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Ecology
Ecosystem functions and services
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I will elaborate little bit more on ecosystem services to drive home the point why we need to be motivated to study ecology and ecosystems. There was an assessment by the UN which was carried out in 2001 to 2005 by more than 1,500 scientists from all over the world which is known as the millennium ecosystem assessment to assess the services provided by because we take it for granted.

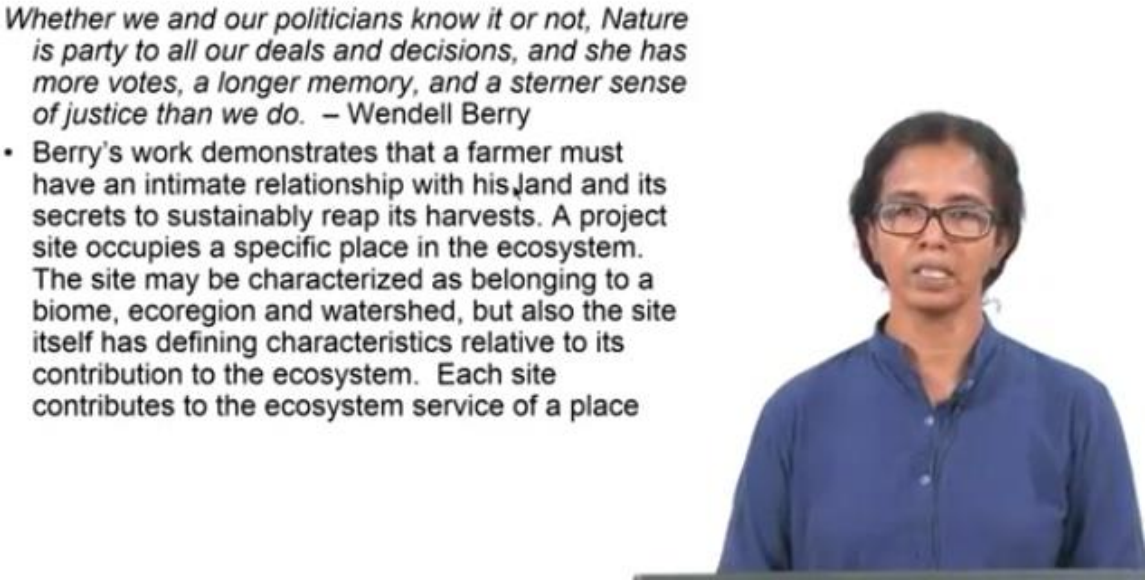
This ecosystem, the millennium ecosystem assessment was carried out by more than 1500 scientists. The reason is like as I said earlier, many times we take it for granted what is provided to us which is existing as the function of the ecosystem, which we take it for granted. And we do not give the due, in return we are not respecting the fact that these systems have to exist for our wellbeing and existence as well.

So, the reason why it is highlighted, and that is why more than 1500 scientists came together to assess what are the services provided by ecosystems and how? For example, we can incorporate this in our modern-day economics which many times ignore the fact that there are services provided by ecosystem. I will site an example, pollution, so for example when the car which is made and which is polluting, who should be paying for it and where should be the, who should be penalized for it? Should the car owner should be penalized, or the car manufacturer should be

penalized, or the company which is producing the diesel, or the gasoline should be penalized or the governments which are regulating this thing should be penalized.

There is no end to this connection that you know there are many users for this. And at the same time, nobody is taking responsibility for saying that once we put the carbon-dioxide or the sulphur-dioxide or the nitrogen-oxide into the atmosphere, there is no assignment of responsibility to anybody. So, it has to be taken care by the environment which is surrounding that is what we call indirectly the ecosystem services. So, carbon-dioxide, for example, the only natural way that it can be taken up is plants which can utilize carbon-dioxide for photosynthesis and convert that into effective biomass or food.

