Basic Environmental Engineering and Pollution Abatement
Professor Prasenjit Mondal
Department of Chemical Engineering
Indian Institute of Technology, Roorkee
Lecture 02
Ecology Environment and Biodiversity

Hello everyone, now we will discuss on the topic Ecology, Environment and Biodiversity. In the previous class, we have seen that nature has a cyclic process, which is regenerative in nature and any disturbances in the natural system is accommodated automatically by the natural processes up to certain extent. We have also come to know that in nature, living and non-living elements of environment, coexist and interacts each other, and this interaction of living organisms with non-living components is the matter of ecology and the systems is also called as ecological system or ecosystem.

And we have seen that, in nature living organisms may be of different types or you can say that diversity is the beauty of nature, different species are available and living together, okay, and this stable diversity is very very essential for the working of the ecosystem or the nature. At this stable biodiversity or stable ecosystem gives number of services to the societies to the human society as well as different living organisms at their levels.

But as I mentioned in the previous class, that the ever increasing population growth and the grit of the human being is disbalancing this cyclic processes. As a result, the naturally healing is not taking place, as a result, the climate change and other different impacts like global warming, health issues, like say pandemic, all those things are coming up because of that.

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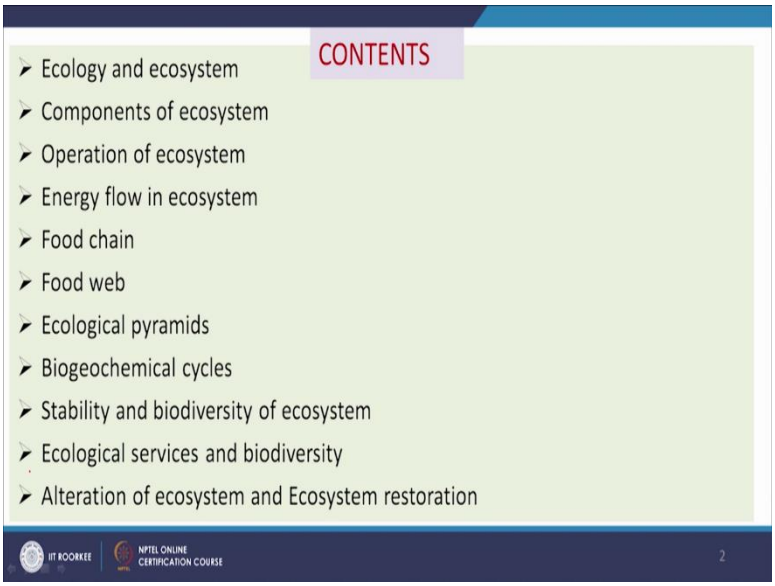

So, in this class we will discuss, what is the ecology and ecosystem, components of ecosystem, then operation of ecosystem, energy flow in ecosystem, food chain, food wave, ecological pyramids, biogeochemical cycles, stability, and biodiversity of ecosystem, ecological services, and biodiversity, and alteration of ecosystem, and ecosystem restoration, so we will be discussing on this topic in this class, you see, what is ecology and ecosystem.

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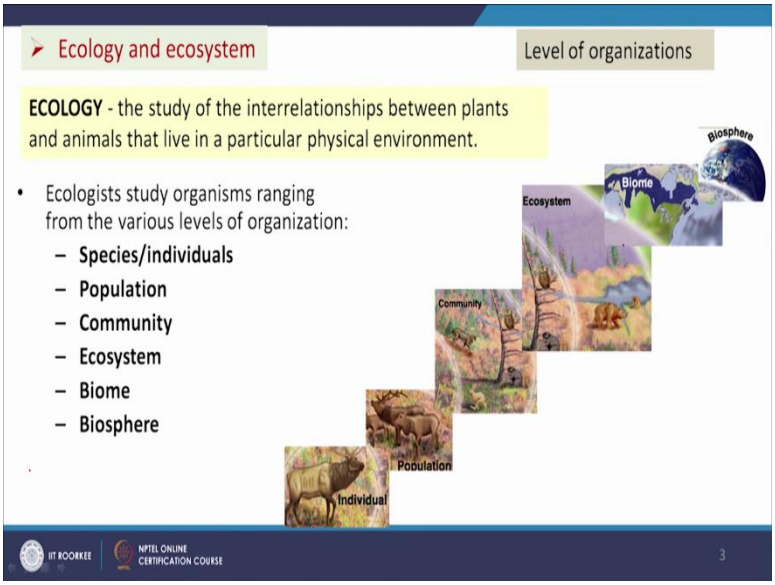

So, ecology is the study of the interrelationship between plants and animals that live in a particular physical environment, okay. So, the ecologists study organisms ranging from the various levels of organization like say individual, population, community, and then ecosystem, then biome, and biosphere, so these are the level of organizations, now we will see what are those.

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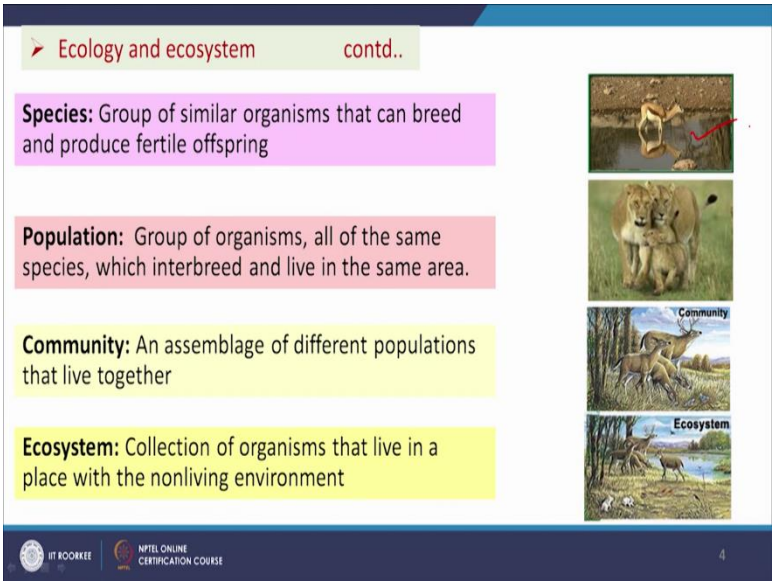

So, species, that group of similar organisms that can breed and produce fertile offsprings and then population group of organisms, all of the same species which interbreed and live in the same area, so this is one tiger population, community and assemblage of different populations that live together, so we have here dear, some other animals, etc., and plants everything are available here, so that is a community, in that community. So, some species are available in some community that is not, that may not be available in other community as well and then ecosystem collection of organisms that live in a place with the non-living environment.

