Conservation Geography
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Module - 9
Human population and conservation
Lecture - 27
Human development and sustainable development

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Namaste! We carry forward our discussion on human population and conservation and in this lecture, we shall have a look at human development and sustainable development. Now, human development and sustainable development have become very important today because we have a large population.

Now, when we have a large number of people, and all of these people require certain resources. They require food, they require clothing, they require houses and so, on. At the same time, they also require a large amount of resources for their development. They require electricity, they require computers, internet connection, good health services and so on.

Now, when the society tries to provide them with these resources, then these resources can be provided either in a sustainable manner or in an unsustainable manner. What is the difference? When we provide the resources in a sustainable manner, we think about the future and we say that, okay, we have so much of resources on this planet and we cannot use all of these resources for ourselves because if we use up all the resources, nothing will be left for the future generations for our children and our grandchildren. And so, we try to reduce our resource use. We try to use as much resources as are very much essential and we try to get them through ways that are as renewable as possible.

That is, if you have an option whether to use electricity using coal or electricity using say solar photovoltaics. So, a sustainable resource usage would go towards the renewable sources of energy such as the solar cells, because we need to conserve our coal and our natural gas and our petroleum even for the future generations. Because these are not just required for energy usage, but they can also be used for making a large number of products. These are chemicals and they can be used in that way as well.

And so, when we talk about sustainable usage, we say that, we are going to reduce our consumption and we are going to save for the future. This is very similar to what people do for the retirement planning. So, if you get salary, you do not spend everything because you need to save something for your retirement is filled, for days when you are not paid any salary. Whereas, in the case of an unsustainable usage, if you get a paycheck and if you use up everything, if you spend everything whether you need something or not if you buy things, then after a while you will end up with a stage where you do not have any savings. So, this is a very similar concept.

And because we have a large population today, so we are making a huge impact on the environment. And the impacts are also leading to several consequences. Consequences like global warming, climate change or pollution of our water resources or filth everywhere. So, in the case of a sustainable resource usage, we will be able to overcome these challenges. So, this is what we are going to discuss about in this lecture, human development and sustainable development.

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And in this context, let us begin by what Gandhi said. Gandhi says that the world has enough for everyone's needs, but not everyone's greed. That is, we have enough resources to meet the needs of every person on this planet. We have enough resources to provide them with food, with shelter, with clothing, with healthcare, with education and everything. But the world does not have enough resources to meet the greeds of people.

So, if somebody says that, I have one car, but I want to have 10 cars or I want to have 100 cars. Now, this is something that the world is unable to provide for. If somebody says that, I need to have a television in every room in my house that is something that the world will probably not be able to provide for. If everybody moved into such a lifestyle, then we will very soon run out of our resources. And so, the world has enough for everyone's needs, but not everyone's greed. So, if we want to have a planet that is supporting us for a very long period of time, we will have to forego the greed, and this is the crux of sustainable development. Sustainable development tries to meet everybody's needs, but not the greed.

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So, sustainable development is defined as development that meets the needs of the present. That is, we are not saying that we are not going to fulfill the needs of people, it is development that meets the needs of the present, but without compromising the ability of the future generations to meet their own needs.

That is, we will provide for the needs of people, we will do a development that provides for everybody's needs, but we will do it in such a manner that we are not hampering the interests of the future generations. That is, if to meet our current needs of electricity, if we use up all of

the coal, if use of all of petroleum, all of natural gas, then the future generations will be in a very precarious state when it comes to meeting their energy needs.

If we trash the planet to such an extent that it becomes inhospitable, it becomes unlivable. If we emit so much amount of carbon dioxide into the atmosphere that the global warming and climate change, melt all the glaciers and so, most of the areas become flooded, there are huge climate extremes in such a situation, how will our future generations meet their needs. We will be putting them in a very sorry state of affairs.

And so, that is not sustainable development. Sustainable Development is one, that meets the needs of the present without compromising the ability of the future generations to meet their own needs. And the most important thing is that it is not the same as economic growth. There is a difference between growth and development.

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So, what is growth? Whenever we talk about development, in the layman terms, we always refer to it as the growth. So, a society becomes more developed, when the GDP increases, that is the normal way of thinking, but that is not development, that is only growth. Increase in GDP is only growth. Growth refers to increase in size or the level of output.

So, basically if you see a child growing, then every year the child increases in its size, the child increases its weight, that is growth that is not development. So, increase in size of something increase in the level of output of something increase in GDP, all of these are only growth, whereas, development is the process by which the economic wellbeing and quality of life of a nation, region or local community are improved according to targeted goals and objectives.

That is, development is a process, it is not a one-shot thing, it is a process. It continues for a very long period of time. And what does this process do? It improves the economic wellbeing and quality of life. So, it not just provides people with more money, but it also improves the quality of life of a nation, region or local community are improved according to targeted goals and objectives.

That is, if we talk about say child development, then child development is not the same as growth. So, when the child increases in size and weight that is growth, but when the child learns new things, when the child has got a better grasp over his or her own reflexes, when the child learns how to speak and so is able to communicate with others then we say that there is a child development that is happening. A development of the mental faculties, a development of the physical abilities.

Now, when we talk about development, it is not the increase in size of something, it is a process in which something is improved, not increased, but something is improved. So, the ability to think is improved, the ability to communicate is improved, the ability to do something is improved, now that is child development. And, similarly, when we talk about the development of the society, then something gets improved.

So, for instance, when we talk about economic growth, we were saying that okay, the society will produce more things, that is growth, increase in the output. But then if you produce a large quantity of greens, but these food greens are not available to people. So, you have a society in which there are a few people who have a major share of resources and there are a large number of people who go hungry then we will say that this is only economic growth we do not have a development.

A very poignant example in our country is the Bengal famine in 1942. So, in the Bengal famine, we had large store of grains in the various granaries, but people did not have physical access and economic access to this food, that is, people did not have sufficient money to buy this food. So, there was food that was available, but because people did not have a physical, social and economic access to food, so, they were going hungry, and the people who had the food grains, they did not provide them to other people. Because they thought that if we provide them to other people, then the price of food grains will go down. So, our profits will go down.

So, on the one hand, there was widespread hunger, there was widespread famine and malnutrition, but on the other hand, the grains that were there in the granaries, they were being destroyed, people were burning them so that the price of the grain remains high. Now, we cannot call such thing as development. So, while we can have economic growth, we can have more amount of production, but development means that this production is available to people to improve their quality of life. So, for instance, if we have a country that has a very high GDP, but in that country, people do not have access to education, our people do not have access to healthcare, then we will not say that this is a developed country, we will say that this is a rich country, but not a developed country.

So, development is the process by which economic wellbeing and quality of life of a nation, region or local community are improved according to targeted goals and objectives. And basically, we define three dimensions of human development. We can look at human development by the life expectancy index. How long can a person expect to live in a

particular country? So, if people have a longer life expectancy, it means that, they have access to healthcare, it means that they have more productive life that can be used to improve the wellbeing of not only themselves, but also of their society.

So, life expectancy is a very important indicator of human development. Second, we have education index. If people have good life expectancy, because of good healthcare facilities, accessible healthcare facilities, what do they do with their life? Are they educated or not? Do they have access to education or not? Because when people have access to education, then they can think more, they can develop their interests, they can, they have a better ability to do what they want to do. So, it provides them with certain amount of freedom.

Freedom of opportunity. So, education is another factor that we consider when we are talking about human development. So, the first is life expectancy, second is education, and third is income. So, if you have people who have long lifespans, who have received good education, but they do not have income, so, in that case, these people will not be able to reach their fullest potentials. So, to allow people to reach their fullest potential, to allow people to develop their abilities, they also require a certain amount of income.

And so, we will say that a society becomes developed, when these three things increase. People have a better life expectancy, mainly through access to better healthcare or access to better sanitation or access to clean drinking water or access to sufficient amount of food so that has to be made available to everybody, so that the life expectancy increases.

Two, when they have a good life expectancy, they should also be getting good education. So, what is the access to education in a country? If you have a country where education is so expensive, that people cannot afford that or you have villages where you do not have any schools, so people have to walk a long distance to go to a school and in that case, I large number of people just drop out of school, we will not call that a developed society. So, education is also important. And third is income, so that, they are able to make good use of their long lifespan and good education. So, that is development.

