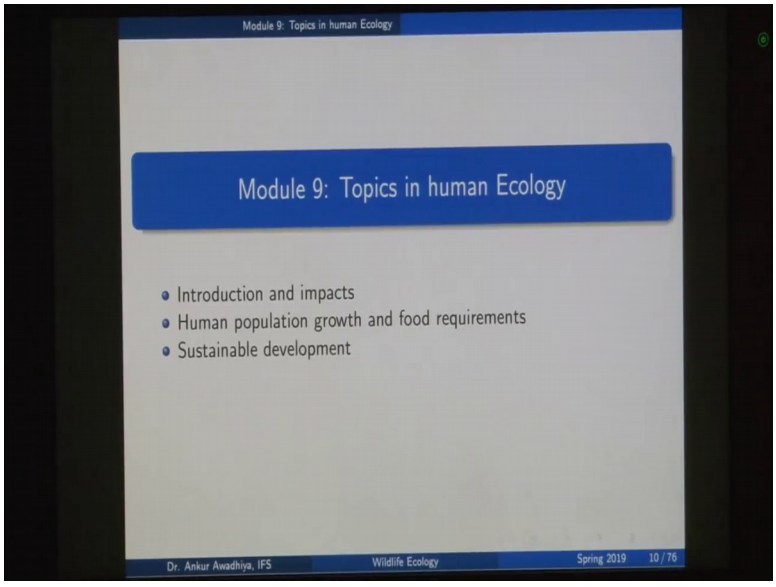
Wildlife Ecology
Dr. Ankur Awadhiya
Department of Biotechnology
Indian Institute of Technology, Kanpur

Lecture – 25
Introduction and impacts

[FL] Today, we begin a new module which is topics in Human Ecology. Now throughout this course, we have seen what are the different biotic and abiotic factors that play a big role in deciding, where an organism will be found; how would that organism will be distributed, how any organism gets energy or drink or nutrients from its surroundings and so on. Now in these days, the human beings are able to exert a very large amount of influence on all of these ecosystems because of our huge populations, because of our technological advances, because of our affluence and so on.

So the impact of human beings on ecology becomes very important. And also we can make use of the principles of ecology to understand how the human population is growing. So, these are the things that we understand in human ecology.

(Refer Slide Time: 01:14)



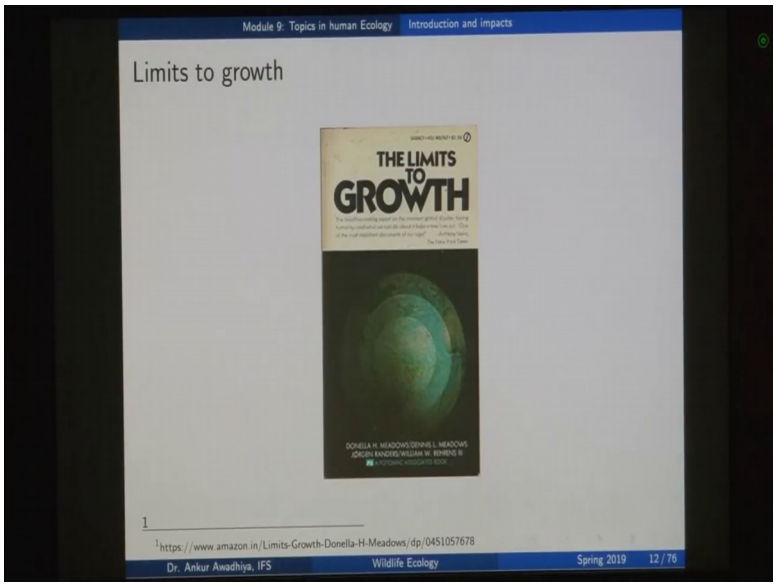
Now, this module is going to have three lectures, the first one is Introduction and impacts. So, why this field is important, what kind of things do we learn in this particular field and so on. The second lecture will be human population growth in food requirements. Now in this case, we will make use of the learning's from ecology,

especially the growth of populations to understand the growth rate of the human population. What is the rate at which we are growing, is there a cap to this particular growth rate or are we going to have an ever increasing population or is this population going to reduce after a time or maybe becomes stabilized after a time, what are the factors that are responsible for that and we will also look at our food requirements.

So, there is this particular Malthusian theory that we had referred to even in our introductory lectures; now we will look at that theory in more detail. According to Thomas Malthus, this theory tells us that the human population increases in a geometric progression. So, essentially from 1 to 2 from 2 to 4, then 4 to 8 and 8 to 16 and so on. So, it becomes a geometric progression increase whereas, the food requirements only increase in arithmetic progression; so, from 1 to 2 then 2 to 3, then 3 to 4 and so on. So, Malthus had predicted that the food requirements will ultimately act as a cap on the growth rate of human populations, because if you do not have food; so people will get into misery and they will start dying.

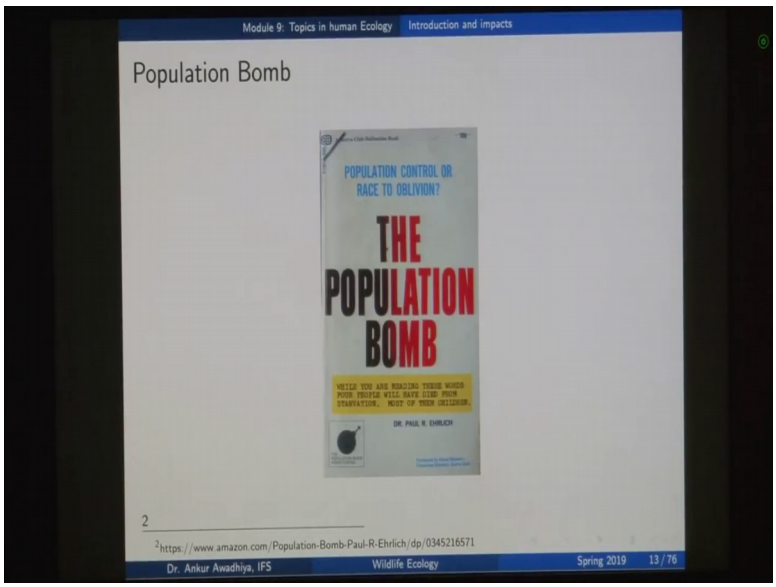
But then this theory had predicted that will have a severe food shortage say in the early 19th century, but even today we do not have a food shortage. So, we will have a look at what are the factors that cause enabled us to move out of the Malthusian trap. And we will look at those topics in more detail when we are talking about sustainable development. Because sustainable development is one mode of development in which we use our technologies in such a way, that we are able to use the resources. But at the same time, we are also able to save the resources for the future generations.

(Refer Slide Time: 03:38)



So, let us begin with the first lecture. Now, here the question is are there any limits to growth, is there a limit to the growth rate of population, is there a limit to the growth rate of technology, is there a limit to the impacts that we are going to have on the biosphere and so on.

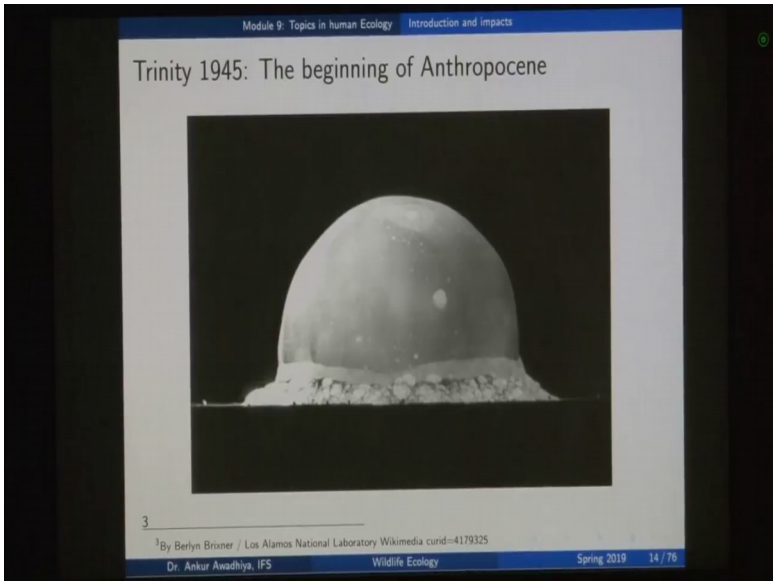
(Refer Slide Time: 03:59)



Now, in this context Paul Ehrlich had written this book The Population Bomb. Now this book it is a bit Malthusian in its outlook, but then this book also states that the human population growth is moving at such a rapid stance that it is a severe problem these days.