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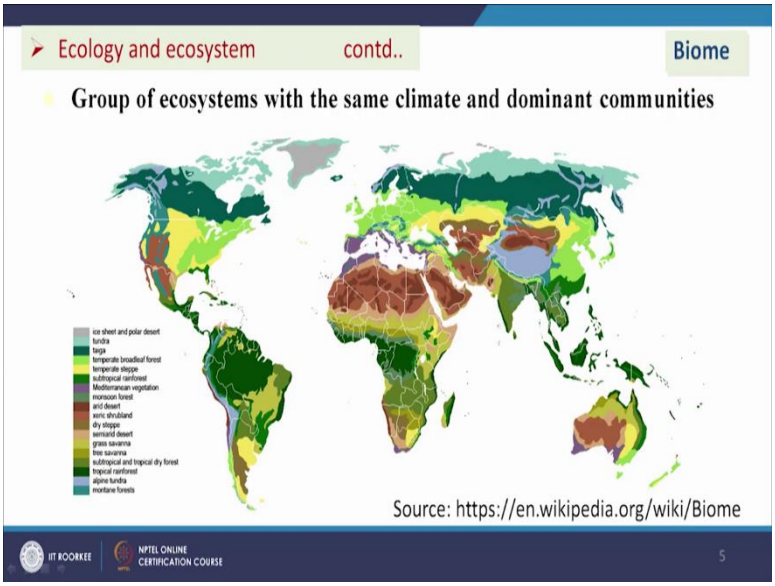

Then biome, what is this? in a group of ecosystems with the same climate and dominant communities, that is biome, and number of biomes will give ultimately the biosphere, so total

place where living organisms coexist with the non-living elements, so that is the biosphere, okay. So, these are some definitions related to the ecosystem.

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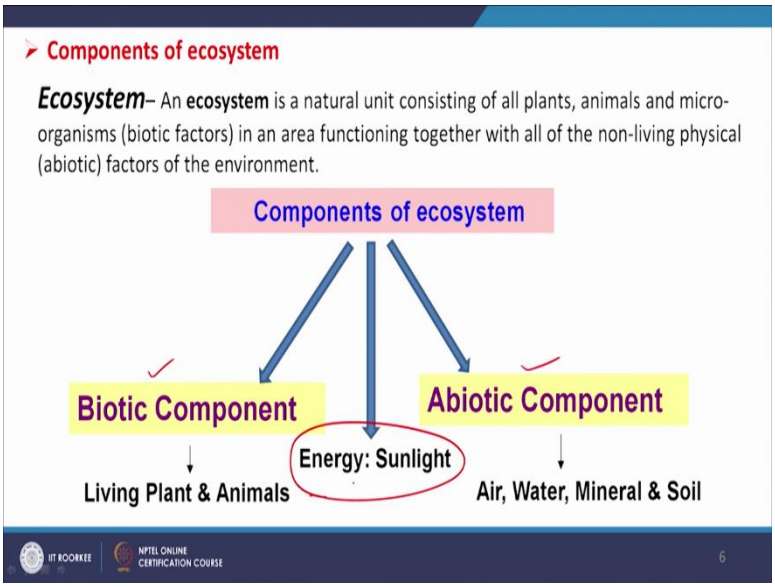

Now, components of ecosystem just like components of environment, the functional components are also the components of ecosystem, and we can get it here biotic component like an abiotic component and sunlight, the energy, that is very very important as already I have discussed in the previous class also. So, biotic plants and animals and abiotic components are air, water, mineral, and soil.

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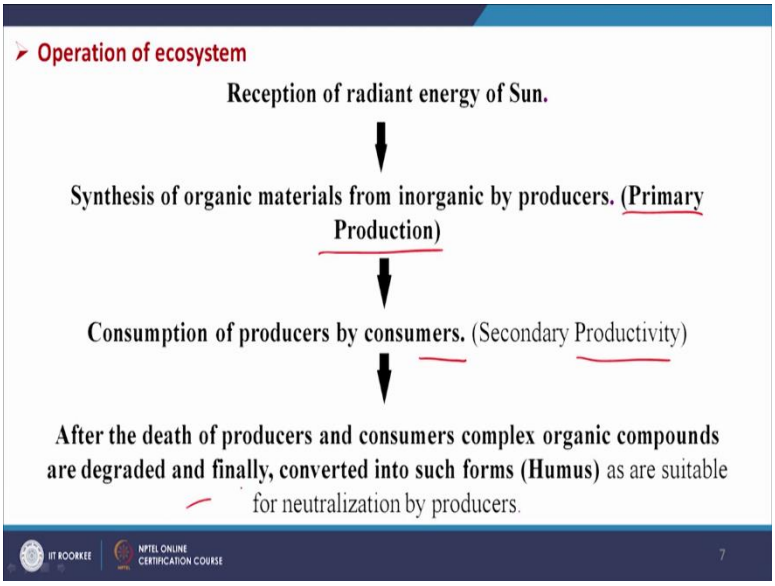

So, how the ecosystem operates or works? the energy comes from the sun and then that energy is taken up by the plants and they produce food and that is the primary production and

then consumption of producers by the consumers, that is the secondary productivity, and then different types of consumers, we can get after the death of producers and consumers complex organic compounds are degraded and finally converted into elemental form, okay, and are suitable for neutralizations by the producers, so this is the operations of the ecosystem. Though, it is called that sun is the source of all energy in the world, okay. So, basically the solar energy is stored in the food by the plant, okay. So, photosynthesis we know it very well, $6CO_2 + 6H_2O + \text{energy} \rightarrow C_6H_{12}O_6 + 6O_2$

carbon dioxide reacts to energy that will give us $C_6H_{12}O_6$.