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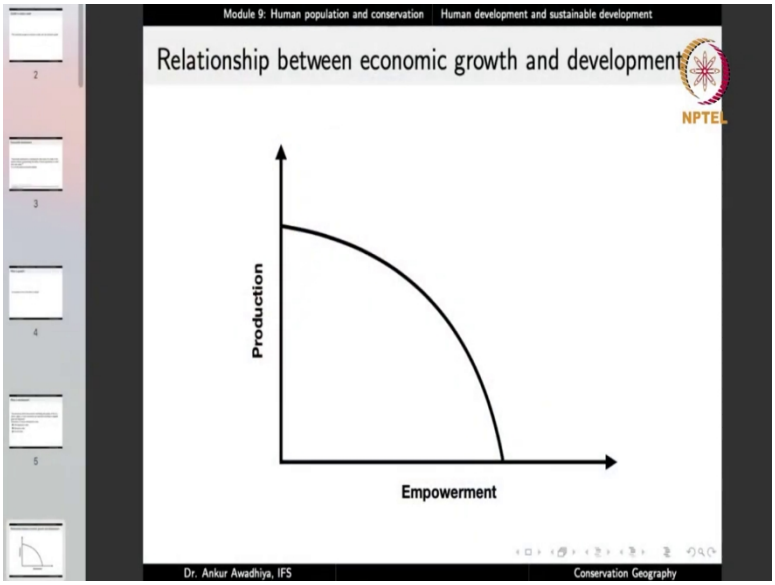

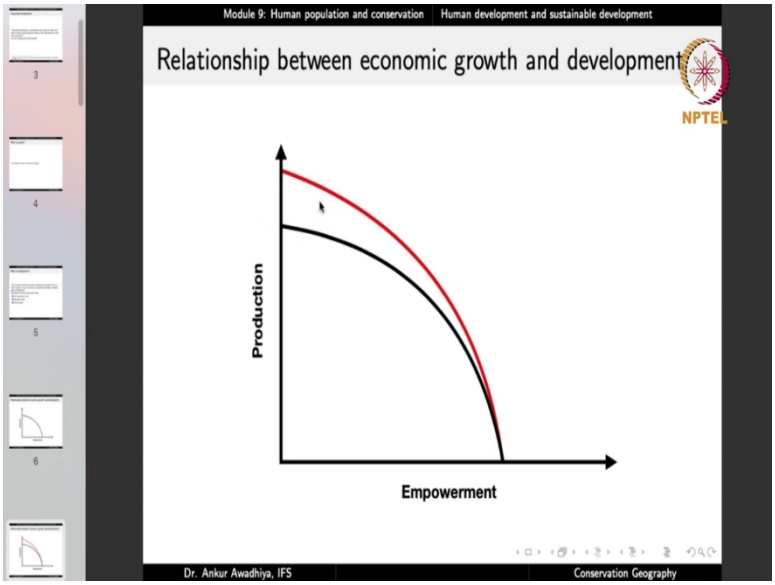

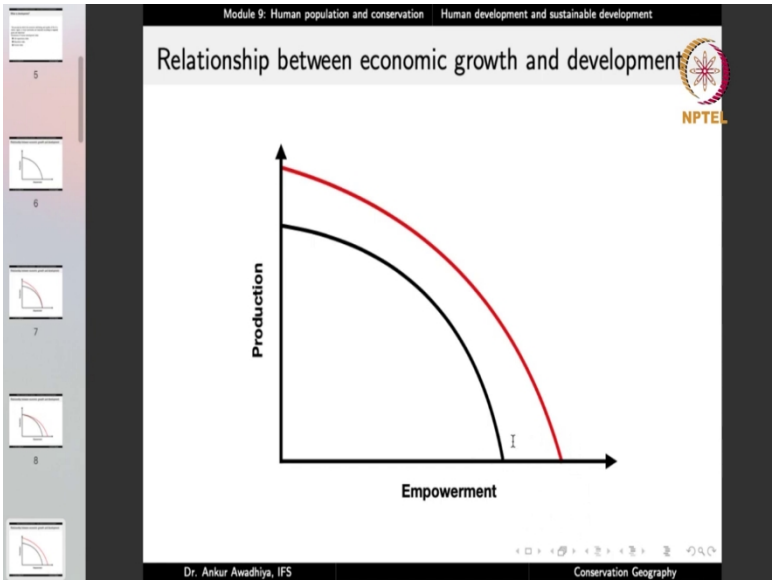

So, if we drew a graph between production in a society and empowerment of people. When we say empowerment, we are talking about these three facets, life expectancy, education and income. So, this is on the x axis and the production in the society or the GDP is on the y axis. And if this is the production possibility frontier, meaning that, the country can choose any point here, but this is the limit to which the country can go to.

Because in any country we have a fixed amount of resources. So, we cannot just go on increase in production because after a while we will have a shortage of raw materials, we will have a shortage of say electricity, we will have a shortage of land and so on. So, things cannot go to infinity. So, there is a limit to the amount of production and the amount of empowerment that any country can do.

But, when the country tries to increase that, when the country tries to improve upon that, say by bringing better technology, then the country has got two options. One is only to increase production. So, in this case, we will be having economic growth without development. Because we are increasing the production, so this is growth, but probably this production increase is coming into the hands of very few people. That is the wealth is getting hoarded by a certain set of people.

It is not translating itself into better life expectancy, better education and better income for the large masses, then we will say that this is economic growth without development. On the other hand, we can also have development or empowerment without an economic growth. So, in this case, the country is trying to increase the development of its citizens. So, it is not trying to increase the production, but it is probably trying to increase the access to healthcare or access to education.

So, the focus is towards development, that is also possible or the country may try to increase both of them. So, the country may try to have better technologies to increase production and at the same time also increase the accessibility of the fruits of economic growth. So, we can have economic growth without development, we can have development without economic growth or we can have economic growth and development together. Now, if we have economic growth and development together that is the best state.

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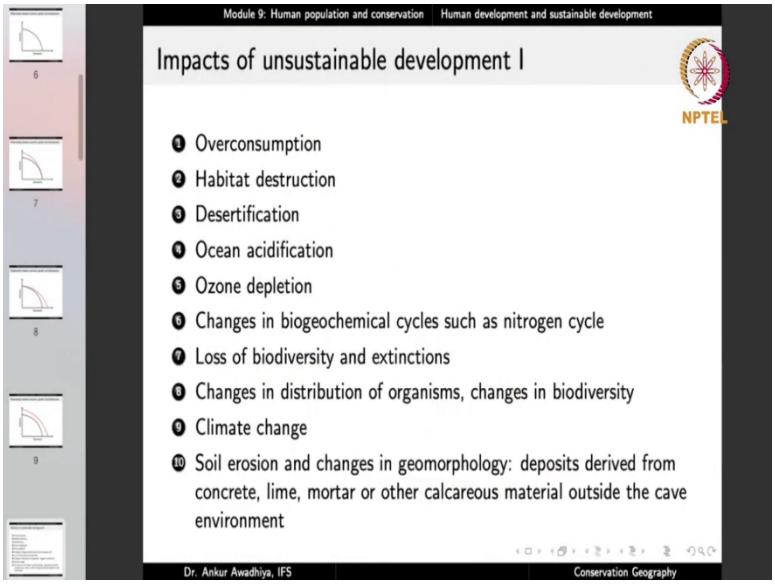

But this increase in economic growth has to be sustainable. Because, if we only focus on economic growth, if we do not focus on development, then we can have the hazards of unsustainable development. A very good example is that a country that tries to increase the production in its industries, and that is the only goal. So, what would that country do?

It would dilute the laws that enable say environmental protection. So, it will make it easy for industries to grab hold of forests, cut trees and set up an industry there or it can read lacks the pollution laws. So, that now, the industries are not penalized when they are polluting the environment.

And in such a situation, the industries will find it easier to thrive, because there are less rules and regulations that the industries have to comply. So, in that case, we will have setting up of more number of industries. But in the absence of good environmental laws what will happen is that the forest will be reduced, so people will not have access to the ecosystem services, there will be lots of pollution, which will have an implication on the health of people.