And then this is a ticking time bomb that needs to be stopped. Now why do we say that human beings or the size of our population has now becoming an issue for the biosphere?

(Refer Slide Time: 04:42)

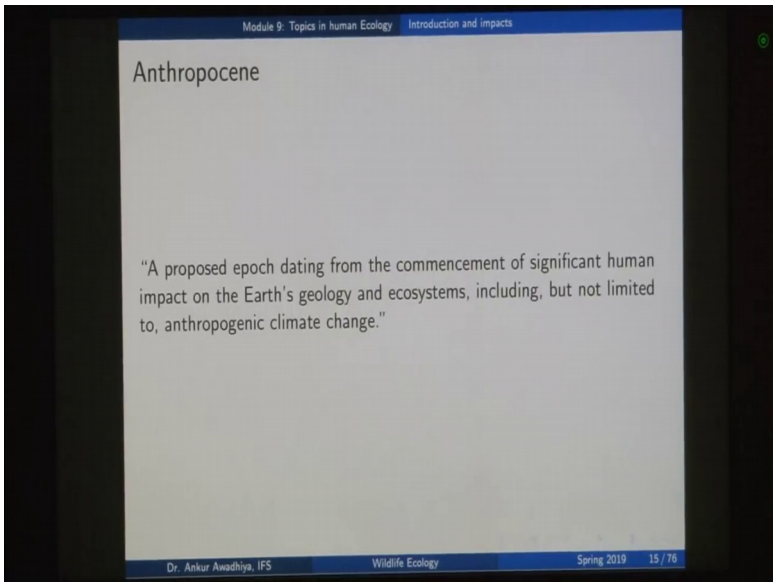


So, there are a number of reasons and the most important is that these days, we are living in the Anthropocene era. Now Anthropocene is a geological time scale which some scholars believe that it started with the atom bomb testing or the trinity testing 1945. And we take this particular time point as that the time point from where the human beings started to have an impact on the ecosystem that was much greater than any other impact.

So, if we consider the impacts of say carnivores and an ecosystem and let us consider the impact of human beings on an ecosystem; so the impact of human beings is much greater than even those of the keystones species or those of the top carnivores or the apex predators and so on.

So, when we say that our impact has become so large that we have demarcated this geological time scale as Anthropocene. Now anthropoce as we know is the human beings. So, anthropocene is the time period of the human beings or the latest time period where the human beings are having a great amount of influence.

(Refer Slide Time: 05:55)

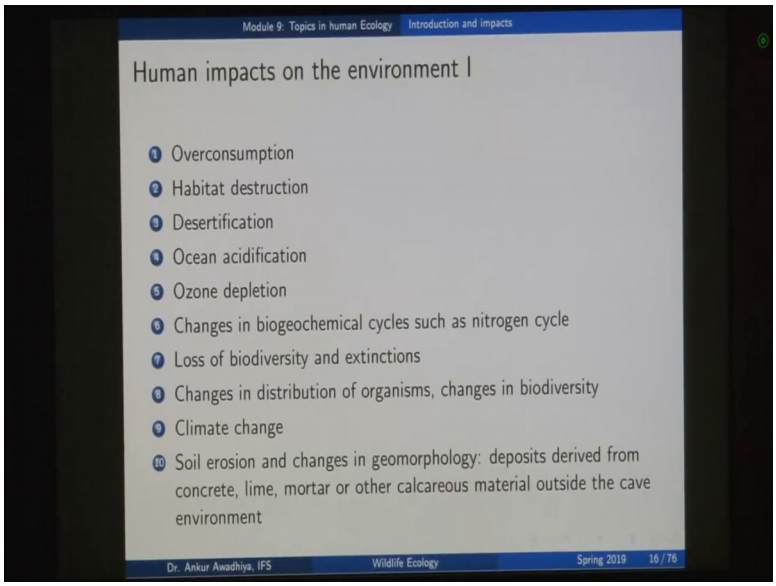


It is a proposed epoch, so epoch is again a time duration dating from the commencement of significant human impact on human on earths geology and ecosystems including, but not limited to anthropogenic climate change.

So it is a proposed epoch, there are some scholars that have already started using this term. But then there are some others who still call it a proposed epoch because it has not yet been finalized. Whether we take this 1945 as a date from which we started to have a very substantial impact or maybe the industrial revolution or maybe some somewhere in between and so on.

But then we define it as a proposed epoch dating from the commencement of significant human impact on earth's geology and ecosystems. Now not only are we impacting the ecosystems the biotic organisms that are living on earth, but also the geology of the earth and this is including, but not limited to anthropogenic climate change.

(Refer Slide Time: 07:01)



So, what are the kinds of impacts that we are talking about? But the first impact is that of overconsumption; more number of people so more amount of resources that are required, plus for every particular individual human being, the amount of consumption has increased through the ages.

Now for instance if you talk about your grandparents. Now, your grandparents might not be having televisions in their homes, they surely or they probably surely did not have a computer in their homes, they did not require Wi-Fi, there were very less number of air conditioners that we had in this country.

So, the amount of resources that were consumed by them was much limited. They probably either never flew in their youth or probably the only flew for a few times. But then these days we are using aero planes as a very common medium of transportation. The amount of resources that we are consuming, so if you talk about moment on land versus moment on an aero plane; an aero plane consumes much more amount of fossil fuels.

So, again if you talk about say the consumption of cotton, so the earlier generations used to have a fewer number of clothes as compared to what we are having today. If we talk about the amount of electrical energy that is being used so these days our amount of electrical consumption is much greater, than those of our ancestors; or if we talk about the amount of fossil fuel that we have been using.

So, these days most of us are moving in cars and those cars are probably air-conditioned whereas, if you talk about the earlier generations they probably were using bicycles or maybe scooters. So, the amount of fossil fuel that has been consumed anywhere and everywhere it has increased drastically. So, when you talk about overconsumption, there are two reasons one is that the population has increased. So, more number of people so more amount of resources are needed and second the per capita requirement or the per capita usage of different resources has increased a lot; so that is overconsumption.

If we even talk about the amount of agricultural resources that we have been using, so if we talk about say the population of the earth say; 100 years back. So, they required less number of food grains.

So, they required less number or less amount of water to irrigate their fields, but then these days the amount of land is more, the amount of water requirement is more. So, there is an overconsumption in a number of sectors. The second impact is that of habitat destruction, now this is very closely related to overconsumption. So, if you have a requirement for more amount of iron and steel. So, you require more number of or more amount of iron ore, you require more amount of coal, more amount of limestone. So, in that case where are you going to get all these resources from because you require all of these resources to satisfy the needs and the wants of the existing population.

So, you are going to get these resources by mining in different areas. Now mining leads to a heavy amount of habitat destruction in a number of areas. Or let us say talk about in the agriculture sector. Now in the case of agriculture earlier we were using less amount of fertilizers maybe more amount of manures less of fertilizers, then there were not many pesticides that were of level in those days and so on.

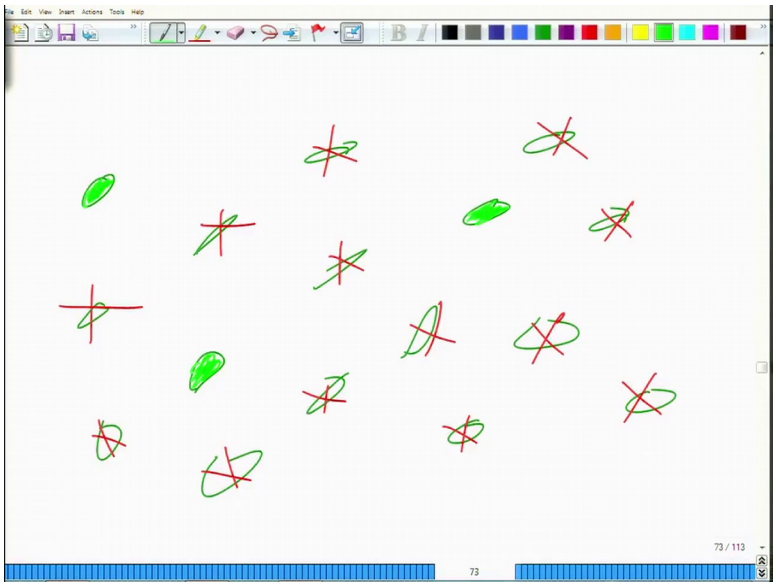
Now, these days because we have a huge population to feed so it is essential that you have more amount of food grains that are being produced. Now to produce more amount of food grains we are using more and more amounts of fertilizers, we are using more and more amount of pesticides. Now throughout this course we had this theme running that if you are using pesticides and suppose the food grades. Now have pesticides on them and even in those areas where the concentration of pesticide is very less even in those areas as you move up with the food chain.