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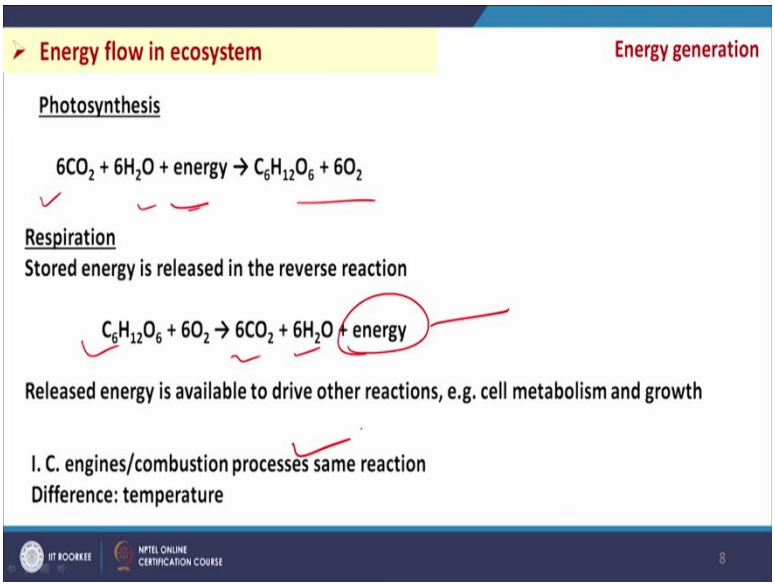

And this $C_6H_{12}O_6$ will be consumed by different consumers and during respiration,

$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + \text{energy}$

The reverse reaction, so we are getting the energy which was stored here that we are getting energy and by this, we are doing different work all living organisms are doing work by this energy.

Now, this energy which is generated in all living organism, we can compare with the I.C. engine. So, in I.C. engine, combustion process takes place, so this is CO_2 and H_2O, here also we get carbohydrate to CO_2 and H_2O. So, the difference is temperature and the mechanism, so that way the energy is generated in the ecosystem and transferred from one level to other, that is producer to consumer.

So, then Autotrophs and Heterotrophs there are another two terms which are related with this ecosystem. Autotrophs means the plants which can produce food themselves, okay, they do not depend on any other organisms for their food, but Heterotrophs are dependent on Autotrophs for their food or for their energy, okay.

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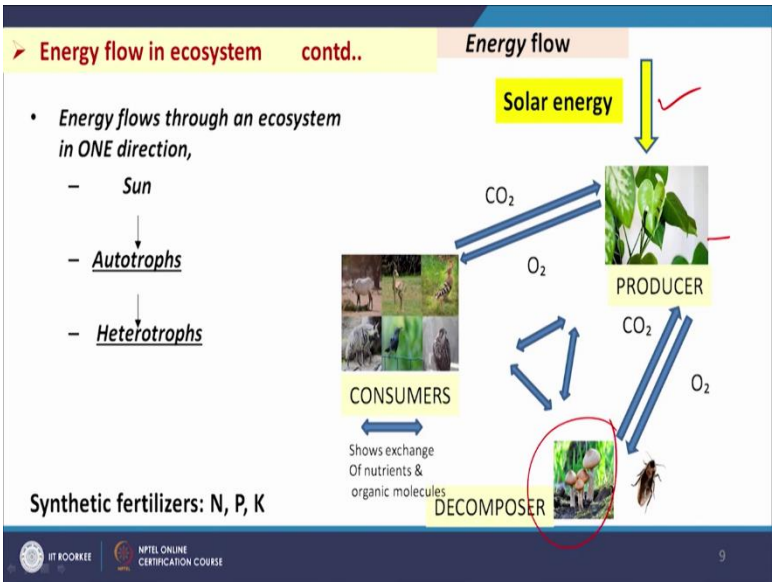

So here, the solar energy is coming, so producers that is your Autotrophs, they are producing this and consumers are taking this one, okay, and then after the date of this both it is coming to the decomposers, so they are converting this biomass into elemental compositions, so again this is the working of the ecosystem.

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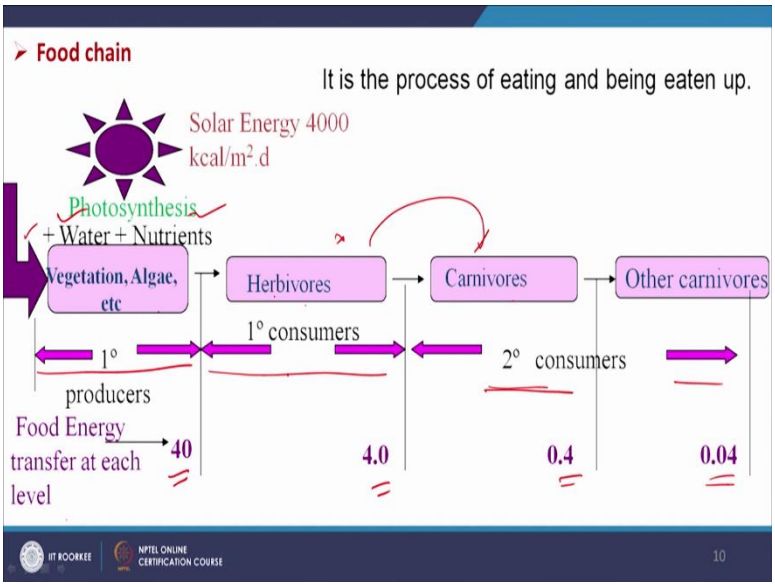

Another important information we are getting here in this ecosystem you know that water nutrients, carbon dioxide, sunlight, that is giving us food and energy stored in food and that food energy is transferred at each level, that is producer level, first degree of level that is your producers, and secondary level that is consumers, and first-degree consumer, second degree consumers, okay. So, this is called your vegetations, and then it is Herbivores, so these species and these living organisms are dependent on this, the plants for their energy and then herbivores to carnivores, so these are dependent on the herbivores and other carnivores that is degree two and degree three.