So, probably the life expectancy would go down. People will start to die because of the large amount of pollution that is there in their environment. So, in that case, we will say that this country is focusing only on economic growth, but not on the development of its citizens. And whenever we have situations where countries go for economic growth and typically unsustainable economic growth, we see a large number of problems that come up.

So, there are issues such as overconsumption, in which case, the societies overuse the resources that are available, and then they run out of resources. That is, if we take up all of the groundwater and attempt to increase agricultural production, then after a while, there will be no more groundwater left and then the agricultural sector will collapse. So, this is a hazard of unsustainable development or consumption. We also observed things like large scale habitat destructions.

Now, the habitats are not just for wildlife, the habitats play a very important role in sustaining the human society as well. They clean air, they clean water, they permit groundwater recharge, they save our soils from erosion. And when there is a large-scale habitat destruction, then all of these facilities that are being provided by a well-functioning ecosystem, they get lost. So, this is another hazard of unsustainable development. We see desertification.

Now, desertification often occurs when you remove the trees, you remove the vegetation, perhaps, to make way for industries or to make way for agriculture. So, the tree cover is lost. Then you overuse of water resources and so you are out of water. Now, this leads to a situation where you have a piece of land with very little amount of water and with very little tree cover.

Now, the trees would have protected the soil against drying against desiccation, because the trees provide shade. In the absence of trees, the soil will get heated up very much because of the sun's rays and the soil will dry up. And in this way, the deserts keep on expanding. So, if you observe desertification in a society that is a result of the unsustainable growth.

Another is acidification of our oceans, primarily, because of the large amounts of carbon dioxide that we have been spewing into the atmosphere. Now, ocean acidification has also long-term impacts on the society. Why? Because it kills a large number of organisms. It not only kills organisms like corals, which are made up of calcium carbonate, but it also reduces their habitats. So, if we talk about a species such as fish, which lays its eggs in the corals,

then once the corals are gone, then these fishes also do not have a place to lay their eggs. And so, slowly, we will start to observe that the amount of fishes in the oceans will go down.

Now, fish is a very important resource for people, because they are a very good source of proteins. So, once the fish catch goes down, we will observe that people now have to spend more amount, more money to get their proteins. And those people who are unable to get the more expensive sources of protein, they will now begin to suffer from malnutrition. And with this malnutrition, probably the life expectancy would go down.

So, ocean acidification is also having a direct relationship with the development of societies. So, this is another impact of unsustainable development. Ozone depletion. So, when the society releases large amounts of chlorofluorocarbons, then the ozone gets depleted. And in such a situation, the ultraviolet rays of the sun can easily reach the surface of the planet, exposing human beings and increasing the chances of diseases such as cataracts or skin cancer.

Now, that again is having a direct bearing on the development of the society, the human development, because now people will be more sick. The life expectancy would also probably go down. Another impact is changes in the biogeochemical cycles such as nitrogen cycle. So, we have chased a large number of biogeochemical cycles to such a large extent that now we are having in excess of nitrogen in many of our water bodies now that leaves to eutrophication, meaning that there is a very fast growth of algae and other water plants, which then take up most of the space in the water body.

Once that happens, and when these plants and algae die, then during the decomposition of their bodies, all of the oxygen in the lake is used up and so, the lake becomes anoxic, a lake without oxygen, which then kills off all the organisms that are there in the lake. Now, once that happens, the societies that are living nearby lose their access to things like potable water or lose their access to food like fishes, that is another impact of unsustainable development that we are observing.

Loss of biodiversity and extinctions, they have been increasing like anything. And when we have a loss of biodiversity, it makes ecosystems less resilient, less resistant to changes, and when the ecosystems collapse, then we lose all the ecosystem benefits. Another impact of unsustainable development or changes in the distribution of organisms changes in biodiversity, we are observing changes in the climate. And when there is a climate change,

then the extreme events in the climate they increase in their frequency and they increase in their magnitude.

So, these days we are observing that in areas that are drier areas, they are becoming even more dry. When there is rainfall, there is an excess of rainfall leading to a flood like situation, when there is a temperature extreme, it goes to such a huge extent that people start dying out of heatstroke. Now, when we have situations like this, when we have a situation when we are having more number of hurricanes and with even greater intensity, even greater magnitude, even greater speeds, then these also impact the human societies they lead to large scale destruction of property and large scale loss of lives.

Now, we cannot say that that is development, in fact, that is against development, because people are losing their lives, people are losing their access to earning income. So, that cannot be development. So, this is another impact of unsustainable development, because we are doing such a great amount of climate change, because we are overusing the resources. We are overusing our fossil fuels, and releasing a large amount of carbon dioxide into the atmosphere that is leading to global warming and climate change. And so, that is again another impact of unsustainable development or rather unsustainable growth. Then there is large scale soil erosion changes in geomorphology.

Now, when there is soil erosion, then it has a direct impact on agriculture, it has an impact on water quality, it has an impact on the sedimentation of our dams of our waterways. We cannot say that, that is a development because that harms people. Similarly, we are observing large scale changes in geomorphology because when you have more amount of soil erosion, then more amount of deposits are getting made in the case of the deltas.

On the other hand, when we construct a dam, then there is a large amount of sediment deposition wherever the dam is, and the deltas are getting deprived of the sediments. So, these are changing the geomorphology of the planet. Earlier, the calcium-rich deposits used to be found only in the cave environments in things like stalactites and stalagmites or pillars, but now we are finding deposits that are derived from concrete lime mortar and other calcareous materials very much outside the cave environment, so that is not natural thing. So that is another impact.

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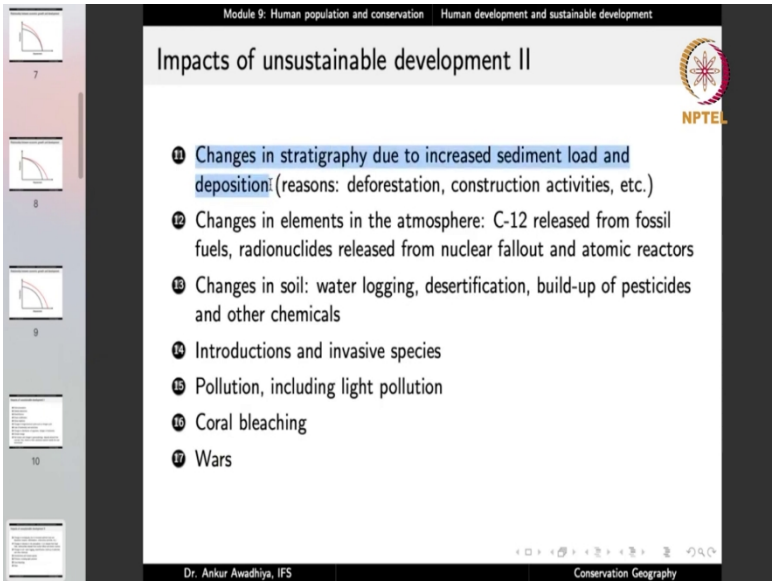

We are observing changes in stratigraphy due to increased sediment load and deposition primarily because of deforestation and construction activities. So, these are changing the stratigraphy of the planet. We are observing changes in the elements in the atmosphere. When we burn fossil fuels, we release that carbon into the atmosphere that was stored over millions of years, and that carbon is less in carbon 14 and it has more amount of carbon 12. And so, the carbon 12, carbon 14 ratio in the atmosphere is changing.

We are also observing that the radionuclides that are released from nuclear fallout and atomic reactors, they are now making a place in the planet. And in this case, the radionuclides such as cobalt or strontium are now increasing in such a large extent that they are now also posing a major problem in certain locations.

We are observing changes in the soil, we are observing water logging, desertification, buildup of pesticides and other chemicals in the soil, and that is not good for the health of the soil. There are large scale introductions and invasive species that are spreading in different areas because of unsustainable development, we are not taking adequate precautions to ensure that the invasive species are not introduced into other areas and they do not spread. And when we do not take sufficient precautions, we actually become a mode for the moment of the invasive species that again leads to large scale destruction of the habitats.

We are observing pollution. And not only do we have air pollution, water pollution, sound pollution, but these days, light pollution is also becoming a major threat. Because in most of our towns and cities, so much amount of light is getting produced that it also is having a negative impact on a large number of species.