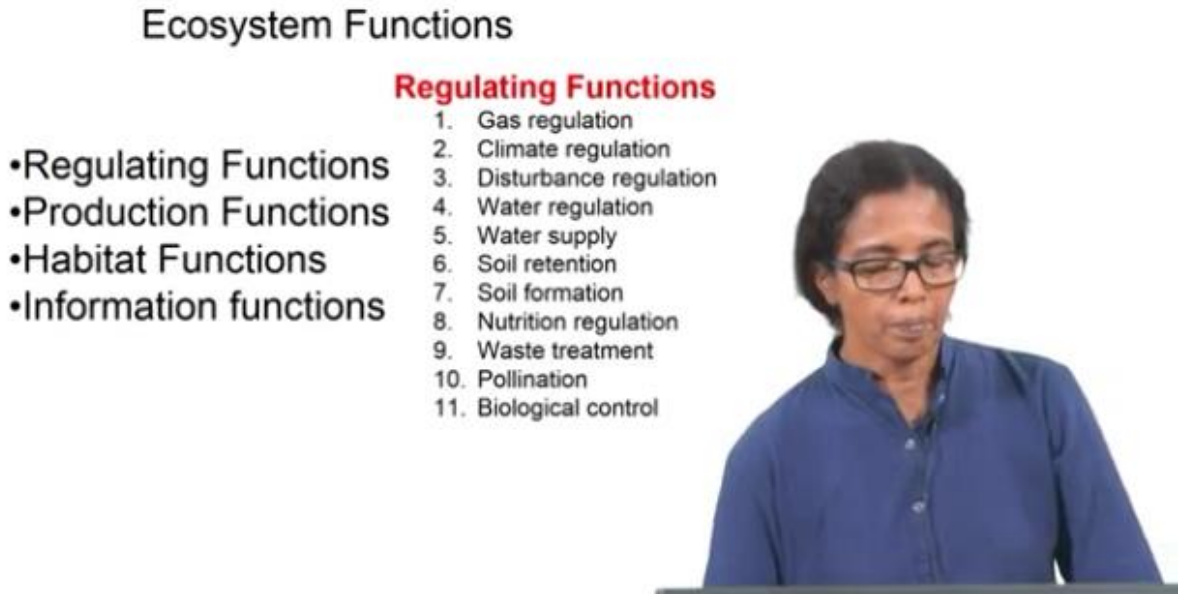
Whereas all other systems when we try to, so that is why we also have need to read the ecology along with the definitions for carbon footprint and also another definition of ecological footprint that we will come to, and the ecosystem services is one that leads to the definition of this terms like ecological footprint and carbon footprint which is indirectly connected to the ecosystem services. So, the central premise of this millennium ecosystem assessment, all the constituents of well-being including security, basic materials for prosperity, health, good social relations and even freedom of choice and action are directly dependent upon ecosystem services.



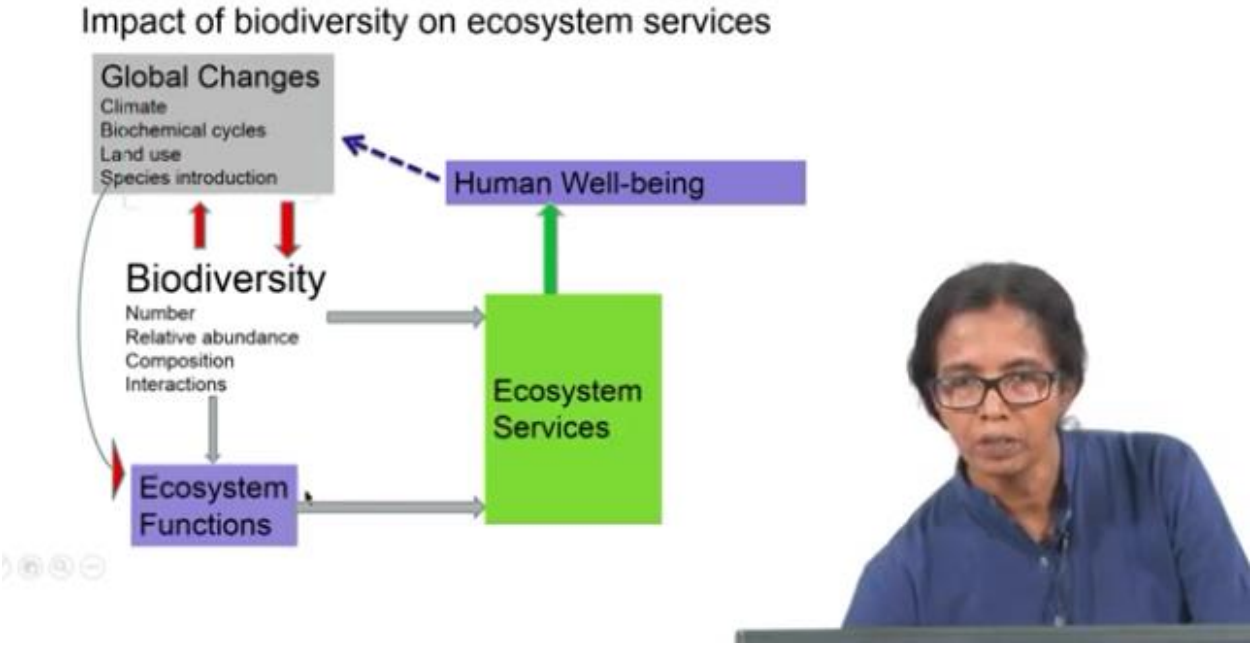
So, what, whether we and our politicians know it or not, it is defined by Wendell Berry that when, whether we and our politician know it or not, nature is party to all our deals and decisions, and she has more votes and longer memory and a sterner sense of justice than we do. So which is many times reflected when the processes on, the natural processes run a mock, for example when floods happen when droughts happen, this are actually kind of you know the mechanisms with which ecosystems are trying to cope up with what we are doing and when it cannot handle the system. So, it will go, going to run away processes, like we say in a chemical reactor, let us say if we do not know, let us say a process which is exothermic.

