the typical day on planet earth, we will lose something like 116 square miles of rainforest or about an acre a second. We all know the importance of rainforest in our lives, so and similarly we will lose another 72 square miles of to encroaching deserts or as a result of human mismanagement and overpopulation. So as we are growing in number, the desert area is also increasing, or desertification is going on.

We may lose 40 to 100 species, and this is we are talking about a typical day on planet earth, we will lose 40 to 100 species, and no one knows whether it is 40 or 100. I asked this question, why we do not know whether it is 40 or 100 because we have not even estimated how many species are there on earth. So before that itself they are you know vanishing at a very, very fast pace, so we do not even know whether we are losing 40 or 50 or 100 or how many species on a single day.

And similarly, today the human population will increase by 250,000 and today we will add about 2,700 this number was given in 1991 so you can imagine how much it would have gone up 2,700 tons of chlorofluorocarbons to the atmosphere and 15 million tons of carbon. Of course, we have removed chlorofluorocarbon elimination into the emitting into the atmosphere, but we still have lot of carbon being added to the atmosphere.

And tonight, the earth will be little hotter, that we all know that we are talking about global warming, and it is waters more acidic, the reason also we may know because we are putting more and more carbon dioxide, nitrous oxide, sulphur oxides into the atmosphere, this comes back as rain and the water is becoming more and more acidic. And as it becomes more acidic the fabric of life becoming more threadbare. So, this is a question Professor Orr is asking us, why we need to worry about this and do we need to know as engineers and scientist do, we need to know how the planet earth works and whether we need to understand ecology.



So, when we come to ecology, there are many definitions before we go into the science of ecology. I will just bring some definitions which are known in literature, which is in 1800 itself. It was defined by Ernst Haeckel, which is one of the best definitions till date. So it is defined as the scientific study of the processes influencing the distribution and abundance of organisms, the interactions among organisms and the interactions between organisms and the transformation and flux of energy and matter. So, this is one of the best definitions of the comprehensive definition of ecology that we could have, and it emphasizes both living and non-living components of the natural world.

So as there are many many questions that are arising out of these definitions, and that is what ecology as a stream of science try to address, to understand this processes that goes on in planet earth or in the universe as such. So, it is also can be defined, I mean various other definitions also came forward in between, so it is called the study and distribution of organisms, so which reinforces the focus on organism as the core of ecology. So, there are various definitions like this in the literature, we are not going into the depth of this definition of whether we should focus on organism or whether we should focus on ecosystem or whether we should look at it as a total system concept.

Similarly, I mean one of the best definitions which encompass all this is given by one of the best ecologist Evelyn Hutchinson he defined ecology as the science of the universe. Why has he defined the science of the universe is, and as I said if it is the science of the universe it is difficult to comprehensively define everything that comes under ecology in our 3 hours of lecture. So that is my job in this course, so I will only define certain things which are very key and critical to this course and understanding ecology and why it is important for humans to understand ecology.