So, if there is say a grasshopper which is there on your fields and when you sprayed your fields with pesticides with pesticides. So, a number of grasshoppers died off, but then their carcasses still remain there. Now there could be some birds that come and feed on these grasshoppers.

So, in that case they are getting exposed to the pesticides or maybe the concentration of pesticide that was sprayed was not large enough to kill all the grasshoppers. So, there are a few that are still living in that area or probably there are a few grasshoppers that now have become resistant to the impact of pesticides, because we have seen that there is this natural selection that is acting at all times.

So, even in the case of a grasshopper population, you will be having some individuals that are more susceptible to the impact of pesticides.

(Refer Slide Time: 12:30)

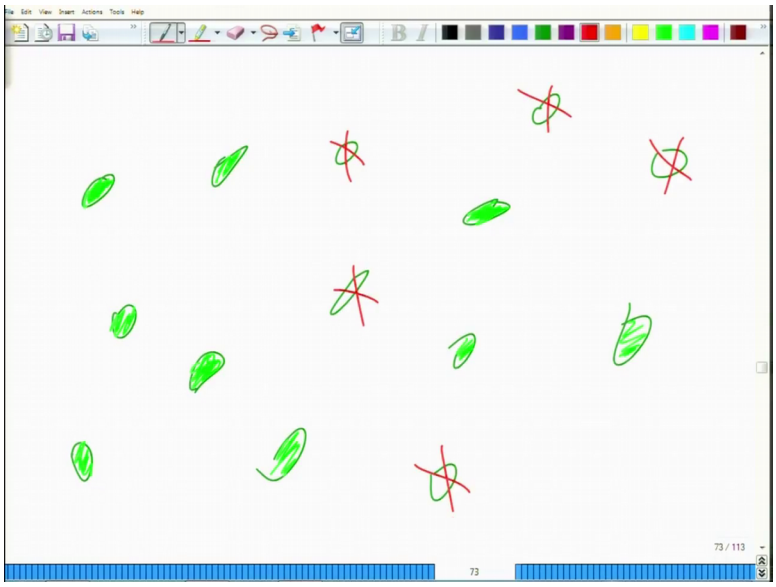


So, let us consider a big population of grasshoppers and suppose grasshoppers are going pests that we are trying to counteract using the pesticides. Now even in this population there will be some individuals that are more resistant to the impact of pesticides. And then there are some individuals that are less resistant to the impact of pesticides. Now when you spray pesticide on this population, there will be a large amount of mortality in this particular population.

So, suppose all of these die out, but then still there will be a few that will remain. So, these three individuals have now remained probably because their bodies were much better at pushing these pesticides out of their system or probably because they had a behavioral response. So, they were sneaking into the crevices that were available in the soil. So, that they were not exposed to the pesticides. So, there could be n number of reasons or maybe the amount of metabolism in their bodies is such that they are able to counteract the pesticides. Now in this particular situation when you have a huge amount of mortality; let us say all of these individuals have died out.

So, all of these individuals are now dead and you are only left with three individuals and all these three individuals are those individuals that are resistant or slightly resistant to the impact of the pesticides. Now what would happen in the next generation?

(Refer Slide Time: 14:18)



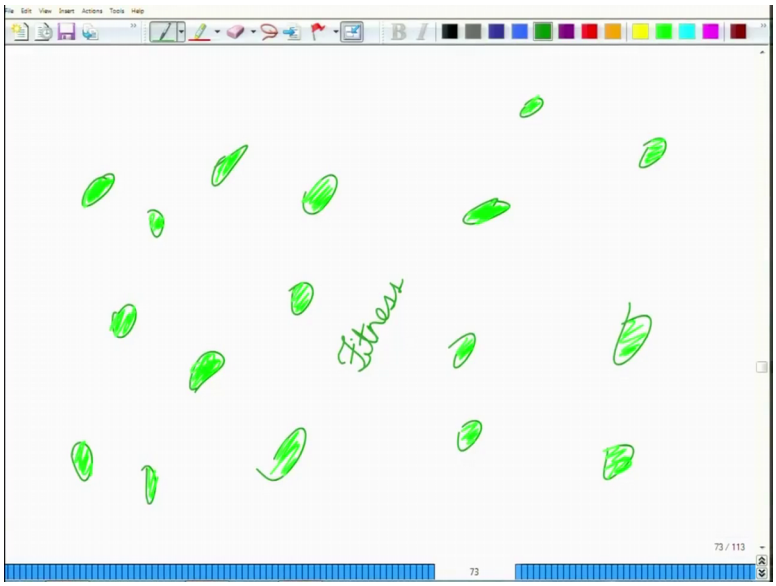
So, there are these three individuals that are surviving they will mate they will give rise to x and then in the next generation, when we again have a large population of these grasshoppers. Now in that case, either all or probably most of these individuals will now be more resistant to the impact of these pesticides.

Now, what happens? You spray the population with pesticides again and again those individuals that are not resistant they die off, but here we can observe that there are lesser number of mortalities or lesser percentage of mortality as compared to what we had seen

in the previous instance. In the previous instance everybody except these three grasshoppers were dead because of the impact of pesticides.

Now, in this case there are only these five individuals that die off and then, you have all these individuals that are surviving.

(Refer Slide Time: 15:19)



Now, what will happen in a few generations from now is that everybody that is there in this population will have these resistance genes; because these resistance genes are what are making these individuals more fit for survival.

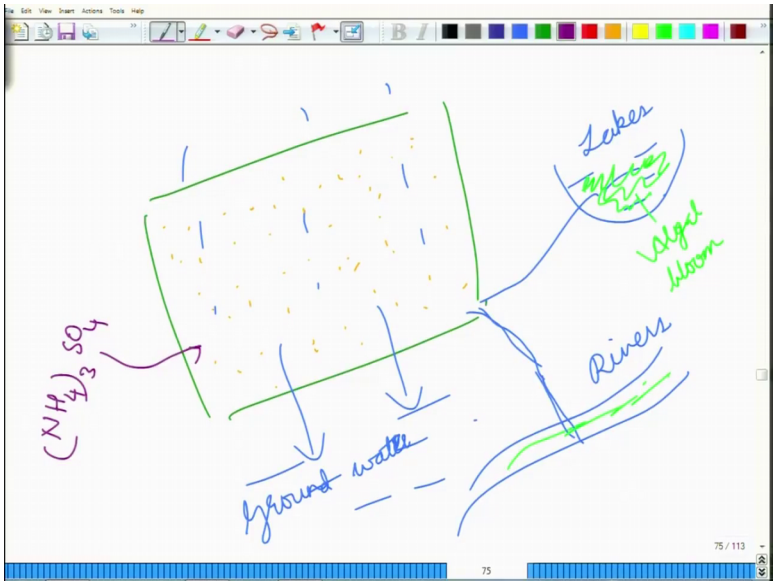
So, again when we are talking about the term fitness, here we have this particular gene or this particular trait that is providing these grasshoppers fitness, either because of the chemical metabolism that, they have or probably because they are better at taking these pesticides out of their system or some behavioral adaptations. Now, if there are some grasshoppers that they prefer living in the crisis. So, they come out feed and then move into the crevices.

So, in this case most of these grasshoppers will now have these kinds of behavioral selections. So, they will always prefer living in the crevices and once that happens what will happen, is that you will you will have to spray more and more amount of pesticides to have the desired impact; because the farmer wants to have this field that is free of pests.

So, the farmer would have to spray pesticides, but then the amount of pesticides that will have to be sprayed will go on increasing with every generation; because with every passing generation; the insects or the pests that are there in the system are becoming more and more resistant. So, the amount of pesticide that needs to be incorporated will also increase.