And exothermic processes, for example, produce heat, so if we do not control the heat which is produced in the system, the reactor can you know have a runaway process, and it can explode, or it can cause problems. So similarly, earth processes are also as I said earlier, these are chemical and physical processes and if we do not understand and if we do not take measures to see that our, what we are contributing as an agents of change to this ecosystem, it can result in runaway processes, which will be in terms of you know floods or droughts or you know unwanted temperature where life cannot be sustained on earth itself.

So, Wendell Berry's work demonstrates that a farmer must have an intimate relationship, so this is also saying you know what should be the relationship of human being with the ecosystems. So here is this, for example, a farmer must have an intimate relationship with his land and its secrets to sustainably reap its harvests. A project site occupies a specific place in the ecosystem, the site may be characterized as belonging to a biome, an ecoregion, and watershed. It may be just a farmland, but it is a part of a biome or what is known as an ecoregion, and maybe it is a part of watershed. These definitions are important for us to know, in ecology you need to know the definitions of these terms to understand what is a biome, what is the eco-region or a watershed and how our activities or acts. Whether it is a farmland or another project that we are envisaging, how it can affect and how it can be in sync with the ecosystems that survive there. But also the site itself has defining characteristics relative to its contribution to the ecosystem, so each site contributes to the ecosystem services of a place and the interacting person whether it is a farmer or whether it is an individual has to see where that project is going to be placed, whether it is a you know an engineering project or whether it is a farming project, so these are the systems, these are the events which interacts with the biomes, the eco-regions, and the watershed.



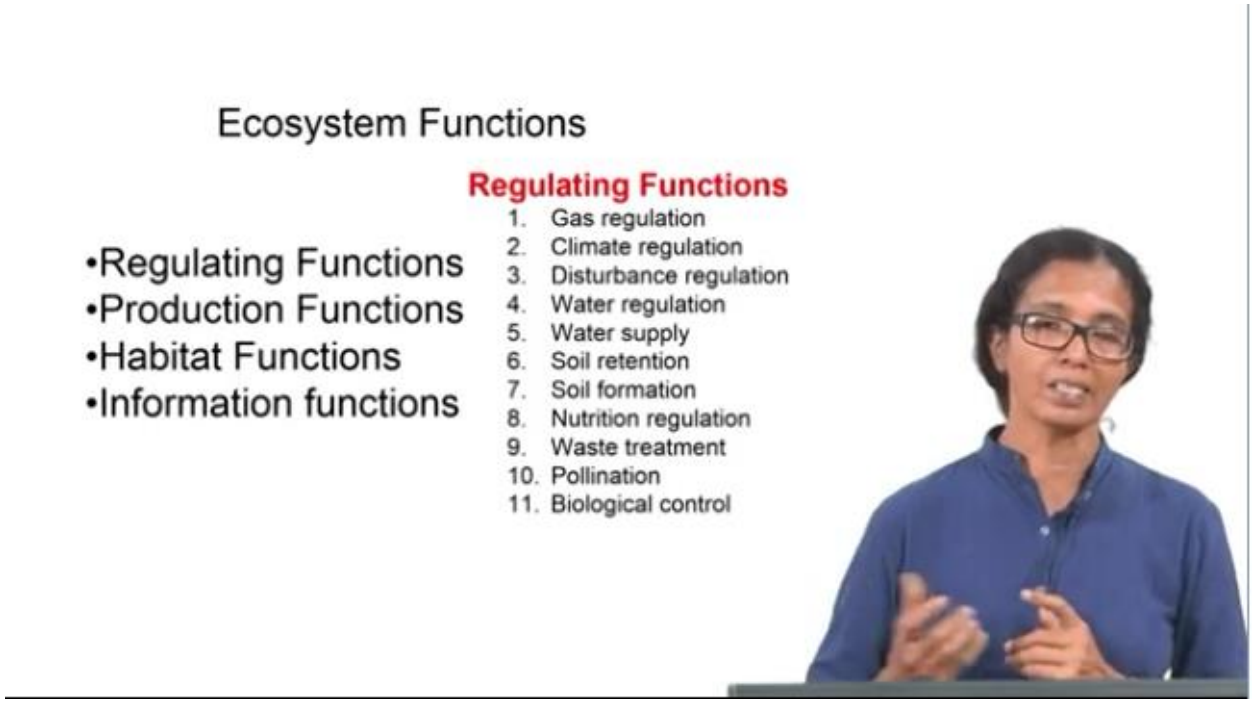
So, to understand ecosystem services, the ecosystem service is an output of, so ecosystem services are basically an output of ecosystem function.