You can say another, that these other carnivores can take both the carnivores and herbivores also omnivorous, we can say like this. So here, one information we are getting if the food energy transferred at each level this here it is 40 then 40 to next it is coming 4 then here it is coming 0.4, here it is 0.04, so one tropic level, so lower to upper level if we go, say energy availability is reduced 10 times, so we can see that we the energy flow will be like a pyramid if we present it in a figure then you can get in a pyramid and we will discuss that.

And another important information here we are getting that food wave and food chain. Here, we have seen that this is dependent on that, this carnivorous dependent on herbivorous, others are dependent on both herbivorous and carnivorous, so one link is there, so that is called food chain, so these are related with their energy or food, so that is the food chain.

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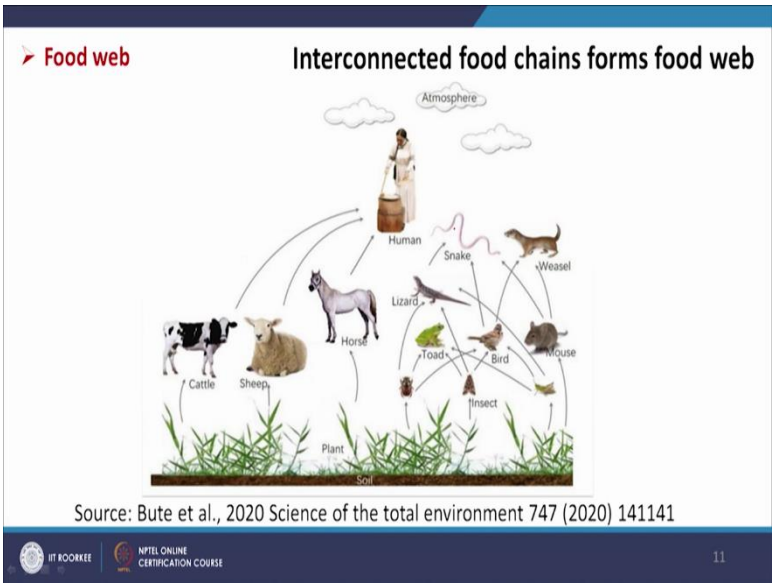

Now, food chain and food wave, they both are the part of the ecosystem, so here for lower level to upper level so we are plants and then herbivorous then carnivorous that way, but here some insects that can be taken up by bird, it can be taken up by toad, many and then this can

be taken up by some other animals, okay. So, there will be some you know wave of connection, so that is called food wave, not only slow chain in a linear chain, it is a wave the interconnection is also possible, so this is there in the ecosystem.

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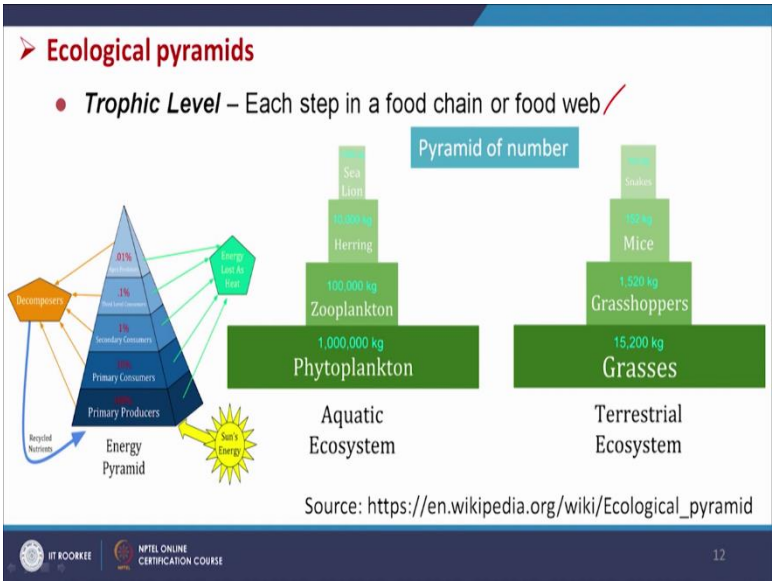

And, as I mentioned that, if you go for that trophic level, each step in a food chain of a food wave that is called the trophic level, so from the autotrophic to heterotrophic and your primary consumer, secondary consumer, tertiary consumers, if you go up, the number, energy content also reduces, number reduces, okay.

So, some example is there, energy pyramid. So, primary producers, primary consumer, secondar, tertiary, like this already have discussed in the previous slide. Now, we will discuss on the some cycles for the maintenance of the you know abiotic components like say water, soil, and air we have maintained, so some other elements which are very very essential for the growth of the animals and plants, those elements are also available in the ecosystem through cyclic processes, that part we are going to discuss here now that is bio geochemical cycles.

So, number of cycles are there like say water cycle, carbon dioxide cycle, nitrogen cycles, and phosphorous cycles, so those are very very important cycles which are available in nature in ecosystem for the management or to ensure the availability of these elements to the living organisms. So, if we do not disturb the natural cycle then there is no problem, but human grit, human development, societal development, you know that is disturbing these cyclic processes, that is why the all negative impacts is coming to the environment.

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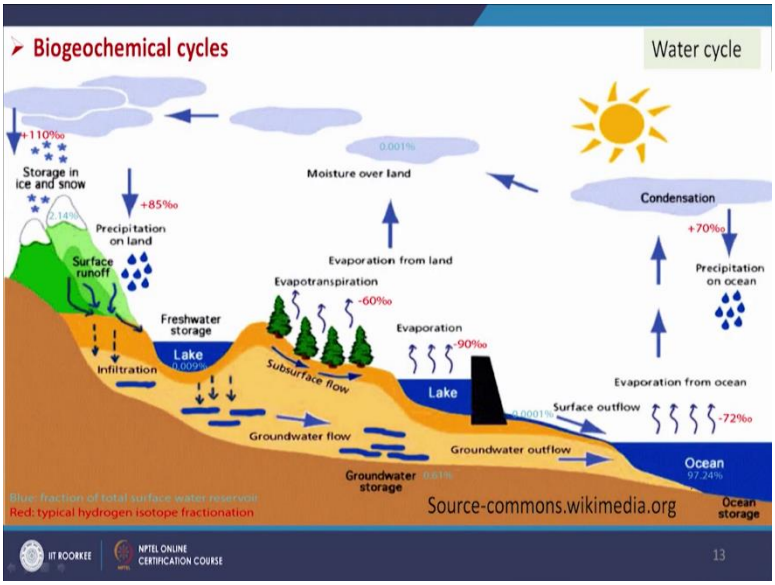

Now with respect to water cycle we see let us see in case of ocean we have around 97.24 percent of water remaining 2.14 percent of water is our fresh water and out of this fresh water, we are very limited say out of this 2.14 percent of this fresh water around 89% is of this ice and snow, and around say 12% like this, we are getting say lake water and ground water. So, lake water is very very less amount which is available, so this distribution as per nature it can serve the purpose of the ecosystem, if we can restrict ourselves from our greeds, okay, by the name of development.