Now what will happen to all these pesticides? These pesticides after while they will leach out into the groundwater because you have ample amount of pesticides everywhere; so if there is rain so along with the rainwater that seeps and becomes a part of the groundwater table, these pesticides will also become a part of the ground water table or probably these pesticides will move along with the different streams.

(Refer Slide Time: 17:22)



So, if you have this particular area which is a farm land and when you have rainfall in this area. So, you can always observe that there are some small streams that are moving away from these agricultural forms. And then these streams then join together and then they become a part of the river and from there it can move into the seas or probably this will go and drain a small pond somewhere.

Now what will happen to all these pesticides is that they will either go into the ground or they will start accumulating in the water bodies. Of course, they will be a large amount that will degrade with time, because there are also a number of influences or the impact of a number of elements such as there would be oxygenation of the pesticide which

would probably render it harmless or probably these pesticides when they are exposed to the sun's rays; so that will also lead to some amount of reactions as we had seen in the case of plastics.

But then whatever happens there would be some amount of pesticides that would start leaching into the groundwater table. So, here we have the groundwater, so some amount of pesticides will start getting into the groundwater or they will start reaching into the lakes or they will start reaching into the rivers.

Once that happens, we will see the impacts of these pesticides not only in these particular fields, but also in the vided ecosystem as well. Or let us say that even if they are not able to reach into these water bodies what will happen is that they will start accumulating in the soil. Now these pesticides were meant to say kill off the grasshoppers which are feeding on the crops, but then when your soil starts becoming saturated with these pesticides, they will start impacting a number of other organisms probably they will start killing off the earthworms. Now we have seen earlier that earthworms are decomposers so they are detritus feeders.

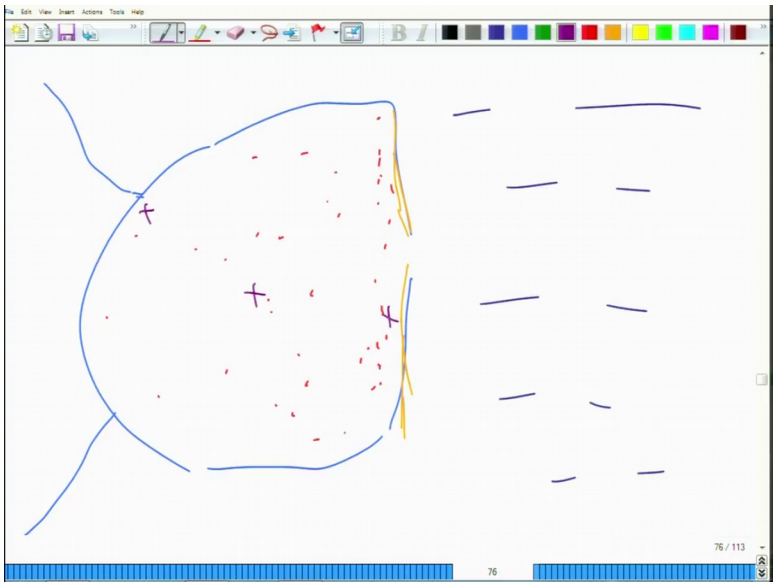
So, if there is any amount of organic matter that is there in this soil, they will feed on it, they will break it up into smaller portions, and then those smaller portions will be preferentially acted upon by different microorganisms. Now what happens if you have an ecosystem? So, here we are talking about the farmland ecosystem and this farmland ecosystem is devoid of all the detritivores or divide of all the decomposers. Now if you have such a system ; this system will start to collapse in a short while.

So, if there is any leaf that has fallen onto the soil. So, this leaf will not be eaten up; it will start accumulating then in there. Now there are also a number of other impacts that we will see so like we talked about the fertilizers and if you have fertilizers that reached into a lake, you will start observing algal bloom here. If they start reaching into the rivers, so here now we are talking about the fertilizers, fertilizers will also start moving into the rivers once that happens again you will see a larger amount of primary productivity.

So, every act of the human beings is now putting a lot of influence on the different ecosystems, what happens to these fertilizers? So, let us talk about say ammonium sulfate; now if we have ammonium sulfate and in this particular system the nitrogen is

taken up by the plant what happens to the sulfate? This sulfate starts accumulating in the soil. Once that happens the soil starts to have more and more amount of these salts, it leads to salinity in the system.

(Refer Slide Time: 21:39)



Now we had seen in the case of the Chilika lagoon; so when we talked about Chilika lagoon we said that we have this big sized lagoon and then, it is separated from the seeds with this sand bars and here we have the Bay of Bengal and you have a number of streams that are coming to the Chilika Lake.

So, in this case the amount of salinity that we have will be very high here which is close to the seas and it will be very less here. And in this case we say that we have different organisms that occupy this sector, different organisms that occupy this sector and different organisms that occupy this sector. Now in your farmlands, if you start having more and more amount of salts, you are again changing the ecosystem in a way that it will it becomes difficult for a number of organisms to live there. Now with all of these we are talking about the destruction of a number of habitats.

So, another influence of human beings on the ecosystem is that of habitat destruction. Now this habitat destruction may at times lead to desertification as well; now we have seen the causes and impacts of desertification in earlier lectures. So, if there is a heavy amount of over grazing in an area, or the plants are eaten up by say goats or sheep in that case the soil becomes exposed; because there is no longer the root system to hold the

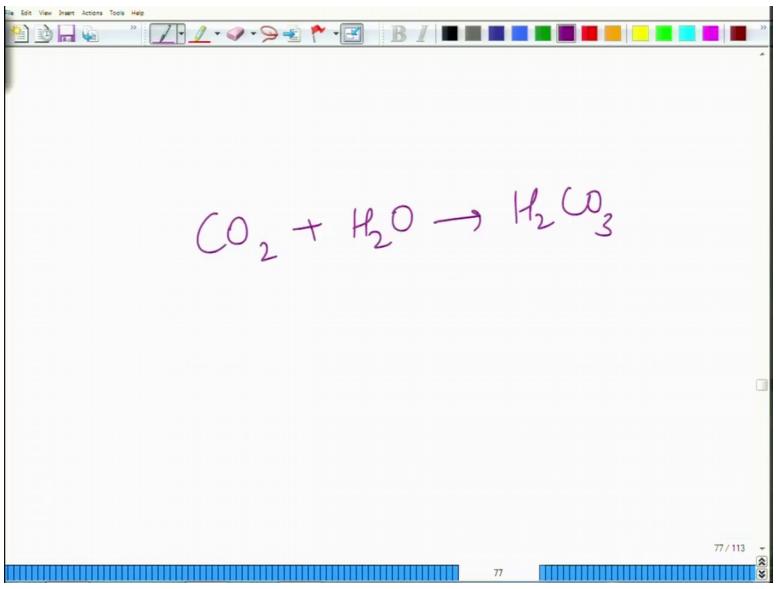
soil. And the soil starts moving it starts drying and in a short time you have converted this very fertile area into a desert; that is also another impact of human beings on the environment.

Or let us talk about ocean acidification now what is happening is that we are using a huge amount of fossil fuels in our vehicles for power generation in a number of industries and so on. Now when we talk about the use of fossil fuels what we are doing is, we are taking out these fossil fuels which are accumulated carbon which is say millions of years old.

So, they were forests a few million years back that because of some reason they got they got in into the earth. So, probably there was some amount of earthquake and because of that earthquake, the all these forests they moved inside the earth. Now with the high amount of temperature and the high amount of pressure and over long periods of time, the other chemical constituents started moving out and what remained was the coals.

Now if you take these coals out and you start to burn these coal; so in that case, you are taking out all these carbon that was stored inside the earth for a very long period of time and by burning this coal, you are releasing carbon dioxide into the atmosphere.