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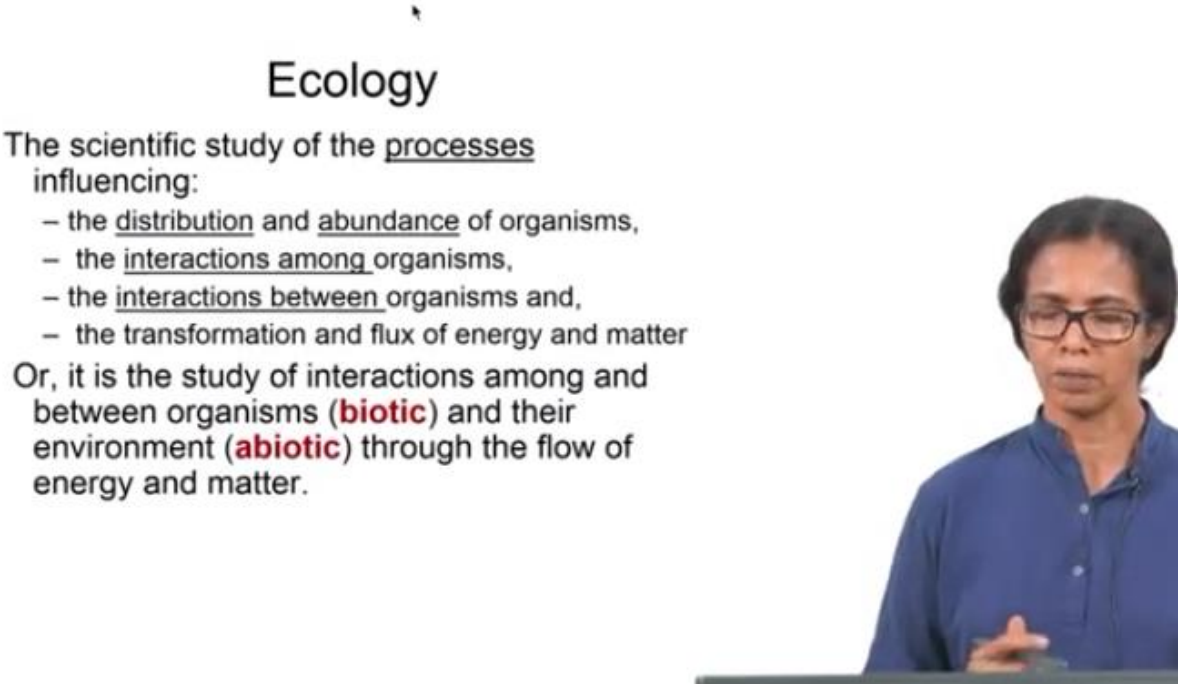
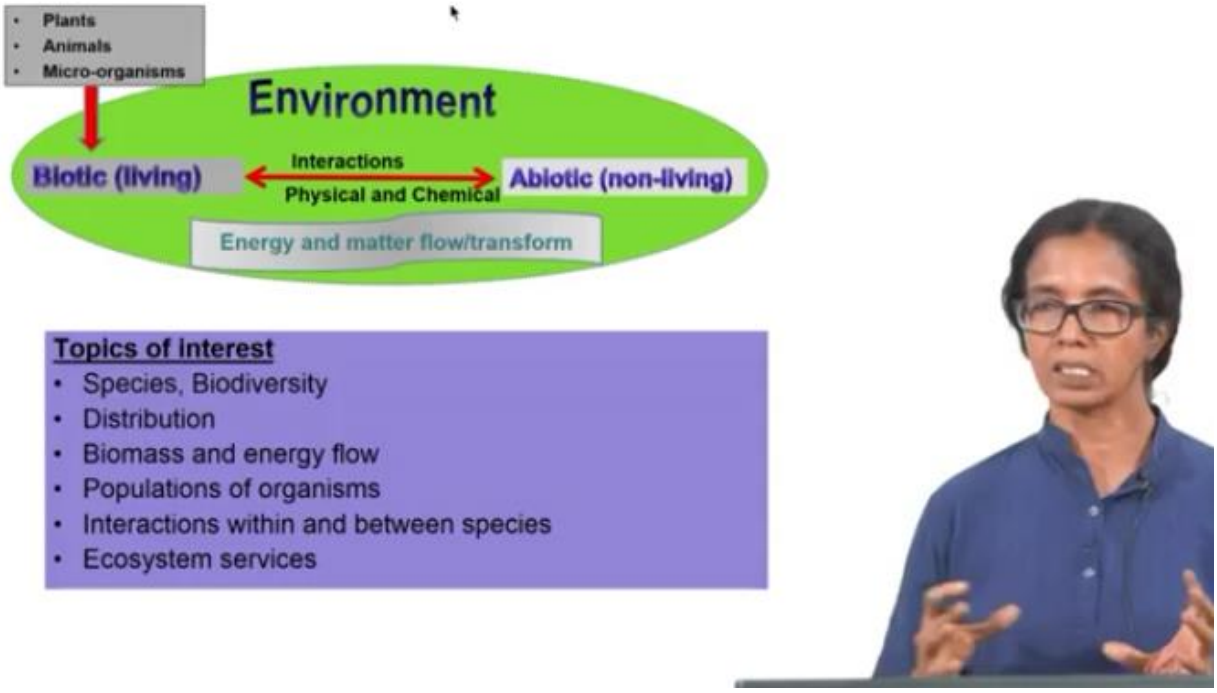