So, ecosystem is not doing a purposeful thing to give us a service, but it is just we in terms of human welfare definition or human well-being, we require this ecosystem services as you can see highlighted here, the ecosystem services is the result of the ecosystem function, so which is a natural functioning of the ecosystem itself. So, as you can see, it is spread by what we call as biodiversity of the ecosystem, so biodiversity has different, you know, things that we define in terms of the number of species. The relative abundance of each species, their composition, and their interactions, all this together feeds into what is biodiversity and in terms and in turn the biodiversity feeds into the ecosystem function. The function of the ecosystem is defined by the biodiversity of the place and which can in turn being affected by, so in backend as you can see these are all like system which has relationship back and forth.

So, biodiversity feeds into global changes of an environment, for example, climate, biogeochemical cycles, land use, and species introduction. So basically it can feed into biodiversity and also it can feed back into global changes.

Similarly, global changes can affect the ecosystem functions, so as you can see biodiversity affect global changes which can, in turn, affect the ecosystem function and ecosystem service that is required for our well-being. So human wellbeing is a key point here which is dictated by biodiversity, ecosystem function, ecosystem services and there is no other way that we can define this better. So what are this ecosystem functions which are result of ecosystem function which results in what we call as the ecosystem services.



So, the functions are of ecosystems, so these can be elaborated one can go and read more about it, so they can be classified into four major categories, one is regulating functions, production functions, habitat functions, and information functions, so these are the functions of ecosystems. So, if you generally look at you know regulating functions what are the kind of things which are regulated by ecosystems, so for example, one is gas regulation in the environment, so we all know that the carbon dioxide, the oxygen level, the nitrogen level all these are regulated by ecosystems like plants, animals.

So, for example, plants we know carbon-dioxide is taken up by plants during photosynthesis and oxygen is liberated. Similarly, when plants are during respiration, they take in oxygen, and they leave carbon-dioxide outside. Similarly all animals and microbes they take in oxygen and leave carbon-dioxide outside. So, you can see the regulation of gas in the environment, is if we do not have any other external processes which are introduced by humans, let us say, and we had only living creatures which were regulating this, so it was going on in a natural way in some sense unless there are some catastrophic events like, let us say, volcano eruption or some other catastrophic temperature changes on the atmosphere, in the atmosphere etcetera that could eventually let us say wipe out large populations of plants then it could have runaway processes, let us say carbon dioxide absorption changes, and it could lead to other processes.