A very good example is turtles. So, when turtles hatch on the sea coast, they typically use the light differences to navigate towards the seas. Because if you go to a sea shore, in the nighttime, over the seas, it will be a bit more brighter, as compared to over the land, because the land has more of dark colored things. So, through evolution, the animals have learned to use this difference in the light intensity to navigate.

So, they move towards areas of greater light. But now, our towns and cities are emitting so much amount of light that now these animals get confused, they start to move towards the towns and cities and when they are unable to reach to a water body, they just die off. Now, that is also a major impact on the survival of these species. Many of our birds are now getting disoriented, because of the amount of light pollution that we have, animals find it difficult to sleep in the right times because there is so much light. So, this is another impact of unsustainable development.

We are observing large scale coral bleaching and death of corals and wars are also another impact of unsustainable development. So, when we talk about sustainable development, one that meets the needs of the present without compromising the ability of the future generations to meet their own needs, we need to be mindful of two concepts. One is the concept of needs. So, there is a difference between needs and wants.

Needs are what we require for our sustenance and for our development. Whereas, when we talk about wants, wants are unlimited, wants are mostly a reflection of the greed of people. So, I may want to have 50 cars, but I do not need 50 cars I probably only need one. So, there is a difference between needs and wants.

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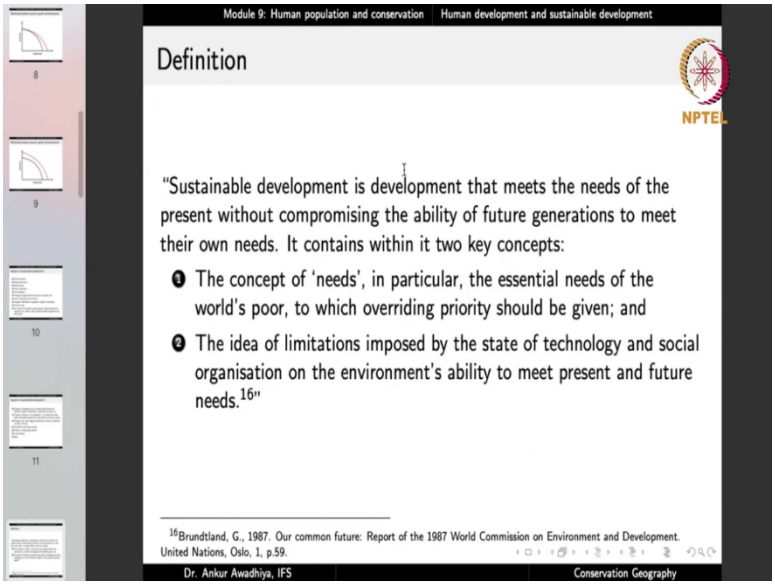

And when we talk about sustainable development, we have to be very mindful of the needs in particular the essential needs of the world's poor to which over trading priority should be given. So, when we say that we want to have a sustainable development, we need to be mindful of the fact that yes, people do have their own needs and these needs have to be fulfilled, if we cut down on our resource use to an extent that people are unable to meet their needs, that is not good for the society.

And the second thing is the idea of limitations imposed by the state of technology and social organization, on the environments ability to meet present and future needs. So, we have needs, but the environment also has its own limitations. It cannot provide us with everything that we want. So, we have to make a choice whether we make use of all the resources today or we save something for the future generations because we cannot do both.

We cannot say that okay we will use all of the coal, all of the petroleum, all of the natural gas and the future generation should also have coal and petroleum and natural gas, no, because the supply is limited. The stocks are limited. Similarly, if we say that okay, we are going to pollute as much as we want, but our future generations should have a clean environment. No, that is not going to happen.

Because the environment has a certain ability to tolerate the pollutants, to process the pollutants and if we cross that limit, then our future generations will be unable to meet their own needs, we will be leaving a very dirty planet for them. So, this is important to keep in mind. There are concepts of needs and there is an idea of limitations imposed by both the

state of technology and the social organization, on the environments ability to meet the needs of the present and the future generations.

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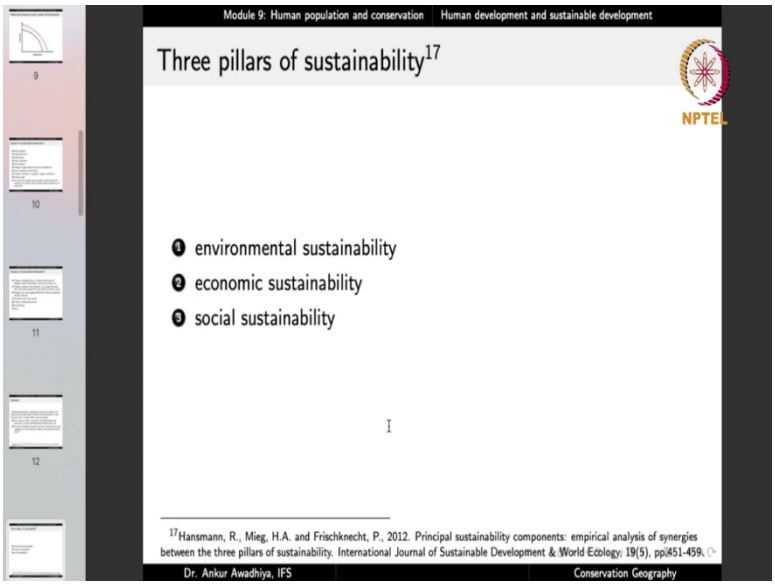

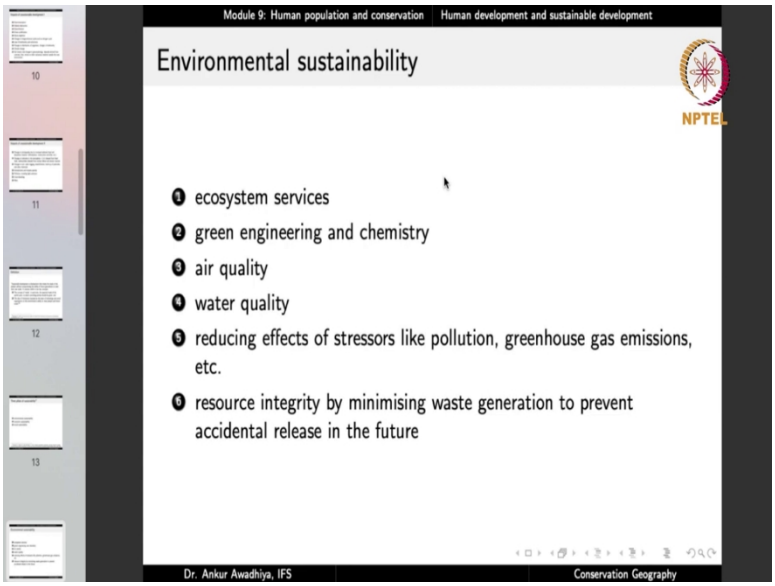

So, when we talk about sustainability, there are three pillars of sustainability. We can talk about environmental sustainability, economic sustainability and social sustainability. So, when we talk about sustainable development, we should have all of these three. Now, what does that mean? Environmental sustainability puts a focus on things like ecosystem services.

So, if you want to have environmental sustainability, you need to ensure that the ecosystems are well functioning and they are able to provide the services in an unhindered way. It talks about things like green engineering and chemistry, that is, we should use engineering and

chemistry in such a manner that we release less and less amount of pollutants into the atmosphere or into the water bodies or into the land.

So, when we have a focus to use technology, and especially chemistry, in such a way that we make little use of resources and we generate less amount of pollution, then we are talking about environmental sustainability. It includes things like maintenance of air quality and water quality, reducing the effects of stressors like pollution, greenhouse gas emissions and so on, especially on different organisms. Resource integrity by minimizing waste generation to prevent accidental release in the future.

So, what is this resource integrity? We have got two options. Say, we generate a large amount of waste and we stored that waste. So, we can see that okay, we are saving our future generations by storing the waste so that it is not released into the atmosphere or into the environment. But if you store the waste, then there is always a chance of having an accident. And so, when we talk about environmental sustainability, we should try to reduce the amount of waste generation barely storing the waste in some location is not going to help. So, these are different examples of environmental sustainability.