(Refer Slide Time: 24:49)

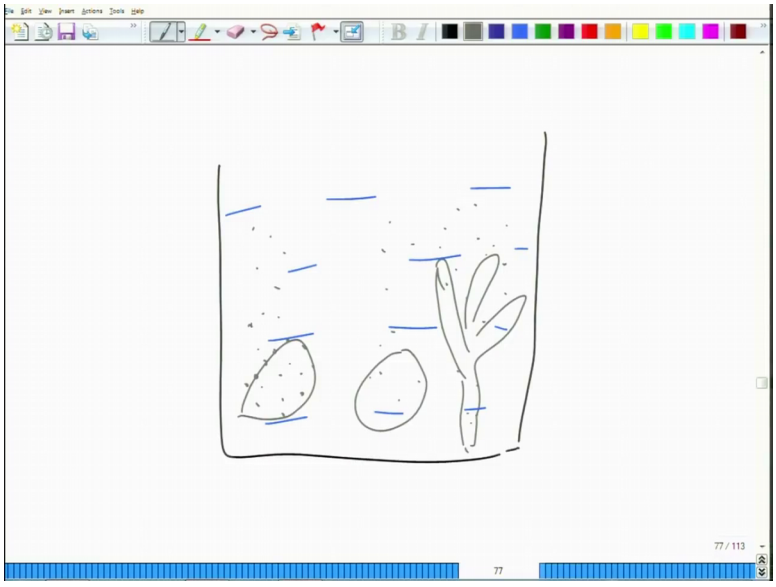


Now, if you have carbon dioxide so if you have CO 2 and when it reacts with water you get H 2 CO 3, which is the carbonic acid. Now where do you get so much amount of

water? You have a huge amount of water that is stored in the oceans. So, by releasing a huge amount of carbon dioxide into the atmosphere, we are increasing the concentration of carbonic acid that is there in the oceans.

So, that is again changing the pH of the oceans and as we know for every organism there is a very definite level of environmental conditions that it can tolerate. We talked about the Shelford's law of tolerance. So, probably there will be a number of organisms that will not be able to tolerate a low pH an acidic environment.

(Refer Slide Time: 25:43)



So, for instance if you take a beaker and in this beaker, say you put a few shells of the mollusks. So, here you have a few shells of the mollusk or probably you are keeping a few corals inside. So, you just keep a few corals inside and then, you fill this beaker with an acid. Let us say you fill this beaker up with carbonic acid, what will happen is that all the calcium carbonate that was stored in all of these animal bodies that will start releasing off the carbon dioxide.

So, you will see all these carbon dioxide bubbles that will start coming out and in a short period of time all of these organisms, their bodies will be completely dissolved in the acid. Now when we are talking about ocean acidification, this is something that has continuously happen in the oceans if you want to have a shell and that field has to be made out of carbon of calcium carbonate. So, you need to have a basic environment or probably a neutral environment, you cannot have an acidic environment. So, with more

in more amount of ocean acidification we are seeing the deaths of a number of organisms such as corals.

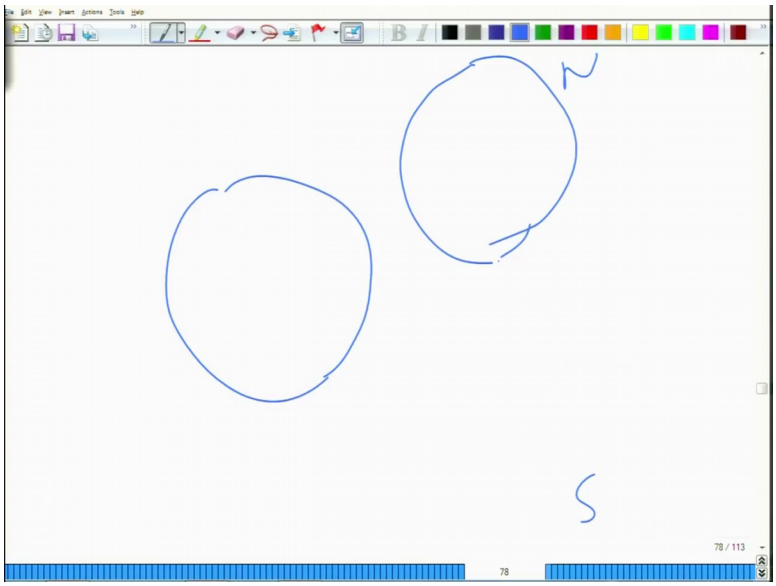
So, we see that the coral start bleaching off and in a short period they start dying off. And corals being keystone species they will also impact a number of other organisms. So, that is also a big human impact on the environment or let us talk about ozone depletion. Now if we release chlorofluorocarbons they eat up the ozone that is there in the stratosphere.

Now ozone is or this layer of ozone is what protects the life on earth from the UV radiations of the sun. Because that is able to use of the UV radiation and so the amount of UV radiation that reaches to the ground is less. Now if you take off the ozone layer more and more amount of UV radiation will start coming to the earth, what will that lead to? That will lead to things like cataracts or maybe burning of the skin of different animals or probably more amount of mutations that we will start seeing in a number of organisms and so on.

So, that is another impact of human beings on the environment. Or changes in the biogeochemical cycles such as the nitrogen cycle; naturally there is a fixed amount of nitrogen that can be taken up by the soil because of the natural processes, such as lightning or say biological nitrogen fixation. But then using our industrial processes such as the Haber process that we have seen earlier, we are putting in much more amount of nitrogen into the soils.

So, we are playing with different biogeochemical cycles such as the nitrogen cycle causing other impacts on the environment; or loss of biodiversity and extinctions that we had discussed before. Or changes in the distribution of organisms or changes in biodiversity, especially because of climate change.

(Refer Slide Time: 29:04)

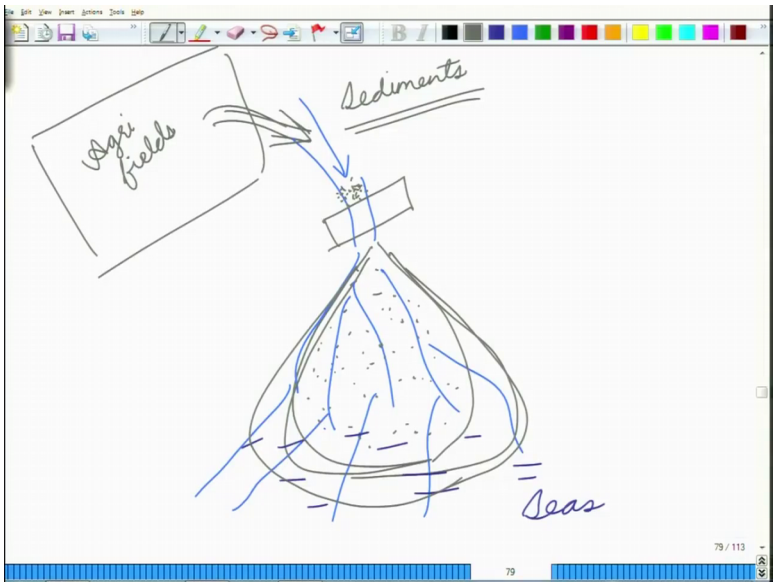


So, in this case we have seen that if you have certain organisms which have see this particular range and this is south, this is north and then if you have more amount of global warming or more amount of climate and then probably the range will shift more northward so that there is a lower temperature that is available for these organisms.

So, changes in distribution of organisms, changes in biodiversity also things like soil erosion and changes in geo morphology or deposits that are derived from concrete, lime, mortar and other calcareous materials outside the cave environment. So, here what we are seeing is that if you have more amount of tillage on the ground if you are ploughing your fields often so there will be more amount of soil erosion; because now the soil is more or less unbound.

So, if there is any wind or if there is water flow this soil will get eroded away and then it will move to other areas. It will lead to changes in the geomorphology. So, for instance if we talk about the Sundarban area.

(Refer Slide Time: 30:15)



So, in the case of any delta so let us say that here we are representing the Sundarban delta. So, you have a number of distributaries that are coming out of the rivers and then, because these rivers have been bringing huge amount of sediments; in these deltas because you are now exposed to a saline environment because it is close to the seas.