So, as I said already, ecology is a study of the processes, it is actually, you can define as you know, many of us in different branches of the engineering and science define different kinds of processes, it could be chemical process, it could be physical process, so that are different processes that goes on.

So, we are talking about processes that dictate, the distribution and abundance of organisms, okay. So, how do we know that you know how many tigers are there in the forest, how many you know Asiatic elephant exist in the wild. So, basically how and where are they distributed? How many of them are there in the wild? And for example, in a particular habitat how many species are there existing, and why do they you know exist in a particular way in a particular place, and do they interact. For example, tiger, we have, just know, we have seen in the particular habitat in a particular region on earth, so is it, why are they restricted to certain regions, who\what are the other organisms they interact with?

And also, the interactions between organisms, for example, tiger interacts with another tiger or an elephant interacts with another elephant. Similarly, a tiger also interacts with species like maybe deer, it maybe you know it is its food you know organism, or it could be, the deer could be interacting with another organism which could be interacting with other deer and it could also be interacting with its surroundings, plants, various other insects, microorganisms. The tiger also has other interactions not just interaction with deer alone, it also has you know interaction with microorganisms maybe it is competing with other tigers for food and other animals also maybe for food. So, there are various kinds of interaction which we call as competition, sometimes you know coexistence of different organism etcetera.

And in all these events what we see is the transformation and flux of energy and matter which flows through the system, okay. So, the essence of ecology as we can summarize for the concept of you know science is that it is the flux of energy and matter or materials through the ecosystem. So, it can be summarized thus the interactions among and between organisms, so the interactions could be among the same species, or it could be between different species which is defined as biotic interactions, and their environment, so this environment which is surrounding it is defined as the non or abiotic or nonliving part of the system.



So, as you can see in this picture you have the environment which is, so basically you have the environment here so which has both living and nonliving part. So, this nonliving and living part interacts through physical and chemical processes. So, this is exactly like physical you know chemical process means it is chemistry based it is a chemical reaction or chemical process, it could be an oxidation, it could be reduction, there are so many processes that goes on in between the biotic and abiotic world.

And in the biotic world we have plants, animals, microorganisms which represent the biotic or the living part, and abiotic means mostly the, I will be detailing these two, and this has, abiotic will have nutrients, energy, water, various components that will affect, also, for example, the the humidity in the atmosphere all this components or temperature this can externally influence the presence of the biotic or the living part of the system. So, the whole environment is encompassing all this, and they have dictated by energy and matter flow and also transformation,

transformation of energy into material form and vice-versa, and also matter in one form is getting converted to another.