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When we talk about social sustainability, then we are talking about environmental justice and empowerment of communities that are burdened by pollution. So, when we talk about things like the polluter pays principle, we are talking about the social sustainability. If you pollute the environment, and you cause a negative side effect on the communities, when people become diseased, their health is impacted, their life expectancy is impacted, then you will have to pay to compensate for these damages.

So, when we talk about these things, we are talking about social sustainability, environmental justice, and empowerment of communities that are burdened by pollution. Similarly, in social sustainability, we also talk about protection, sustenance and improvement of human health, increasing the participation of stakeholders. How much voice to the stakeholders have when there is a decision being made? So, if a factory is being set up in a certain area, do the people in the locality have a voice to say that is this factory going to generate a huge amount of pollution? What are the steps being taken to reduce pollution and so on? Are they heard or not? Are they asked for the views or not?

We also talk about education about sustainability, especially, in schools and colleges. Do people talk about sustainability or are they only talking about the physical aspects? They are not talking about sustainability? In the chemistry education, is green chemistry taught or not? When we talk about making off roads, do we talk about making underpasses or not? When we talk about the economics of production, do we also consider the economics of sustainable production are not?

So, education about sustainability is also a part of the pillar of social sustainability. Then, we also have protection, maintenance and access to resources and promotion of sustainable living. Does the society promote sustainable living or not? For example, in a country do we have, say, tax breaks if people want to go for electric vehicles or not? So, if the government promotes sustainable living, if the society promotes sustainable living by say incentivizing all the actions that are done towards a sustainable living, then we say that this is also a component of social sustainability.

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And when we talk about economic sustainability, we want to have a job security for everybody. Because remember that when we talk about sustainability, it should be able to meet the needs of the present generation, especially the needs of the poor people. And so, it should incorporate job security for everybody. Everybody should have access to resources, so that they can have a maximum development of their own lives. So, that is a part of economic sustainability.

Similarly, we have incentivization of sustainable practices through things like taxations or tax breaks or subsidies, then we should have market practices for sustainability. Does the market promote sustainability or not? Do we have things like natural resource accounting? So, when we talk about the profits and losses of companies do they, do we also talk about how much amount of natural resources they have used or they have conserved. So, that is a part of the economic sustainability.

Lifecycle cost assessment. When we look at the cost of something, do we incorporate the lifecycle cost or not? That is when we talk about things like say a plastic bag. Now, a plastic bag today is very cheap, you can have a plastic bag for less than a rupee, but if you look at the lifecycle cost, the lifecycle cost is tremendous. Because to make that plastic bag we require things like petroleum, so petroleum has to be mined from somewhere, that has its own environmental consequences, then there is a huge amount of transportation that happens.

When the plastics bags are manufactured, they also lead to the emission of pollutants, so this is all happening before the plastic bag even got made. So, even before making of the plastic bag it led to emission of greenhouse gases, it led to destruction of habitats. Now, once you have the plastic bag, once you are done with using the plastic bag it is generally thrown somewhere, and a large portion of the plastic bags that we are using are getting released into the environment, they get into our waterbodies, they get into the oceans. Once they are in the oceans animals confuse them for food, they eat up these plastic bags which then chock up their intestines, so this is leading to a huge loss of biodiversity.

If we wanted to preserve and conserve our biodiversity, we would have to device mechanisms through which these plastic bags would be removed from the environment that again would meet a tremendous amount of cost. Now, who pays these costs? The people who are using the plastic bags or the people who are living in the areas that are near to our coasts?

Because once you have a large amount of plastic bags that are thrown into the environment then the fish catch would reduce which would impact the earnings of the coastal

communities. When you throw the plastic bags then a large number of our beaches will be trashed, and so that would impact the amount of tourists that come to visit these places. Again, we are impacting the income of the local communities, we are impacting the health and the economic conditions of the local communities.

And in these cases, the people who are using the plastic bags are not paying the cost, but if all of these lifecycle costs were incorporated into the costs of plastic bag. So, when we talk about the buying and selling price of a plastic bag, if we incorporated all of these costs then probably the plastic bag would have been much more expensive. And if you increase the cost of the plastic bag then less and less number of people would want to use this plastic bag, it would become more unaffordable for large portion of people, which ultimately would be good for the environment.

So, when we talk about economic sustainability we ask the question are the lifecycle costs assist, and are they incorporated into the cost of various things? And similarly, do we have cost structures to reduce the risk and promote new technologies? Because a large portion of the newer technologies are more efficient technologies, they help us reduce our consumption of resources, they help us reduce the amount that we are causing. So, when we talk about economic sustainability, we also ask the question, does the society promote the development and usage of newer technologies? Again, through means of incentivization, such as, things like tax breaks. So, these are the components of sustainability.

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And when we incorporate all of these three into the accounting framework we talk about the triple bottom line. That is, if we want to go for sustainability we should not just look at the

sales that a company makes and the expenses of the company, we should also look at the social environmental and financial costs and benefits to the society. When these are incorporated we are talking about the triple bottom line.

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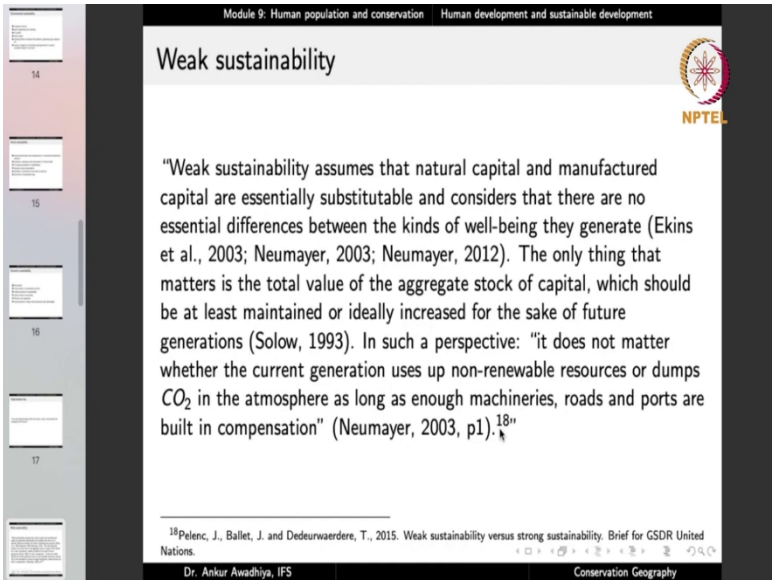

Now, in this context, we can talk about weak and strong sustainability. Weak sustainability assumes that natural capital and manufactured capital are essentially substitutable and considers that there are no essential differences between the kinds of well-being that they generate. Meaning that, if you overuse the natural capital and make manufactured capital that is okay for the society. That is, if you say overuse the coal and petroleum and natural gas, but you are giving people electricity, so that is okay, we do not need the natural resources separately from the manufactured resources, that is weak sustainability.

The only thing that matters is the total value of aggregated stock of capital, which would be at least maintained or ideally increase for the sake of future generations. In such a perspective, it does not matter whether the current generation uses up non-renewable resources or dumps carbon dioxide in the atmosphere, as long as enough machineries roads and ports are built in compensation. Now, this is weak sustainability.

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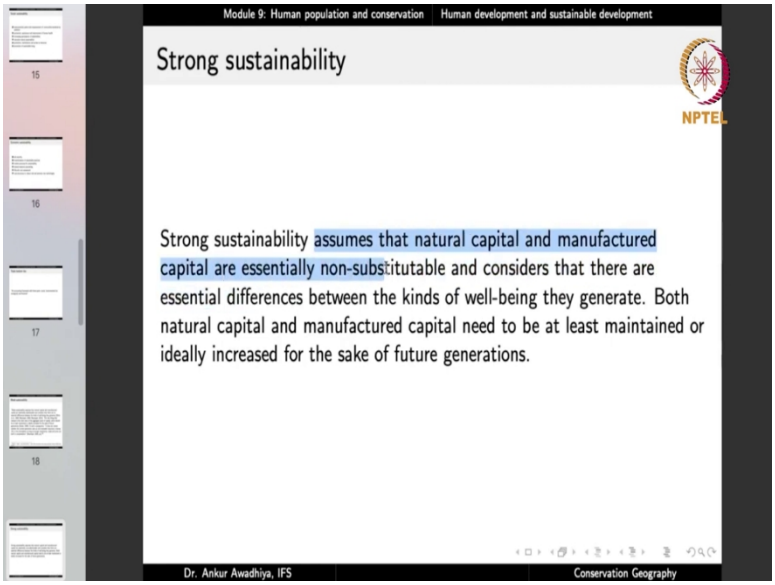

But we also have the viewpoint of strong sustainability, which assumes that natural capital and manufactured capital are essentially non substitutable and considers that there are essential differences between the kinds of wellbeing that they generate. That is, the kind of wellbeing that people get out of visiting a forest area and seeing a tiger is very different from the kind of wellbeing that they would have received if this area was cut and converted into say, a farmland.