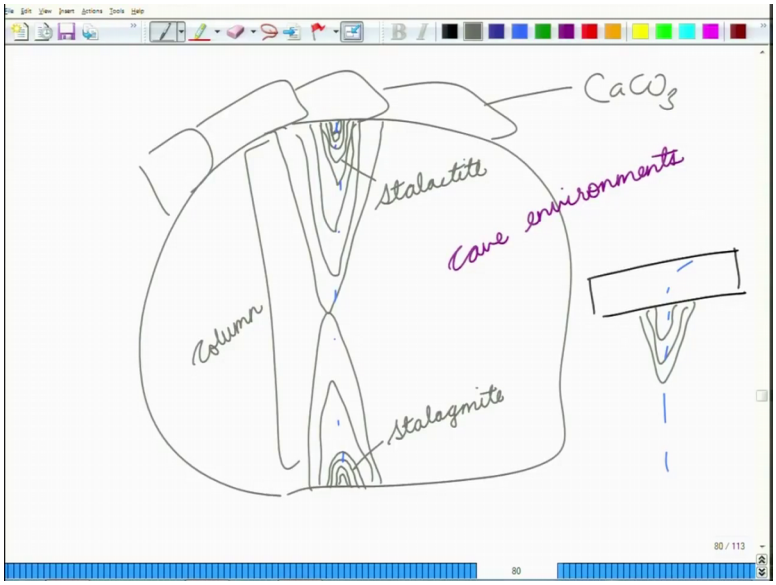
So, these sediments start coming out of the water and they start getting deposited here which is how we form a delta. So, in the case of a delta the sediments that were brought by the rivers from the upper areas such as the mountains or the plains they come to these delta areas and they get deposited here. Now if we play with the amount of sediment load, say if you have more amount of ploughing in the upslope area. So, there are a number of agricultural fields and they are not being managed properly.

So, there is a heavy amount of sediment that is coming into the rivers, what happens in that case? The size of the delta increases, because you have more amount of sediments that are now available in this area or suppose you reduce the amount of sediments. Let us say we constructed a dam here and because of this dam all the sediments that this river was bringing it gets accumulated here only.

So, it does not reach the deltas; in that case the size of the deltas will start reducing. So, the impacts of human beings are leading to soil erosion, they are leading to changes in the geomorphology; also because we have created a number of artificial materials such

as concrete, lime and mortar we are seeing some amount of stalactite like substances that are coming out of the; that are coming not in the cave environment, but outside.

(Refer Slide Time: 32:32)

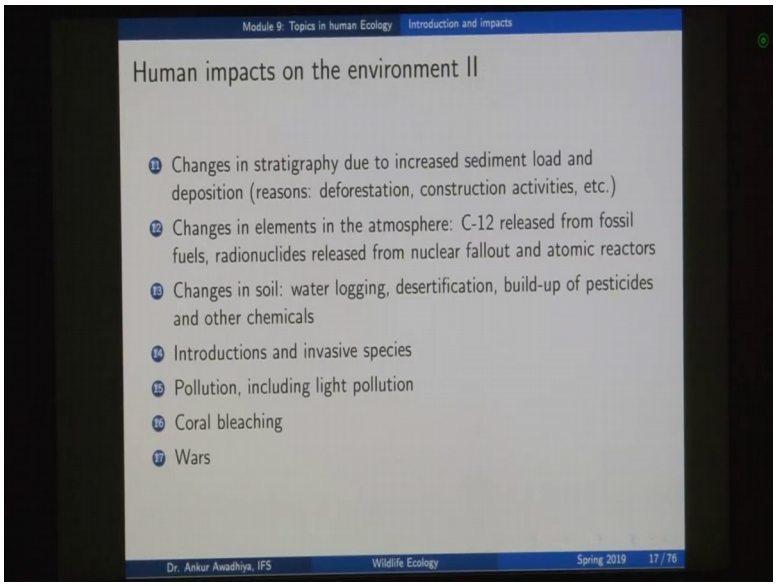


Now, what are stalactites? So, if you have say a cave and in this cave this area is a full of calcium carbonate and you have water that is dripping from the top to this bottom.

So, in this case some amount of calcium carbonate will start accumulating here because it is getting deposited along with the water and if it is getting crystallized there. And then we will also see some amount of calcium carbonate deposit that starts building up at the bottom. So, the upper portions are known as stalactites and the bottom portion is known as stalagmite and if both of these continue for a very long period of time. So, they go on increasing in their sizes and then after a while, they will meet each other and once that happens; the whole thing will be called a column.

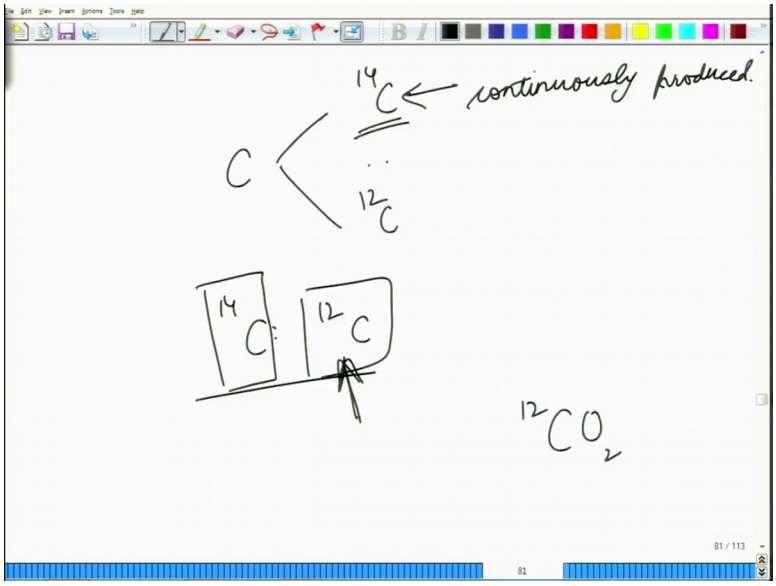
So, this is now these formations such as stalactites, stalagmites and columns which were earlier seen only in the cave environments produce some very specific ecosystems and very specific habitats for a number of organisms. But now what is happening is that, you go to a parking lot and in this parking lot, you see some amount of water that is dribbling out and then you will start seeing these formations that are there in the parking lots as well. So, now, we are changing the habitats in a number of areas.

(Refer Slide Time: 34:22)



And which is also a big impact of human beings on the environment. Or let us talk about the changes in stratigraphy due to increased sediment load and deposition as in the case of deltas or talking about the changes in the elements in the atmosphere; such as carbon trail that is released from the fossil fuels and radionuclides that are released from nuclear fallout and atomic reactors. What we are talking about here is that if we consider the element carbon and carbon as they are present in the case of carbon dioxide.

(Refer Slide Time: 34:44)



So, carbon is present in two isotopes: so carbon can be either carbon 14 or it can be carbon 12. Now carbon 14 is continuously being produced and this element which is radioactive element it starts degrading with its own half life. And so the amount of carbon 14 to carbon 12 that is there in the atmosphere, it remains constant because you have a constant amount of carbon film and there is a carbon 14 that has been produced at a continuous constant rate. Now what happens when we burn up the fossil fuels? Is that the carbon that was stored for a very long period of time so that has a very low amount of carbon 14.

So, that is practically or you can say that it is more or less pure carbon film when you are burning it off. So, you are changing the elementary or the isotope composition that is there in the atmosphere, because you are increasing the amount of carbon 12 that is there in the atmosphere or when we talk about other radioactive nuclides or elements that have being released because of the nuclear fallout in atomic reactors.

Let us say you talk about strontium, now strontium is not something that you normally find in the atmosphere or in the soil, but then if there is a nuclear fallout say because of fukushima. So, you will see that there is a huge amount of strontium that has been released into the atmosphere and has come into the soil.

Now what is very specific about strontium is that it is able to replace calcium that is there in our bodies. So, this is strontium might get might start getting deposited in the bones of different organisms and because it is radioactive, so it will start killing of the bone marrow cells, it will start giving up cancers to different organisms. So, these are the kinds of changes that we are bringing about in the environment or changes in the soil; we can have water logging; especially in those farmlands that are extensively being irrigated or in those areas where you have constructed a dam.