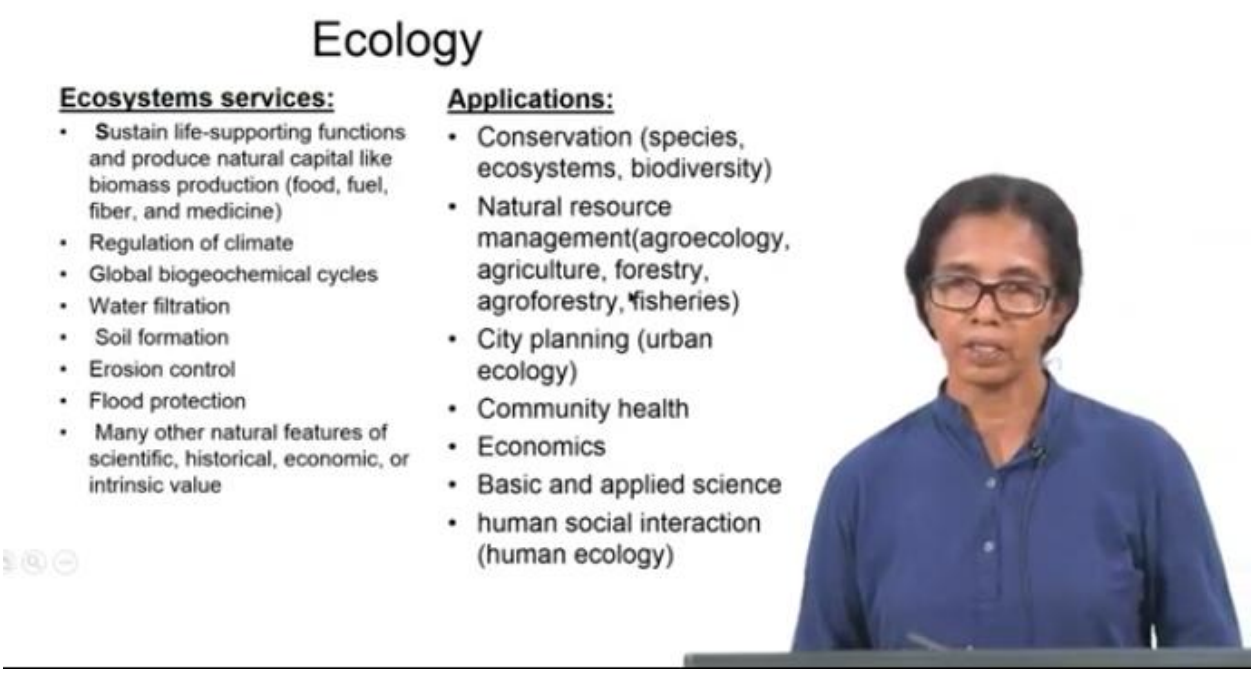
So, the topics of interest that emerges here are what is meant by different species and how they originate? What is meant by biodiversity? What is meant by distribution of different species? We may not be able to dwell into the details of each of this, but the topics that arise which is of interest out of this discussion on biotic and abiotic interaction are these topics.

Similarly, biomass, how is it formed? What is meant by biomass? Is the living mass of the systems like whether it is a microbe or whether it is an animal, or whether it is a plant, the living mass that you can get is the biomass of the organism. And the energy that flows in the system from one system to another, for example, for food, we have to take food from the surroundings. And that food is what brings energy to our system, or any living animal, for example, gets, there is no directory of taking energy from the sun and then converting it, the only source that can convert solar energy to useful matter or energy form is plants on earth. So, the plants convert this energy from the sun and then gets transfer into other organisms whether it is a herbivore, whether it is a carnivore, it flows through the ecosystem as we understand and that is, that generates what is known as population of organisms.

How many numbers thrive in a particular community or a particular species, and how they distribute themselves in different parts of the planet? The other as I said, is the interaction within and between species, it is again a kind of you know balancing act for obtaining the energy that is flowing in the system. So how do we optimize or maximize the energy flow into each of this organism, and each organism is striving to harness this energy in some form, this is the essence of ecosystem functioning.

And similarly, as humans who are part of this ecosystem or we part of the ecosystem is a very important question that we have to rise here, and we define this for our convenience or understanding to call this as the ecosystem services, okay. The functioning of the earth or the functioning of different ecosystems and the matter and energy flow on the earth can be you know defined in something called ecosystem services that is the services that are rendered by the ecosystems that is existing on planet.

Also typical, you know, ecosystem that all of us understand, this is you know a caricature of a forest ecosystem where you know, and the one of the important questions that rise here is, are there boundaries? Or you know when you define an ecosystem, where is its boundary. For example a tree, for example, can be defined as an ecosystem in itself when you know there are different creatures which may depend on it. And it could you know, for example, for a microbe which may be thriving on the plant, it could also be the system with different interactions possible there, or for example there is a pond which is depicted here which could or a lake which is depicted here could be an independent entity in itself, and it could form an ecosystem. And it is surrounded by let us say forest, but at the same time, the whole system also can be called an ecosystem which require the water supply to the animals in the ecosystem and the plants and the other animals who may depend on this system.