And for the fullest wellbeing of the society, we need both these kinds of well beings. So, both, natural capital and manufactured capital need to be at least maintained or ideally increased for the sake of the future generations. So, we need to maintain and increase, both, natural and manufactured capital.

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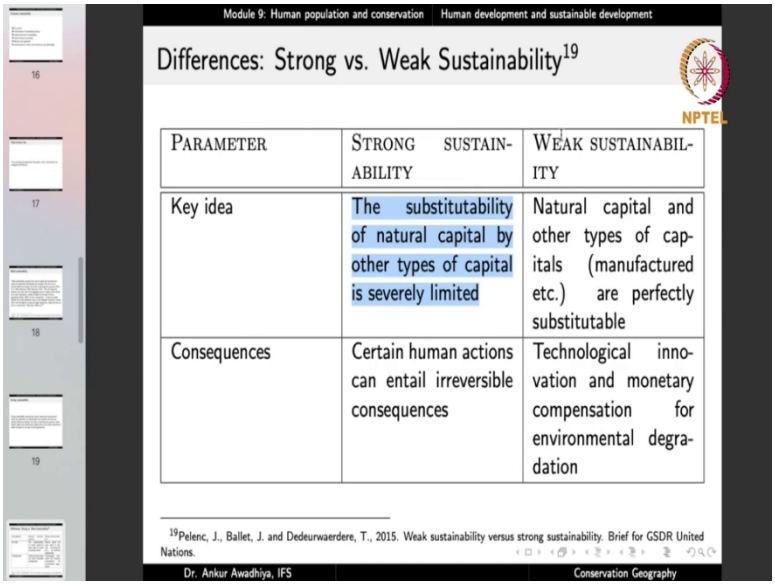
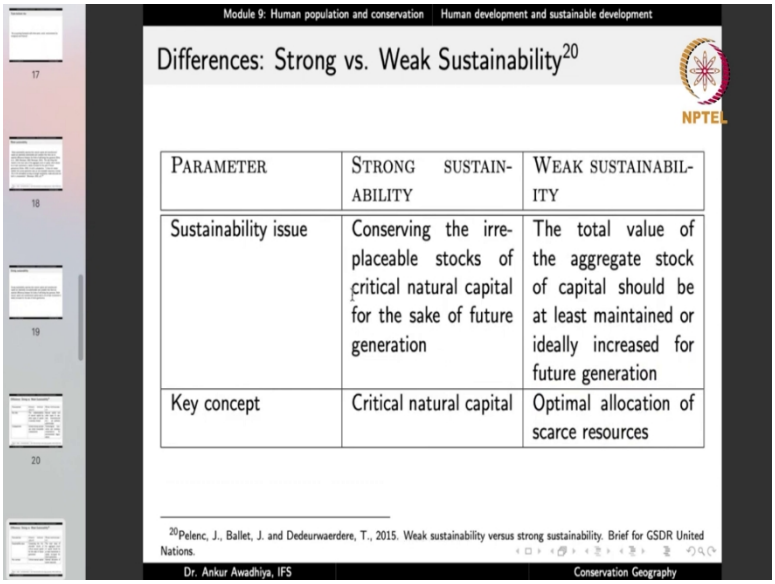


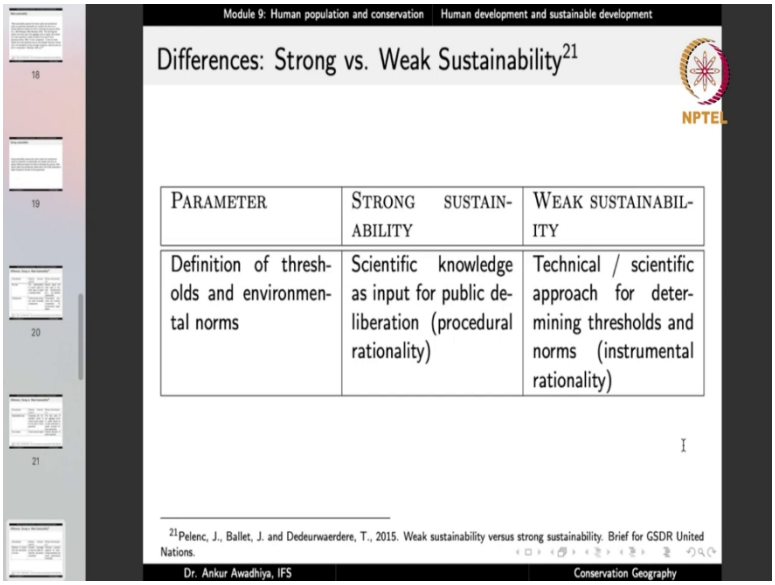
PARAMETER	STRONG SUSTAINABILITY	WEAK SUSTAINABILITY
Key idea	The substitutability of natural capital by other types of capital is severely limited	Natural capital and other types of capitals (manufactured etc.) are perfectly substitutable
Consequences	Certain human actions can entail irreversible consequences	Technological innovation and monetary compensation for environmental degradation

[19] Pelenc, J., Ballet, J. and Dedeurwaerdere, T., 2015. Weak sustainability versus strong sustainability. Brief for GSDR United Nations.



PARAMETER	STRONG SUSTAINABILITY	WEAK SUSTAINABILITY
Sustainability issue	Conserving the irreplaceable stocks of critical natural capital for the sake of future generation	The total value of the aggregate stock of capital should be at least maintained or ideally increased for future generation
Key concept	Critical natural capital	Optimal allocation of scarce resources

[20] Pelenc, J., Ballet, J. and Dedeurwaerdere, T., 2015. Weak sustainability versus strong sustainability. Brief for GSDR United Nations.



PARAMETER	STRONG SUSTAINABILITY	WEAK SUSTAINABILITY
Definition of thresholds and environmental norms	Scientific knowledge as input for public deliberation (procedural rationality)	Technical / scientific approach for determining thresholds and norms (instrumental rationality)

[21] Pelenc, J., Ballet, J. and Dedeurwaerdere, T., 2015. Weak sustainability versus strong sustainability. Brief for GSDR United Nations.

So, if you look at the differences, the key idea in strong sustainability is that the substitutability of natural capital by other types of capital is severely limited, you cannot trade one for the other whereas, weak sustainability assumes that these are perfectly substitutable. Consequences, certain human actions can entail irreversible consequences is what the strong sustainability believes.

Whereas weak sustainability says that, if there is environmental degradation, we can have technological innovation and monetary compensation and that is fine for the society. So, it is a weak form of sustainability. In the case of strong sustainability, the issue is conserving the irreplaceable stocks of critical national capital for the sake of the future generation. So, these have to be conserved.

But in weak sustainability, the total value of the aggregate stock of capital should be maintained or increased. So, it considers that there is nothing that is irreplaceable. In the case of strong sustainability, the key concept is critical natural capital. So, this is critical so this has to be maintained. In the case of weak sustainability, it only looks at optimal allocation of scarce resources. So, they can be used or even overuse that is fine.

And in the case of strong sustainability, the scientific knowledge is an input for public deliberation so it focuses on procedural rationality. Whereas, the weak sustainability says that technical and scientific approach are necessary for determining thresholds and norms and so, it only talks about instrumental rationality. That is, in the case of strong sustainability, we say that the society should decide, which of the stocks are replaceable and which of the stocks are irreplaceable.

So, the people should have a say, the stakeholders should have a say. But in the case of weak sustainability, we only say that we require a certain amount of instrumental rationality, such that if one stock is overused, then other is increased. So, these are the differences between strong and weak sustainability.