You see how nicely it is done, so these waters are available and due to the heat from the sun, it is vaporized from the sea it goes off and in the air, it in the atmosphere it comes as a cloud and then again precipitation takes place, okay, both in sea and in the land also. So, this precipitated water comes and maintain the water level which is required for the normal life in the ecosystem. So, this is our water cycle which is available and which is working in nature nicely. If you see the bio geochemical cycles, that is carbon cycle, so here also the ocean is the reserve here, okay.

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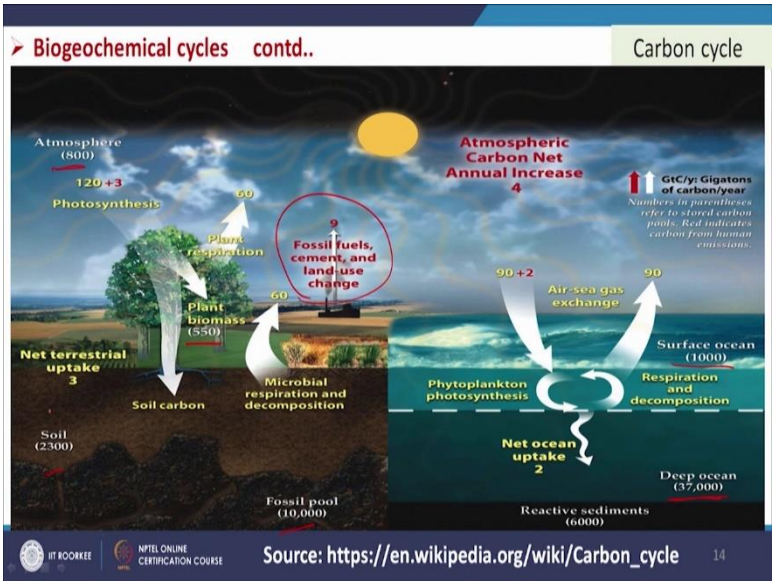

You see here, then 37,000 unit, if we have carbon dioxide in the deep ocean, then 1,000 will be in the surface ocean and 10,000 will be in the fossil fuels and soil will be having 2,300, 800 in atmosphere, so these are the availability and out of these 800 which is available in atmosphere, our plants take off and 550 unit is coming into the plant biomass.

So, this has some distribution, I mean this cycle works nicely then the environmental quality will be maintained, but human activities is creating some other addition of carbon dioxide to the environment. As a result, the nature which is available and the carbon cycle that is not able to accommodate that carbon dioxide, additional carbon dioxide which is coming into the atmosphere to convert it into other forms.

So, from atmosphere to sea or any soil or fossil fuel, so that is not immediately converted or distributed, that is the major reason why we are facing the global warming like this. Now, we see the nitrogen cycle, so in nitrogen cycle, again nitrogen is available in the air, we know that around 79 to 80 % is our nitrogen.

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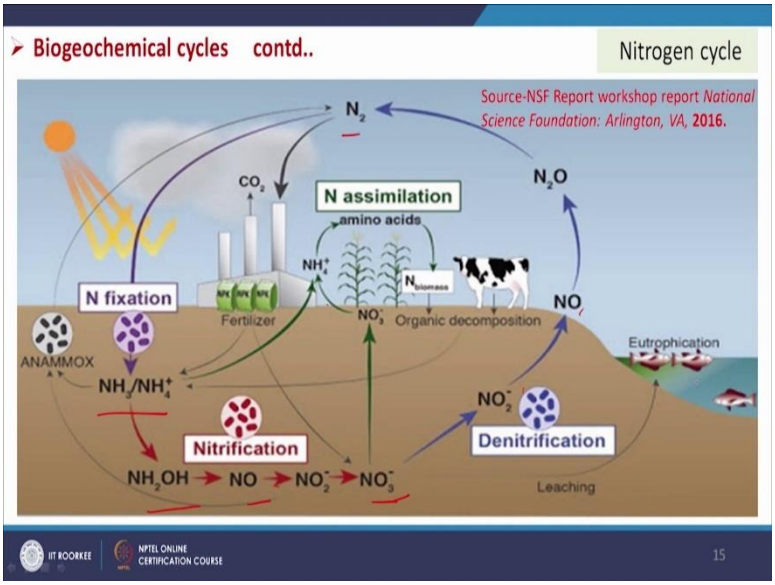

So, that nitrogen is taken up by the plants and this there are some microorganisms, nitrogen fixation, they are coming into the soil from the air, like say ammonia to nitrous oxide, so nitrate, so that is nitrification, and some denitrification is also there, so that microbes are also there those are working on the nitrate, and then nitrite, and nitrous oxide, and then ultimately again the nitrogen.

So, cyclic process some group of microorganisms working on it is converting nitrogen to nitrate and some group of organisms are also working on the reverse direction that is nitrate to nitrogen, so both are available in the nature. And some man-made activities are also there, we are taking nitrogen from it and we are producing fertilizer, ammoniacal, ammonia-based fertilizer that is urea, ammonia, etc.

So here, nitrogen is taken from the air and any reactions a pyrolysis reactions, again nitrogen is taken up from the air, okay, or any other experimentations or analytical purpose, again nitrogen is taken up from the air and these nitrogen, you know, assimilation takes place through this when ammonia to amino acids, the plants also takes nitrogen and forms amino acids, okay, and the protein, so that way it is also coming to the animals and nitrogen cycle works on that way, okay.