So, on a human point of view, there are two ways in which ecology becomes useful for human sustenance on earth, and we need to look at it in two ways. One is how we, how ecosystems are affecting our lives, and the other is how we are affecting the existence of the ecosystems and how it can, in turn, affect the existence of other species also on earth. So, there in that context, there are two things that we bring forward that is one is what are the services provided by ecosystems for the existence of life on earth, so and the other is the how this ecology can be used in various applications. So ecosystem service is an important concept here to understand and appreciate ecology and to appreciate the conservation of ecosystems.

So, the brief introduction in ecosystem services is, I will detail this in the next few lectures, one is important is that sustain life-supporting functions and produce natural capital like biomass production. So what we mean by sustain life-supporting functions as we know that the earth has it's you know for all living systems that we have oxygen, and air, water, and food are the most important criteria that required for supporting life functions or sustain life on earth. So, so the food, fuel, fiber, and medicine etcetera are secondary things that we require for sustaining human life on earth, so in other words, ecosystems provide the fundamental services for existence of life on earth.

So second thing that is written in gist here is regulation of climate. How the, I mean the climate on earth is dictated by ecosystems, for example, oxygen. Which is, which was not there in the beginning of the planets evolution. If you look at, and there are many theories on how oxygen came into the atmosphere, and then eventually how life started getting supported on oxygen. And how a living system started using oxygen, or similarly how carbon dioxide is taken up by plants

and oxygen is liberated into the atmosphere. All these processes basically is an, what is known as an oxidation process that happens on earth where in the primitive periods of the earth's evolution. If you look at the processes that we are going on were mostly reductive in nature, and the hypothesis say that when the water molecule started breaking down to hydrogen and oxygen in the presence of either the ionosphere, where ionization could happen. And hydrogen and oxygen started separating, oxygen started staying back in the atmosphere and hydrogen being liberated outside. Or similarly plants contribution to, through photosynthesis how oxygen started coming into the atmosphere and the other living systems started evolving based on this.

So, and from then onwards we know that the climate is regulated very, on a very fine basis for sustenance of life on earth. For example, temperature on earth's surface we talk about global warming because the temperature if it goes from the current average temperature to some about 2 degree Celsius, the catastrophic effects that it can bring due to various other processes which are regulated by this temperature. So, this temperature is linked again to the amount of carbon-dioxide in the atmosphere or other greenhouse gases as we know like water vapor and methane present in the atmosphere, so all this regulate the climate and in turn, the temperature on the earth and that can affect the life itself on earth.

Similarly, ecosystems are also serving global biogeochemical cycles so which all of us know what is meant by biogeochemical cycles, you would have studied it in school, this is with reference to the various cycles that we study. One is carbon-dioxide cycle, water cycle, nitrogen cycle, phosphorous cycle there are many cycles which are regulated by living and nonliving systems together or in general what are known as ecosystem services again. So if you take each of this cycle that dictates the micro and macro climate on earth, it is very important to see how they are all of different ecosystems or living organisms and other interactions with its surroundings affect the global biogeochemical cycles, which is in in turn contributing to the regulation of the climate as well.

Similarly when we drink water, for example, we do not realize how we get those water in those systems, for example, today when I say water filtration. An example is can we all drink water from our wells today, it is many times it is very difficult to drink directly the water that is coming in a tap in public places today because we do not trust the quality of water and we believe that it may be contaminated. It is all possibility because of various kinds of pollution that we are causing and how this water can get filtered, so in a natural system maybe 50 years ago you could go and drink water from anywhere, from a stream or a well or a pond.

How did we trust this water? Most of the time this water would have been clean, and this is one of the biggest services that ecosystems provide cleaning or the filtration of water and that happens through various systems that is beautifully placed on earth.

Similarly, another important services soil formation bio-microbes from various decaying matter and other minerals, the decomposition generate healthy living soil which is important for sustenance of life on earth again because we plant, we grow plants, and then our food is coming from you know good soil formation.