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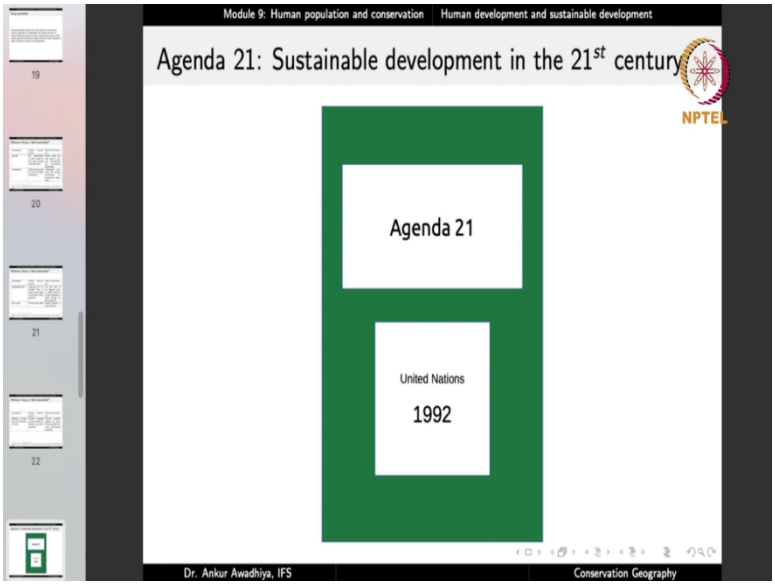

Currently, when we talk about sustainability, the most important document is Agenda 21 of the United Nations. So, this talks about sustainable development in the 21st century, and it has set up certain sustainable development goals. So, there are 17 goals, including no poverty, zero hunger, good health and wellbeing, quality education, gender equality, clean water and sanitation. affordable and clean energy, decent work and economic growth, industry innovation and infrastructure, reduced inequalities, sustainable cities and communities, responsible consumption and production, climate action, preservation and conservation of life below water, life on land, peace, justice and strong institutions and partnership for the goals.

Now, it is easy to see that these sustainable development goals are trying to increase the human development by increasing the life expectancy, increasing the healthcare access or by

increasing the amount of education or by increasing the amount of employment that is available to people. So, these are things that are necessary for sustainable development.

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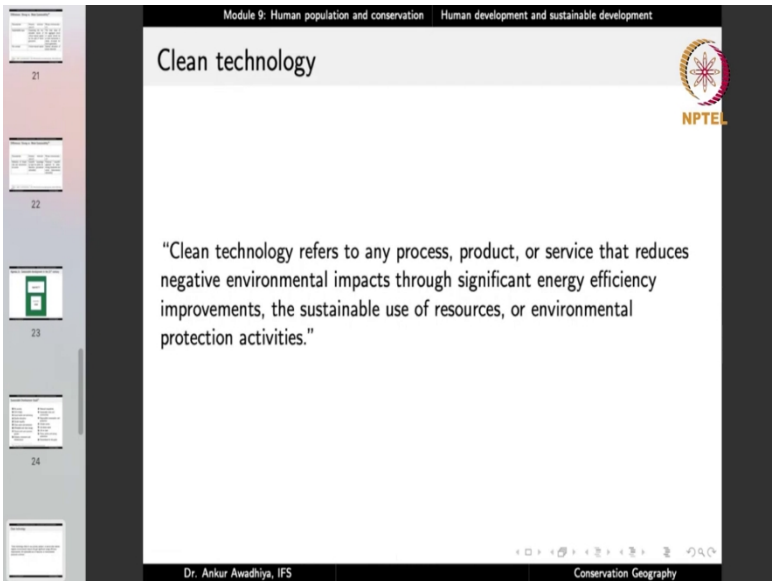

And in this context, we can talk about clean technologies. So, when we talk about things like industry, innovation, infrastructure or sustainable cities and communities or responsible consumption and production in a large of these we need to make use of clean technologies. It refers to any process, product or service that reduces negative environmental impacts through significant energy efficiency improvements.

The sustainable use of resources or environmental protection activities. So, clean technology does three things, it can make use of energy efficiency improvements or sustainable use of

resources, primarily, using less amount of resources and environmental protection activities to reduce the negative environmental impacts.

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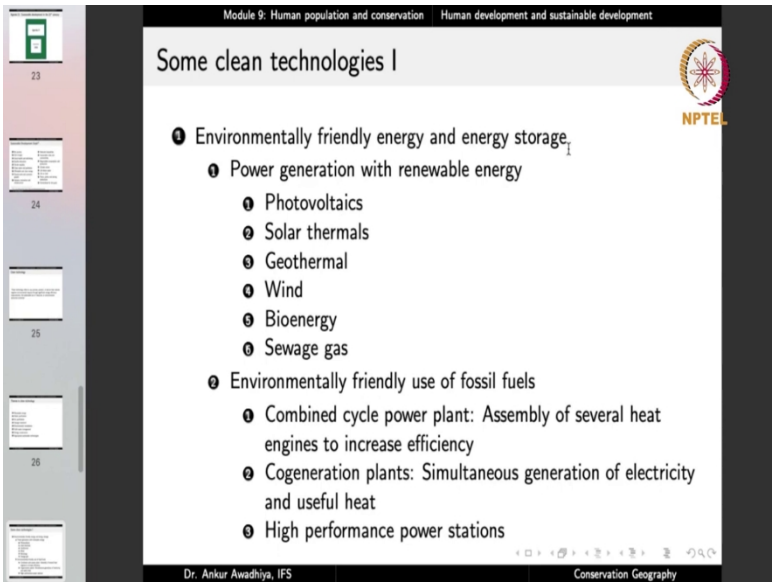
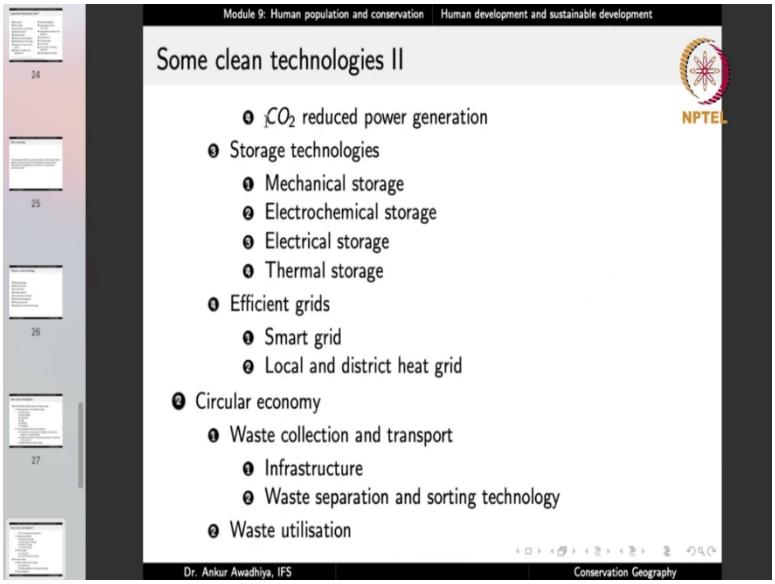
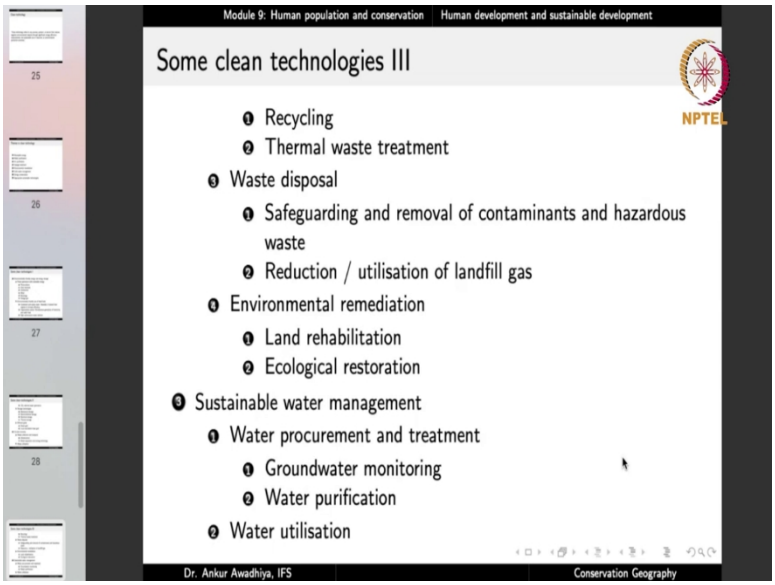
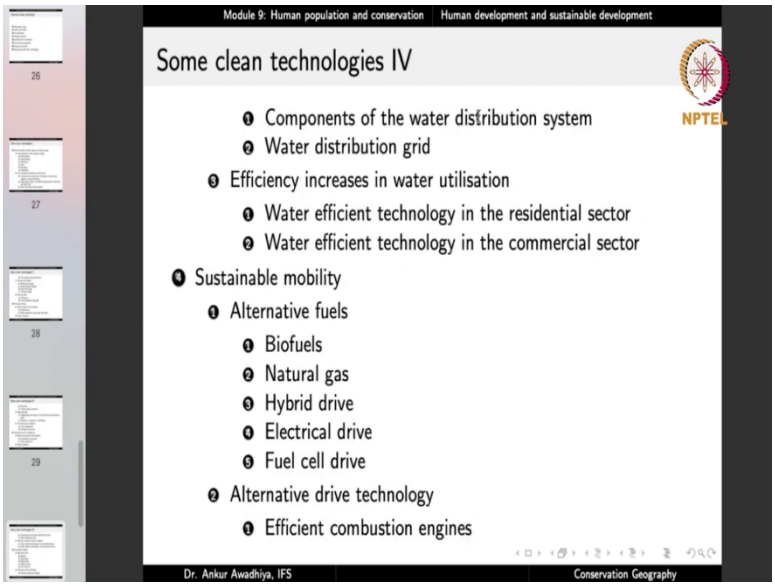