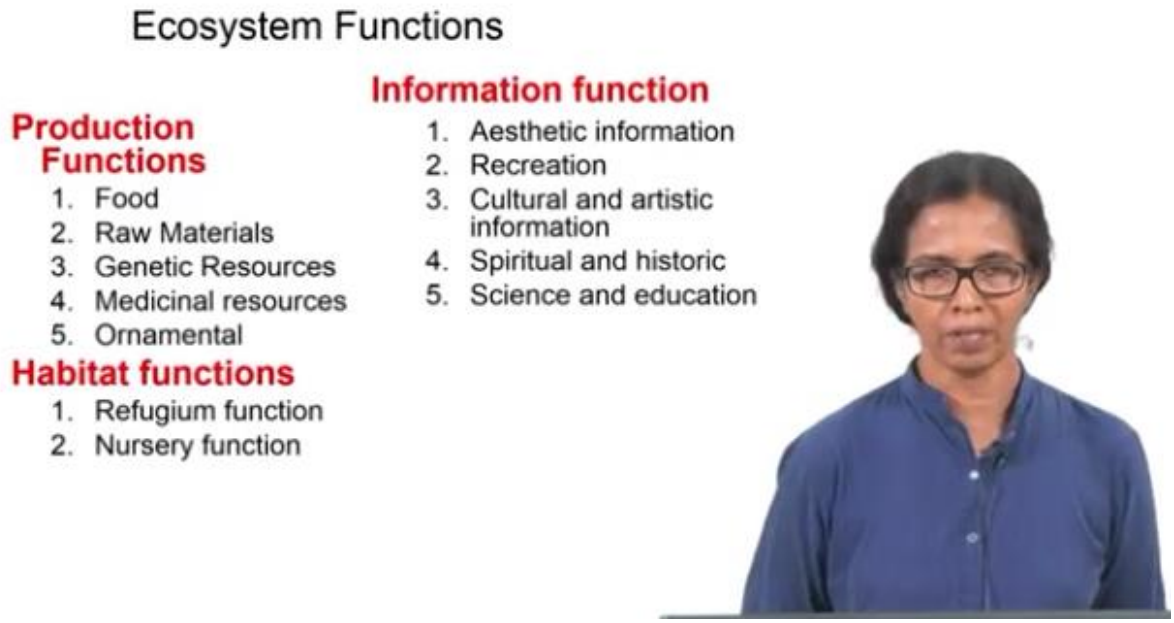
So, for example, that if we say that we are heading towards another mass extinction, the 6 mass extinction, there were extinctions before also which were controlled by this natural processes. Which are kind of runaway processes in some sense, you know, the earlier ice age had more of carbon dioxide on the earth's atmosphere which was due to, for example, the tilting of earth's rotation angle so which could change the temperature itself. And so this is the very finely controlled physical and chemical processes that goes on in the environment which leads to the functioning of earth itself and the living beings there.

So, the gas regulation is an important function here which if you go and read, we will learn that you know how finely controlled is the concentration, for example of carbon-dioxide in the atmosphere, it is about you know 0.03% is only carbon-dioxide. But when it shoots up by little amount, for example, if you turn it into in terms of ppm, the 350 ppm is the upper limit that is set by scientist to say that in the atmosphere, that is parts per million that is if you take million molecules of air, million parts of air you will see 350 parts only carbon-dioxide. So when it shoots up let us say it becomes 400 or when it becomes 450 it is climbing up currently due to carbon dioxide emission from various industrial processes and other processes that we are engaging other than the natural breathing in and breathing out by living systems. So the gas concentration in the atmosphere is increasing which can intern affect the climate and other things.

So, the climate regulation, that second point is climate regulation which is finally dictated again by the gas regulation in the environment. Similarly, disturbance regulation, again to do with the, so if you consider any system when we, so this is a dynamically operating system which has you know different time scales and different for the processes that is going on here. So it can get disturbed from what is known as, I mean there is no equilibrium states here, it is constantly in flux and it is moving and different processes are going on the planet due to, the contributions from different ecosystems which are interacting and forming the biome itself. And so the disturbance regulation is another factor that is constantly at the back of this which is a process that can be controlled by the ecosystem services.

So, for example, if a system is disturbed, what we mean by disturbance is, let us say we cut down a forest for agriculture purpose. So if a disturbance affects a particular ecosystem and if enough time is given the disturbance, the system itself regulates and you know takes control of it.

Similarly, a regulation of water, water supply, soil retention, soil formation, nutrition, waste treatment, pollination, and biological control of organisms, so all this are regulating functions and which one can see in the ecosystem.