Erosion control this is also very important for flood control and other processes as well. And many other natural features of scientific, historic and economic and intrinsic value are supplied by an ecosystem's services, which can be, so the question is because we are calling it service, is it possible to assign an economic value to it? That is a big question that we need to address and so what is known as ecological economics. So, the applications of ecology comes up in terms of you know, if you are an ecologist who is trained in ecology or you are interested in ecology, you can help within the conservation of species. For example, this comes when globally we know that many species are threatened, as I said in the first slide, 40 to 100 species are vanishing from earth every day due to increasing human population and conversion of natural habitats to agriculture lands or industries or other human-occupied areas where other species are finding it difficult to exist. So, the conservation of species ecosystems and biodiversity are very, very important as you can see from the left-hand side for the services that they are providing, and it is one of the important application that arising out of ecology, learning ecology.

Similarly, how one should manage. I mean the word should not be used here, earth knows its own management, but at the same time since human beings are an overarching phenomenon on earth currently, natural resource management has become a big you know area in itself. For example, agriculture, agroecology, forestry, agroforestry, fisheries, all these are what are known as natural resources in some way or other. So this how do we you know how humans are managing this, humans are part of the system but at the same time managing this system.

Similarly, city planning, how urban ecology whether how for example most of the cities around the world are becoming you know almost unlivable because of the pollution intensity there, the noise, the light, everything that is not very favorable for existence of life is happening. And how do we plan cities in future, for example, or currently to favor a better and better living condition, how do we control, for example, floods in cities. Almost every city in India has faced a severe flood when there is a huge rain happening because again urban planning where ecology is not considered is one of the reasons why this happens periodically. For example, lakes are vanishing from urban environment, so this is an important thing for planning for cities. So, we need to look at the ecosystems which are supporting, for example, flood control in the city, so where did they vanish? Can we bring them back? How do we incorporate you know ecology for naturally existing systems in these cities?

Similarly, community help, it is a very important criteria and important factor as we all know that in urban areas or in semi-urban areas, as human population is increasing and various other

organisms are also able to thrive. An example is mosquitos, so this is many times it is correlated to the destruction of forest habitats, and many of this, some of the disease germs, for example, existing in forest can come in contact with human communities as more and more forests are getting destroyed and that is a possibility.

And similarly, health as such is you know if you have clear air with no need to tell or emphasize anything more, health is something that comes from clean air or clean food and clean water. So all this are naturally provided by ecosystems, and there is no need to emphasize more on health on any other accounts. So as we pollute more our health is in danger, and earth services are reducing, so naturally services should be promoted here, and the ecosystem services have to be given a role there for taking care of the health as well, so human health is at jeopardy because of we are destroying the ecosystem.

Similarly, as I said economics, so if you put all the services which are listed on the left-hand side of this panel and look at it, and if you could assign some values to it we know the economics that is generated which is you know, which is not visible to us many times. So, we can do some calculation to show that, for example, purification of water using a natural ecosystem in a lake and if I could drink the water directly from the lake instead of artificially creating cleaning systems or desalination systems etcetera to drink that water again. You can estimate the cost to see how much is the what is lost in terms of converting a natural system by polluting it, and then you going back and then again doing a cleaning to get that water in the form that we could consume. Or for example, if I could eat the food which is clean, the after effects of it being not good food is much more, in terms of health benefits or in terms of the you know human wellbeing. All these are cannot be put into in economic terms, current economic terms and that is one of the reasons why we are not able to you know appreciate what ecosystems are providing us. So, which is very important to you know consider the left-hand panel very of this slide, to understand that how this ecosystem services are related to economics.

And of course, this is also an understanding of basic and applied science and human social interaction and what is known as human ecology. So basically, as I said we are not out of this system, we are just part of the system, and we have existence which are related to only this how well the system is performing. So it is very important to appreciate the services provided by the ecosystems and how human beings are interacting and how we are affecting the ecosystems, and how ecosystems are affecting us.

Thank you