And another is nitrogen, you know due to the use of excessive fertilizer, nitrogen is coming into the water stream surface water, so when it is coming in surface water the eutrophication is taking place, so eutrophication is taking place means the algae blooming is taking place. So, algae which is growing at the surface of the lake, so they are these are not allowing light to penetrate or air to penetrate through it, so as a result DO level is reduced and the living

species and other aquatic plants and animals, basically the animals are being under threat. So, that way the human activities are basically responsible for the breaking this nitrogen cycle and any other bio geochemical cycles, and which is hampering the normal working of the ecosystem, as a result we are getting the pollution.

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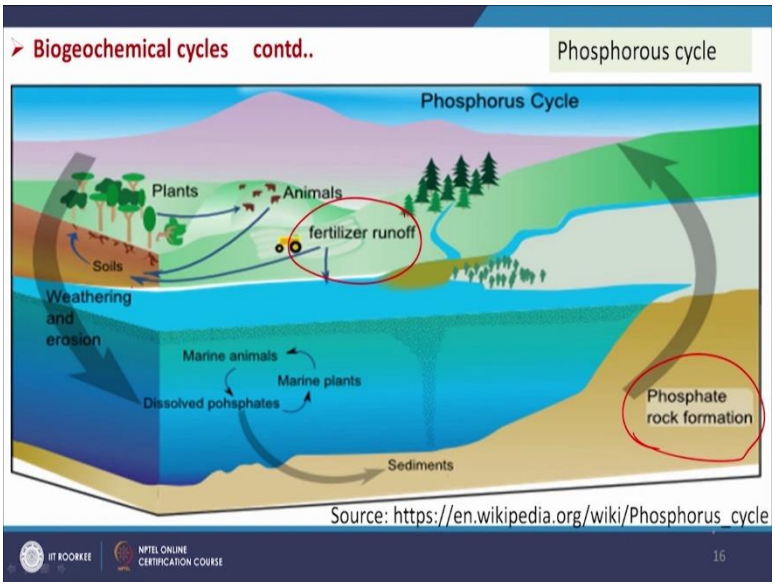

Similarly, for phosphorous cycle we know, phosphorus is present in terms of phosphate rock, so phosphate rock is taken off and then it is used for the fertilizer productions, then it is given to the plants, the plants takes it, okay, and fertilizer runoff comes to the water, again there will be some eutrophication's in case of phosphorus, also the lake, the micro algae will also grow by that way. And this weathering and erosion can also helps to the return of this phosphorous to the water and the sediments, so that way the process is there, but if we can maintain here, we are not using much fertilizer then phosphorous will not come into the systems automatically, it will be in recycle mode and the environment will not be affected.

So, that is why nowadays organic fertilizer use is being encouraged. Now, we will see the stability and biodiversity of ecosystem, okay. So, we have seen that the diversity is the beauty of nature and all organization or trophic levels. we have seen different type of species are available and if it is available, then this is a stable system.

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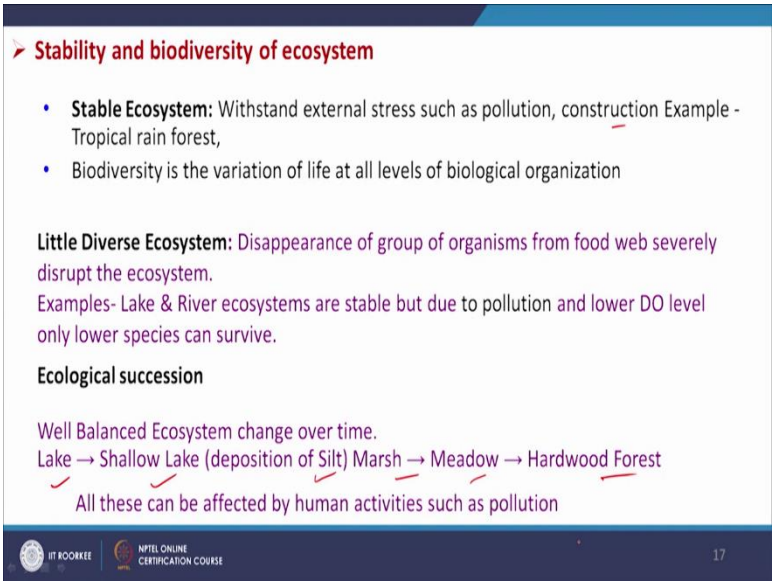

So, take a stable ecosystem that withstand external stress such as pollution, construction, etc. for example, tropical rainforest. And biodiversity is the variation of life at all levels of biological organization.

Now, this one is your stable ecosystem, and little diverse ecosystem, and ecological succession there are two similar terms we should know. So, that is little diverse ecosystem, that is disappearance of group of organisms from food wave severely disrupt the ecosystem, for examples lake and river ecosystems are stable, but due to pollution and lower DO level only lower species can survive. Just I have given some example that in case of lake, so if eutrophication takes place then DO level will be reduced and plant your aquatic plants, basically like say species, aquatic animals, basically say fishes will be in danger, but very small species can be survived and now this is one little diverse ecosystem that is not normally working, it is diverted to some extent but some living organisms can also exist in the system.

But ecological succession, well balanced ecosystem can also change over time that is called succession. Like say, lake to shallow lake, due to the deposition of silt, then marsh, meadow, and then hardwood forest. It can be converted to hardwood forest and all these can be affected by human activities such as pollution. Now, we will see the ecological services and biodiversity.

So, as I mentioned the stable ecosystem will be highly diversified, all organization levels will be having diversified species, and all those diversified species will do their work and indirectly provide some services to the human society as well as other living organisms as well, okay.