Module 9: Human population and conservation
Human development and sustainable development
Some clean technologies II
NPTEL
1. CO_2 reduced power generation
3. Storage technologies
   1. Mechanical storage
   2. Electrochemical storage
   3. Electrical storage
   4. Thermal storage
4. Efficient grids
   1. Smart grid
   2. Local and district heat grid
2. Circular economy
   1. Waste collection and transport
      1. Infrastructure
      2. Waste separation and sorting technology
   2. Waste utilisation
Dr. Ankur Awadhiya, IFS
Conservation Geography


Module 9: Human population and conservation
Human development and sustainable development
Some clean technologies III
NPTEL
1. Recycling
2. Thermal waste treatment
3. Waste disposal
   1. Safeguarding and removal of contaminants and hazardous waste
   2. Reduction / utilisation of landfill gas
4. Environmental remediation
   1. Land rehabilitation
   2. Ecological restoration
3. Sustainable water management
   1. Water procurement and treatment
      1. Groundwater monitoring
      2. Water purification
   2. Water utilisation
Dr. Ankur Awadhiya, IFS
Conservation Geography


Module 9: Human population and conservation
Human development and sustainable development
Some clean technologies IV
NPTEL
1. Components of the water distribution system
2. Water distribution grid
3. Efficiency increases in water utilisation
   1. Water efficient technology in the residential sector
   2. Water efficient technology in the commercial sector
4. Sustainable mobility
   1. Alternative fuels
      1. Biofuels
      2. Natural gas
      3. Hybrid drive
      4. Electrical drive
      5. Fuel cell drive
   2. Alternative drive technology
      1. Efficient combustion engines
Dr. Ankur Awadhiya, IFS
Conservation Geography

Some clean technologies V

2. Environmentally friendly vehicle design
3. Infrastructure and traffic control
   1. Intelligent traffic control
   2. Integrated traffic infrastructure
   3. Electric charging stations
   4. Natural gas fuelling stations
4. Sustainable mobility management
   1. Carsharing
   2. Vehicle fleet management
5. Resource and material efficiency
   1. Cross-sectional technology
      1. Biotechnology
      2. Nanotechnology
      3. Mechanical engineering / process technology

Some clean technologies VI

2. New materials
   1. Compound materials
   2. Bioplastics
3. Material-efficient processes
   1. Optimisation of existing processes
   2. Utilisation of new materials
   3. Reduction of operating supplies
4. Sustainable design
   1. Ecodesign: "an approach to designing products with special consideration for the environmental impacts of the product during its whole lifecycle"
   2. Life cycle assessment
6. Energy efficiency
   1. Industry-specific, energy-efficient production processes

Some clean technologies VII

1. Automation and control technology
2. Efficient engines
3. Heat recovery
2. Efficient appliances
   1. Electric appliances
   2. Information and communication technology
   3. Illumination
3. Energy efficient buildings
   1. Technical
   2. Building equipment
   3. Building shell (insulation and windows)

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[23] By DCTI, EuPD Research, KPMG in: Cleantech-Standortgutachten 2013 in Anlehnung an BMU/Roland Berger 2012 - Own work, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=32896152

And here we have themes like renewable energy, water purification, air purification, sewage treatment, environmental remediation, solid waste management, energy conservation, and appropriate sustainable technologies. And the examples include things like environmentally friendly energy and energy storage, using power generation with renewable energy, things like solar cells and photovoltaics, solar thermals, geothermal, energy, wind, biogas, sewage gas.

Environmentally friendly use of fossil fuels, such as, combined cycle power plant, where you have an assembly of several heat engines to increase the efficiency or cogeneration plants which have a simultaneous generation of electricity and useful heat, high performance power stations, carbon dioxide reduce power generation storage technologies, including mechanical, electrochemical, electrical and thermal storage, efficient grids, including smart grids using automation and technology and local and district heat grids.

Then, another theme is circular economy. So, we have things like waste collection and transport, infrastructure, separation and sorting technologies, waste utilization, including recycling and thermal waste treatment, waste disposal, such as safeguarding and removing of contaminants and hazardous waste, reduction and utilization of landfill gas, environmental remediation, including land rehabilitation and ecological restoration.

Sustainable water management, such as water procurement, intake and treatment technologies, including groundwater monitoring and water purification, water utilization, where we talk about the components of the water distribution system to reduce the losses in the whole system. We make a water distribution grid so that everybody has access to water in a sustainable manner. And we try to increase the efficiency in water utilization both in the residential sector and in the commercial sector.

Then there is sustainable mobility using alternative fuels such as biofuels, natural gas, hybrid drives, electric drives and fuel cell drives. So, we are trying to reduce our dependence on the fossil fuels. Then there is a talk of alternative drive technology, such as, efficient combustion engines, environmentally friendly vehicle design. Then we have infrastructure and traffic control, including things like intelligent traffic control, because a lot of energy is also wasted when people are waiting at the red-light signals. So, can we make it more intelligent, so that the stoppages at the red lights are reduced?

Integrated traffic infrastructure, electric charging stations, natural gas fueling stations. Then there is sustainable mobility management including car sharing a vehicle fleet management,

resource and material efficiency, including cross-sectional technologies such as biotechnology, nanotechnology, mechanical and process engineering. Newer materials like compound body deals and bioplastics, material efficient processes, such as optimization of existing processes, utilization of new materials, reduction of operating supplies and sustainable design such as eco design and lifecycle assessment.

Now, eco design is an approach to designing products with special consideration for environmental impacts of the product during its whole lifecycle. And we also talk about energy efficiency, including industry-specific, energy efficient production processes**,** automation and control technologies, efficient engines, heat recovery, efficient appliances, including electric appliances, information and communication technology appliances, and illumination.

Now, illumination is also important to reduce the amount of light pollution that we are causing. So, it is not just a saving of energy, but also saving from light pollution. Then we have teams like energy efficient buildings, where we talk about the technical blueprints, the building equipment's, the building shells, such as insulation and windows.

So, in a large number of cases, if you have a good amount of shell, then the interiors can be protected from the extremes of temperature during day and night. What is the placement of windows that you can make such that you have a climate control without use of large amount of energy? So, in all of these clean technologies, you can see that there are two themes that are always running. One, how to make the processes more efficient, by using less resources and two, how to reduce the negative impacts that are caused by pollution by reducing the amount of pollutant root in the environment. So, if we do both of these, then we are shifting towards a cleaner technology. So, that is all for today. Thank you for your attention. Jai Hind!