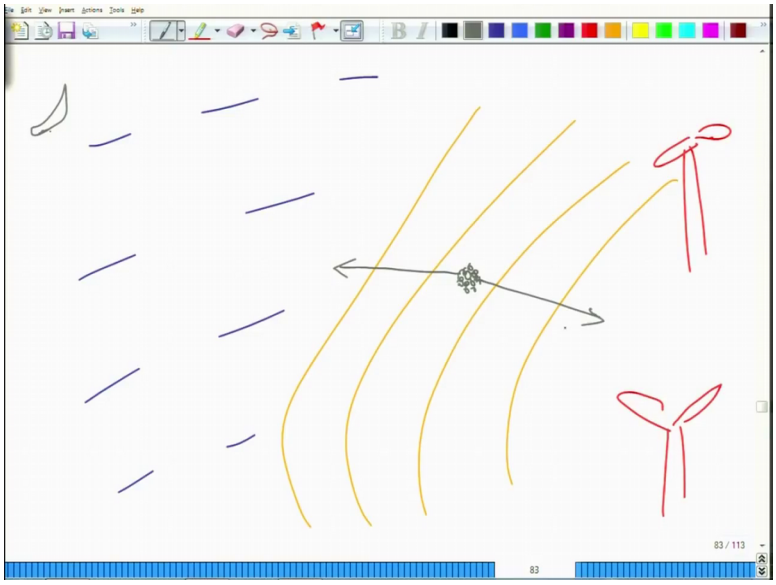
So, in those areas there is so much amount of water that is now mixed with the soil that it has created conditions of water logging, in which case the soil does not have any amount of air that is left; it is completely saturated with water or desertification or buildup of pesticides and other chemicals in the soil or introductions of a species and invasive species.

So, when we talk about things like lantana now, lantana is an invasive species in our country; it is a big problem for us; because it once it enters into a forest ecosystem it is

able to outcompete most of the native vegetation most of the native flora and then you will have a forest that is only full of lantana. Now this invasive species was brought by human beings from Africa to India so that it can be used in the case of gardens because it has beautiful flowers.

Now when we are bringing any species from one place to another; we can bring in those species that might become in a very invasive species in the new environment. And that is another impact of human beings on the environment or things like pollution including light pollution.

(Refer Slide Time: 38:39)

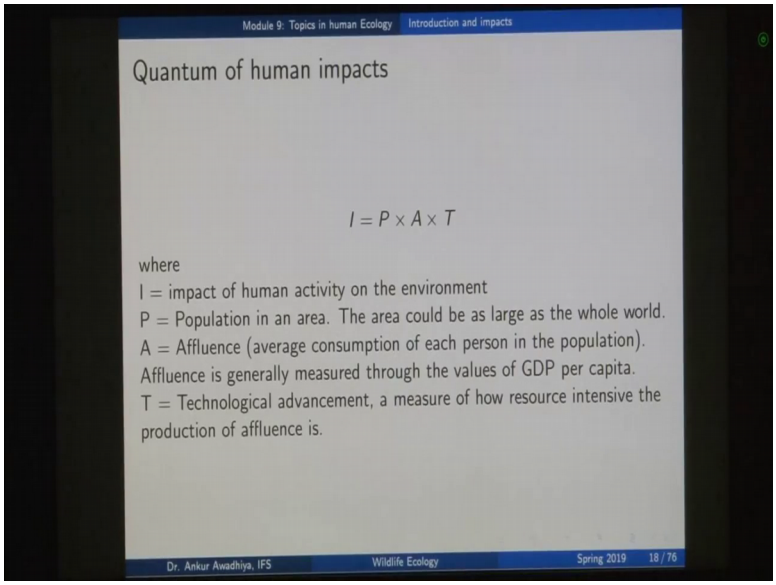


Now, in the case of a number of organisms such as turtles, turtles when they have given birth when they have laid their eggs on a sea beach. Let us say that this is a sea beach and here you have the oceans.

And suppose there is a turtle and it has given it has made a small nest here and then it has given a number and it has laid a number of eggs. Now when the young ones hatch out then they make use of the moon that is there or some amount of light that is there in the ocean side to guide them towards the oceans; because they need to move towards the oceans. Now in the case of our human influences suppose you have these streetlights that are now giving out much more amount of light that is there on the oceanic side, these young turtles they get disoriented and they start moving towards the roadside.

So, light pollution is also one big impact of human beings on the environment or things like coral bleaching in wars that are now going on. So, all of these are different impacts of human beings on the environment which is why now it is becoming more and more important to understand the rules of human beings on the environment; because they can change the ecosystems in big ways and also to see if we can reduce these impacts.

(Refer Slide Time: 40:02)



So talking about the impacts, we can quantify the impacts using this equation. So, this is an empirical equation which says that the amount of impact of human activity on the environment is given by the population in that area and when we talk about an area this area could be as large as the world in total. So, for instance for cases like climate change or global warming; this area would include the whole of the world.

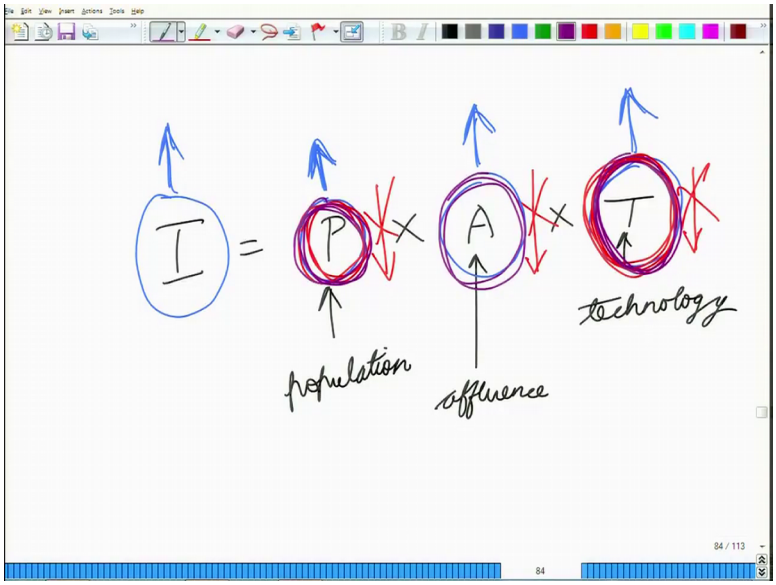
So, we will consider all the human beings that are there on this planet. So, P is the population in the area multiplied by A and is the affluence of the human beings that are there in that area. So, affluence tells us the average consumption of each person in the population. So, remember when we were talking about your grandparental generation versus the current generation. Now affluence will give you an indication of how much are you consuming and how much were your grandparents consuming in their times and affluence is generally measured through the values of GDP per capita.

So, the more amount of money that you have per person the more amount of resources that you have per person, the more amount of consumption that is possible per person;

multiplied by T. And T is the technological advancement or a measure of how resource intensive the production of effluences. So, if we are talking about say the requirement of food grains, now food grains can be manufactured in the old technique which was more or less in some sort of organic farming with some amount of menus that were put into the system or because of technological advances, we can be making more and more use of pesticides and fertilizers.

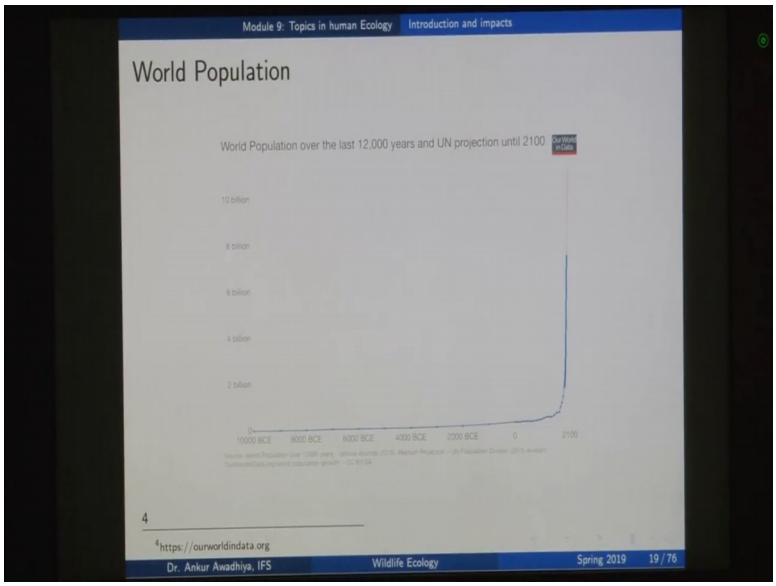
So, here T will tell us that for the same number of people for the same amount of requirements you can produce these food grains either in an organic manner or by using pesticides and fertilizers. So, the amount of technological advancement is also playing a bigger role on the quantum of human impacts on the environment.

(Refer Slide Time: 42:16)



So, this is the formula that we need to remember which is I or the impact is equal to P into A into T, where P is the population, the number of people A is the affluence, and T is the technology. Now we will look at all these three one by one.