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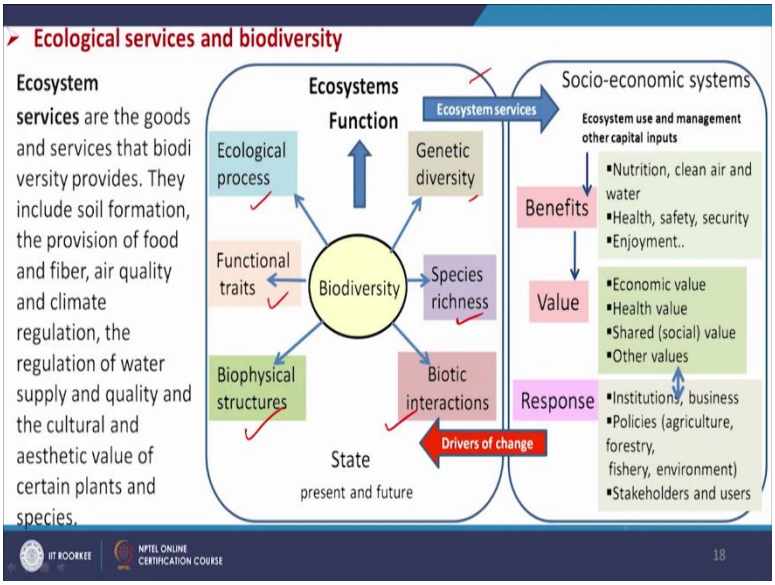

So, we will be getting the benefits due to ecosystem services, our socioeconomic systems will be strengthened by this, okay. Ecosystems use and management, other capital inputs like say number of benefits we can get from the services, like say it ecosystem ensures our nutrition clean water and air, okay, health, safety, security, and enjoyment, and it gives us economic value, it helps us to improve our economy, our health and other societal values as well.

So, if we see the ecosystem functions, then biodiversity is very very essential, it will be having genetic diversity, species richness, and then biotic interactions, biophysical structures, functional traits, and ecological processes, so there will be some good interactions and interrelations between living and non-living organisms and also in between living organisms there is good relationship, okay, interactions.

So, if we can maintain this certainly or automatically, our society will get the benefits from it. But to maintain this diversity in the ecosystem, we need some regulations, we need some framework, policies, okay, then only it is possible. Because the increasing population, and the grids of the human being have already damaged the ecosystem diversity in many places, so we have to prevent it and in to some extent we have to restore the damaged ecosystem as well for our future and clean environment. And you know we have to be more responsible, and all the stakeholders has to be more responsible to achieve this biodiversity, and maintain this biodiversity in future as well. And as I mentioned that the cyclic processes are working nicely, but in some cases because of the population growth and human greed, that you, that this system is not working well, and it is being disbalanced.

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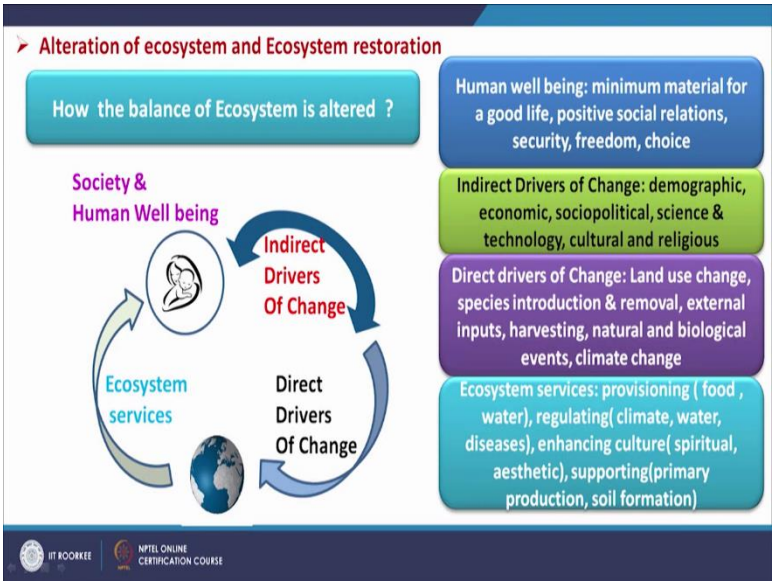

So, how the balance of ecosystem is altered, we see already, we have discussed, because our main objective is our society and human well-being, we are more concerned with it and for that we take the services from ecosystem, but at the same time, we are in many cases, we are not able to protect the biodiversity of the ecosystem, okay. There are many direct and indirect drivers for these changes in the ecosystem, so direct you see here, the direct drivers of changes, land use change, so urbanization, road constructions, all those things are going on. So, land use change and then species introductions and removal external inputs harvesting natural and biological events climate change, so all those are your direct drivers, the ecosystem, when it is affected, we have to restore it by these drivers itself, we have to take policies on the basis of this direct drivers.

And also the indirect drivers like your demographic, economic, socio political, science and technology, cultural and religious factors, we have to consider and that way only the restorations of the damaged ecosystems and the conservations of the existing ecosystem can be possible.

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If we see the example, according to the millennium ecosystem assessment, 60% of the world's ecosystem services have been degraded over the past 50 years. And you see since many ecosystem services are received for free, we often take them for granted until the ecosystem is degraded, and the services are declining or at risk. Decision makers and institutions need to develop creative ways of protecting ecosystem services.

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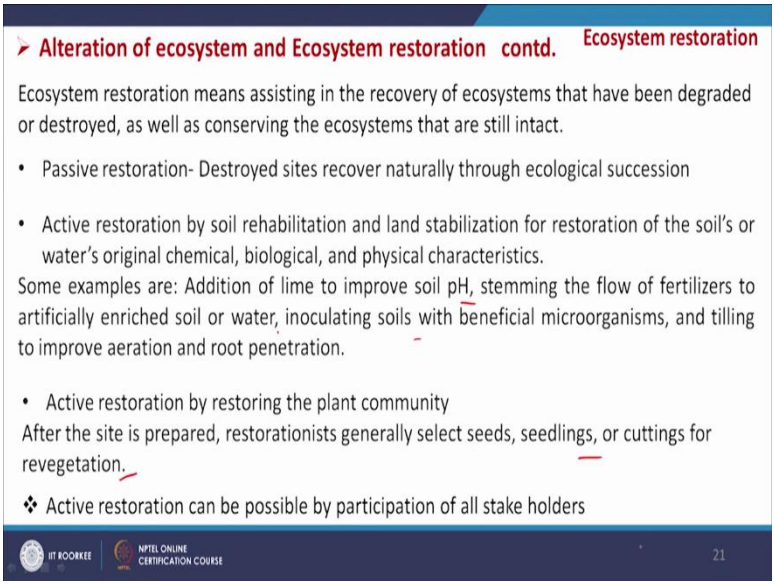

So, ecosystem restoration means assisting in the recovery of ecosystems that have been degraded or destroyed as well as conserving the ecosystems that are still intact, and this can be done by passive restoration or active restoration mode. So, passive restoration means destroyed sites recover naturally through ecological succession, and active restoration is by

human activities, by rehabilitation, and land stabilization for restorations of the soils or waters, original, chemical, biological, and physical characteristics. For some example, addition of lime to improve the soil pH, if some soil pH is reduced due to some acidic effect, so we can add some alkali, so the pH will be increased so that way that will be restored to its initial position.