If you look at ecosystem functions, it can be classified into different categories as I mentioned, as a regulating functions, production functions, habitat functions, and information function. So, we have already discussed what are regulatory functions, where ecosystems regulate the gases, the system, water, the air, everything that we come across is regulated by ecosystem functions, and if we assume that if we have to generate all this now on an artificial scale it will be humongous cost. So there was an experiment which was conducted called biosphere to see whether it is easy to, whether it is possible to reproduce an earth and in it all its functions elsewhere, let us say in either in moon or in mars or somewhere where we want to colonize, for example, so if we have to reproduce all the functions so that we can have a living atmosphere and living planet there, so this is an experiment that you can go and refer to known as Biosphere 2. And how much it cost is one of the reasons why it is very, very prohibitive in it's you know economics, to know what is the function that is served by Biosphere 1 that is our planet earth.

So, when it comes to production functions as it is listed, the ecosystems provide us the food and so i was elaborate, I am elaborating little bit on the food part. When we say food okay, when we all eat, either wheat or rice or some pulses and fruits and other things to supplement ourselves, but when we say that there was, you will say that it is actually produced by some farmer. Is that the truth that this is produced by farmer or is it by the ecosystem, or it is a part of an ecosystem service.

To understand this let us say what does the farmer do? Farmer has to go and sow some seeds, and will it grow or not is depending on the various other factors. For example it is also detected by the climatic functions, so it is regulated by the let us say the weather, the local weather, whether it is going to rain more, less, whether it is going to be drought, whether it is going to be hot, whether it is cold, all this dictates whether the food is going to be produced. That is one of the functions that is you know dictated by ecosystem service, that is regulatory function.

Second is that we all take it for granted, let us say farmer goes and put the seeds and then he waters, and then he provides let us say fertilizer and then weeds and then removes the weeds or whatever that is unwanted from the farm, and let us say he has this monoculture of let us say wheat or paddy or whatever that you are trying to grow.

Will you get enough food? Nothing else is being done, you will get but then what we are taking for granted is something called pollination. Which is one of the very important functions that is served by the you know the ecosystem, so where an invisible army of insects like example honeybees or some other, various other insects which are involved for example in pollinating plants.

Pollination is one of the, very, very important function which can be embedded in providing food for all living systems, without pollination there is no food. So this is something that you cannot take out and say that you know I will eliminate all the insects because they all look like harmful to me. But so this is where we need to appreciate the function that is served by the insects or birds let us say or some other, okay, which is not under our control but it is existing there in the ecosystem which is providing the function.

Similarly, all other raw materials that we have has so many interconnections as we have seen in the first slide which is the biotic and the abiotic world is interacting and this processes which you have seen in that slide which is like the biotic and abiotic community. How they interact is through millions and billions and trillions of microbes which are operating day in and out in the presence of oxygen and absence of oxygen to convert the materials that we use, and produce in back and forth into elements and being made available in the environment, and in the soil for this materials to grow, and food to grow and provide us a service.

Similarly, the production function also involves, for example, the genetic resources that is available so why do we need to know about this genetic resources, so we depend on a large number of genetic resources today for food growing as well as for various other requirements that we need to meet.

Medicinal resources that is another service that is provided through the function of you know protection function, about 30% of current modern allopathic medicine is derived directly from plants itself. So, you can imagine you know how much of service that is provided, and if you scan through the remaining you know plants also there will be many, many components that could be useful in terms of their potential medicinal value for example.

And ornamental is another production function where it is pleasing to our aesthetic you know senses. Similarly, ecosystems also function as habitats for us as well as for other creatures. So one of the first function is as refuge, refugium means refuge, it is a refuge for other creatures as well, okay, so where a bird should be living, or an animal should be living it provides the right refuge as a function, and which is very necessary for its wellbeing and in turn wellbeing of the ecosystem and us.