And stemming the flow of fertilizers to artificially enriched soil or water inoculating soils with beneficial microorganisms and telling to improve aeration and root penetration, so these are some examples of your active restoration process. Active restoration by restoring the plant community also, another approach, so when after the site is prepared, then the restorationists generally select seeds, seedlings or cuttings for revegetation and the restorations of the land can take place. Active restoration can be possible by participations of the all stakeholders. If we want to restore a degraded ecosystem it is very essential that all stakeholders should understand the importance of it and be responsible to restore it, so then it will be highly effective and successful.

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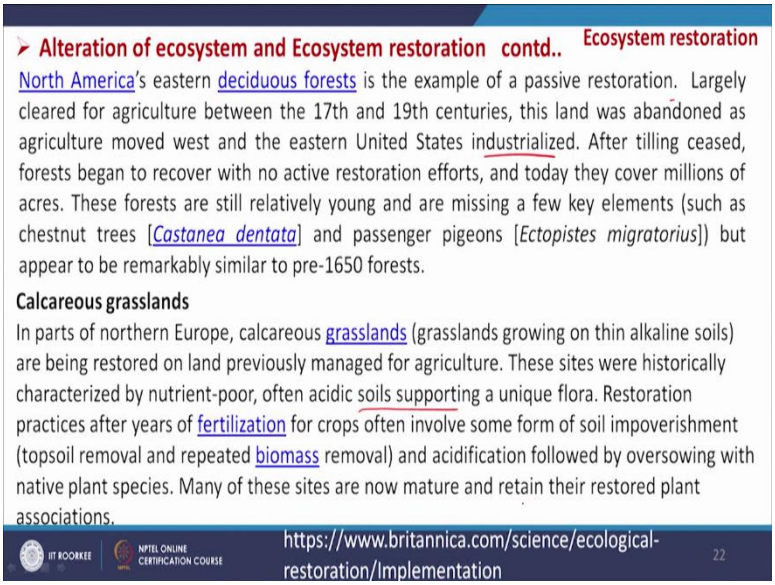

Some examples of your natural restoration or passive restoration is North America's eastern deciduous forests, this is example of passive restoration, largely cleared for agriculture between the 17th and 19th centuries, this land was abundant as agriculture moved west and the eastern united states industrialized, okay.

So, after tilling ceased, forest began to recover with no active restoration efforts, and today they cover millions of acres. These forests are still relatively young and are missing a few key elements, and another example is your Calcareous Grasslands in Europe. So, here also in part

of Northern Europe, Calcareous Grasslands are being restored on land previously managed for agriculture. These sites were historically characterized by nutrient-poor, often acidic soils supporting a unique flora. And restoration practices after years of fertilization for crops often involve some form of soil impoverishment and acidification followed by oversowing with native plant species. Many of these sites are now mature and retain their restored plant associations. And in India, also some efforts are there for the ecosystem restoration.

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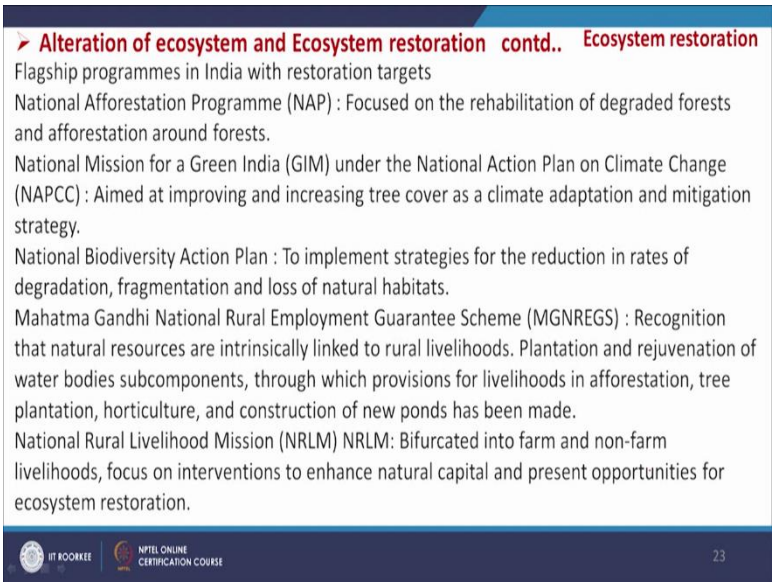

Like say some flagship programs in India with restoration targets are National Afforestation Program, which is focused on the rehabilitation of degraded forests and afforestation around forests. A National Mission for a Green India under the National Action Plan on Climate Change that is NAPCC, which is aimed at improving and increasing tree cover as a climate adaptation and mitigation strategy.

National Biodiversity Action Plan to implement strategies for the reduction in rates of degradation, fragmentation and loss of natural habitats. Mahatma Gandhi National Rural Employment Guarantee Schemes that is MGNREGS, recognition that natural resources are intrinsically linked to rural livelihoods. Plantations and rejuvenation of water bodies subcomponents, through which provisions for livelihoods in afforestation, tree plantation, horticulture, and constructions of new ponds have been made.

National Rural Livelihood Mission NRLM that bifurcated into farm and non-farm livelihoods, focus on interventions to enhance natural capital and present opportunities for ecosystem restoration. So, up to this in this class. Thank you very much for your patience.