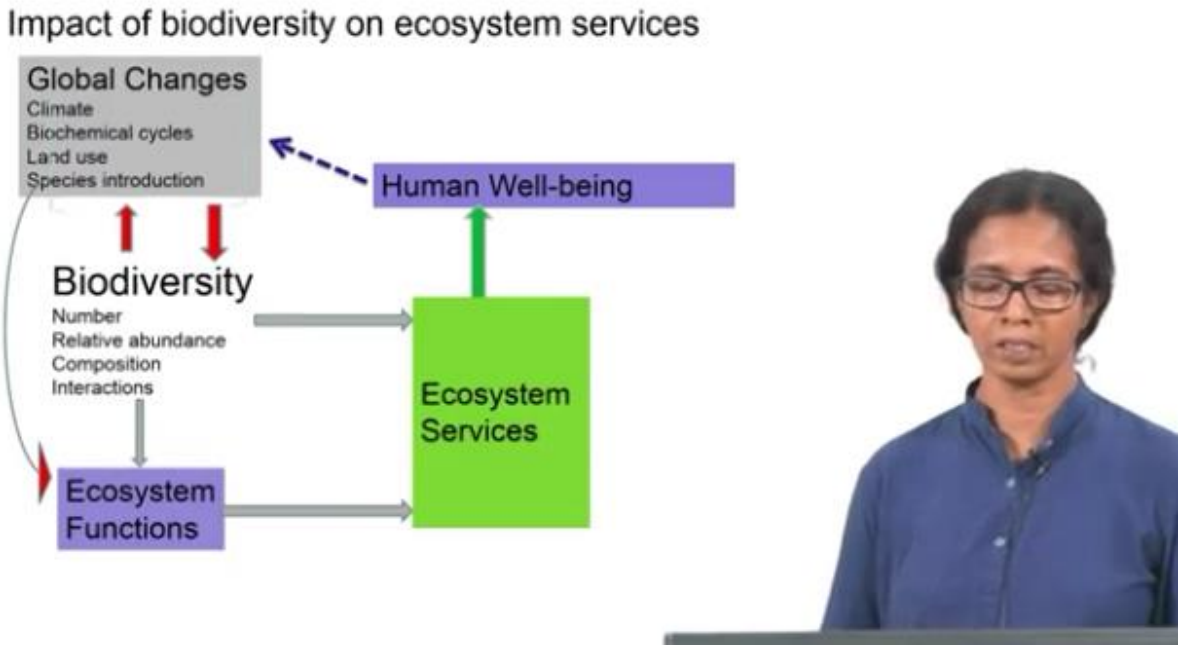
Secondly, it provides the nursery function, what is meant by nursery function is? Like the human nursery, the young ones need protection from whether it is an animal or whether it is a bird or whether it is some other young one, it needs you know protection from various other elements

maybe predators or from other environmental reasons. So it, ecosystems provide the necessary protection function through providing nursery.

It serves also as information function, so information, how information flows in the ecosystem and which gives us what is known as the aesthetic information, okay, when we see an object which is in nature how do we appreciate in terms of what is known as aesthetics. This is probably a human try to only to appreciate the other creatures in terms of aesthetics. So otherwise in each species they have an appreciation for the male, female, which is mostly oriented towards the sexual and attraction. Otherwise in general, human definition of aesthetics is to endless and our certain components of nature as aesthetically beautiful, let us say, a river flowing or a rivulet flowing or a mountain range or you know when we see you know pond or a lake we have an aesthetic value associated with it, which also is an important function that is served by, indirectly served by ecosystems.

And this is also serving here, this is when we was talking about this ecosystem services which is mostly in the context of human beings. So, the other you know aspect of it is recreation, so recreation is there in the every other creature also like if you look around, they also recreate or do you know what you call enjoy themselves in nature. So, which gives you lot of relaxations, so basically this function serve by it.

Similarly, cultural and artistic information is another service that is provided by ecosystems. Spiritual and historic, and science and education, so as I said it is the science of the universe and understanding nature itself and in detail is what every other branch of science is doing. Whether we are looking at ecology or not when we go into every minute details of it, it is basically the science or education that is provided by as an ecosystem function which we are using in terms of our understanding of universe itself.



So, as I summarize it, the biodiversity is at the heart of this service that is provided by ecosystems, and we just in turn, we just, due to the functions that are served by the ecosystem, okay. The ecosystem works whether it is providing service or not, but all living creatures including us is making use of this functions and then which helps us our well-being.

I have put a dotted line here for showing that human beings have an indirect connection to these global changes which are also affected, so it is not only that this flow is like this, and then reaching the well-being of humans, well-being of the ecosystem is also going to be affected by human beings. So, in general, we are also affecting today, the climate as you would know the biogeochemical cycles or land use pattern is changing, we are introducing species to various you know ecosystems, sometimes with our knowledge, sometimes without our knowledge, these are all affecting the indirectly or directly the biodiversity, ecosystem services. And then so it is it is going in a loop as you can see that how we treat the ecosystems will come back to us through this loop, so that is why it is very, very important how we protect the ecosystems and how we keep the ecosystem services the more intact, the better.

So, we should not be adversely affecting the ecosystem services by our acts.

Thank you