(Refer Slide Time: 42:40)

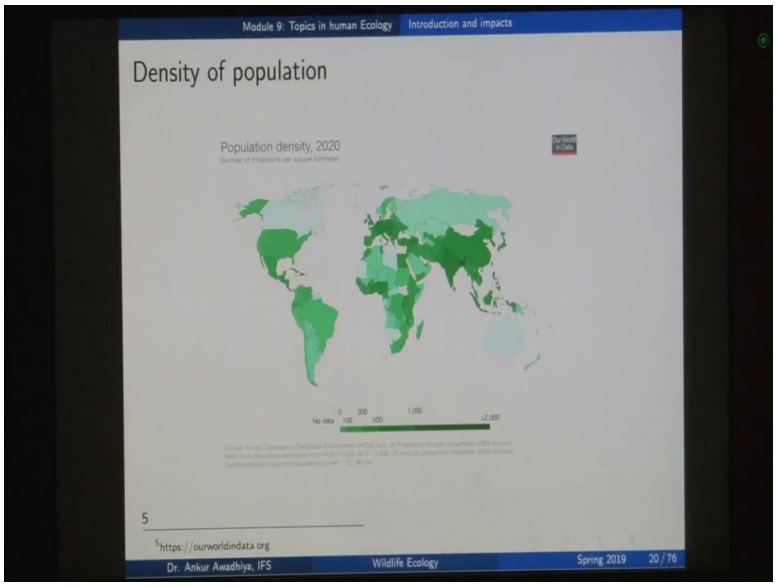


So, let us begin with the population if you look at the world population. So, here on the x axis we have the world population from 10000 BC to present and also some future predictions and here you have the on the population on the y axis. So, we can see that from 10000 BCE the right up to say around 1500 AD; there was hardly any population growth; because the number of births were being matched by the number of deaths. Or in certain instances if you had a big epidemic like bubonic plague, you could have situations where the number of deaths even exceeded the number of births.

So, both of these were in sync. Now with the industrial revolution, we started having more and more amount of resources that were available to us. Now everybody did not have to work in the field there could be some people who could devote themselves to other professions as well, you had more and more amount of medical advancements that came in. And because of that the death rate reduced drastically, but then the birth rates did not reduce as fast as the death rates reduced. Now in that case the population started moving exponentially.

Here we can see that the population till say around 1800 was less than a billion and now it is reaching close to or it is crossed close to around 7 billions. So, when we talk about this equation I is equal to P A T; the P portion is increasing with time and not only are the numbers increasing, but then we can also look at the density of population in different areas.

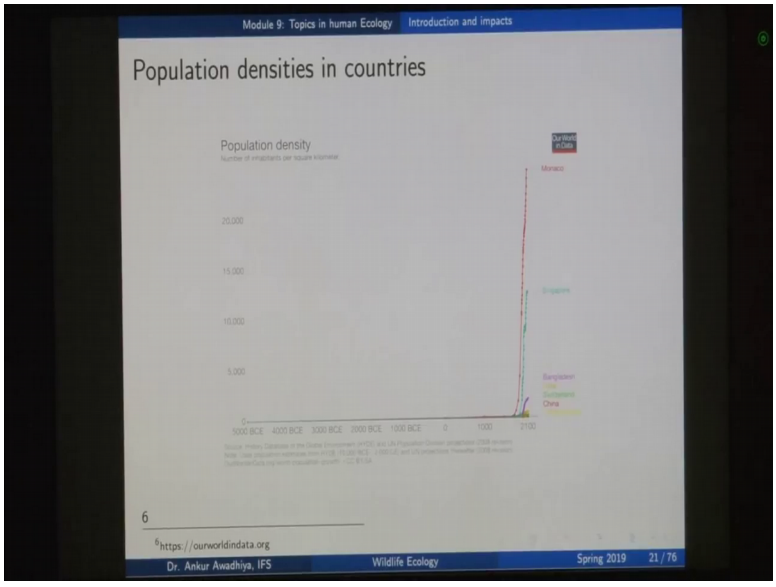
(Refer Slide Time: 44:26)



Now, if we talk about see the people of Russia, they might not be able to bring about a very huge amount of impact on their ecosystem because the density of people is less.

So, there are less number of people per unit piece of land or say people in Australia or people in Canada, but then in these areas where we have more number of people; per unit area the impact of the human beings will be much greater.

(Refer Slide Time: 44:56)

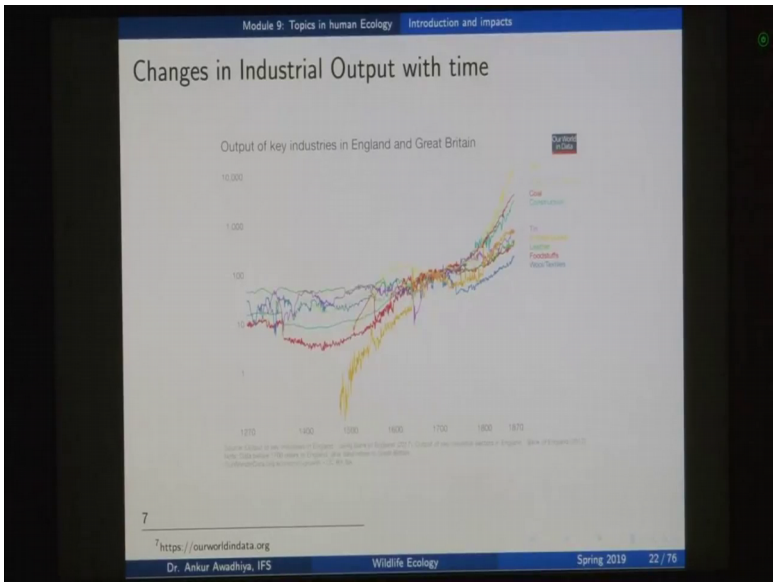


And in the case of certain countries or certain territories such as Monaco, the population is as high as more than 20000 people living per square kilometer.

And these population densities they have also risen with time so you can see an exponential increase in the number of people and in the number of people per unit area. Now let us talk about the next thing which is the affluence. Now affluence tells you how much is the amount of material that is available to you per person, or how much is the amount of purchasing power that you have? Now suppose you have purchasing power suppose you have say 1000 dollars with you, but then there is nothing in the market that is available.

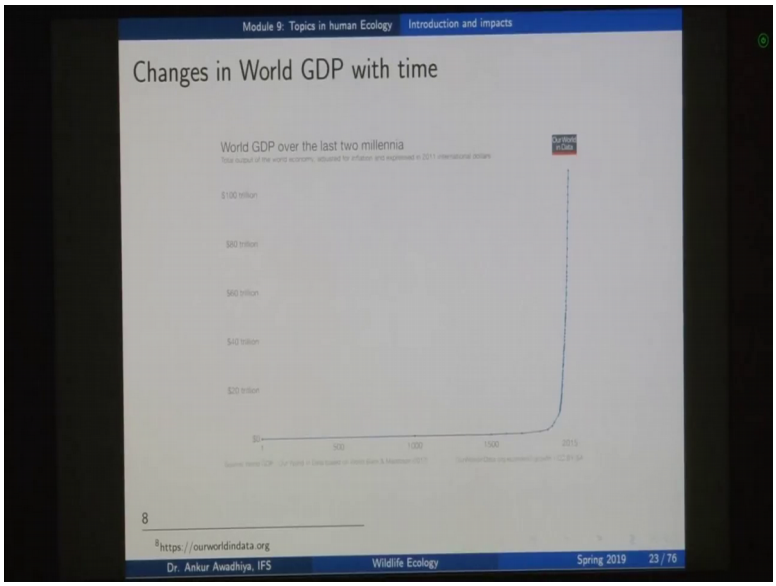
So that 1000 dollars do not make any sense. So, affluence has to be matched by the production of things.

(Refer Slide Time: 45:57)



Now, if we look at changes in the industrial output with time here on the x axis we have the time and we have started it from 1270 and it has ended in 1870 and here on the y axis we have the output of key industries. So, here we can see that right about say around 1600 which is the point where we see that the industrial revolution began, here we can see that the industrial output is it started rising. So, more and more amount of things were available for different people.

(Refer Slide Time: 46:33)



So, the affluence started increasing and if we look at the world GDP through a time we can see that the GDP has also increased with time. So, say around 1500 AD; the world GDP was not much, but now it is coming close to 100 trillion dollars of GDP.

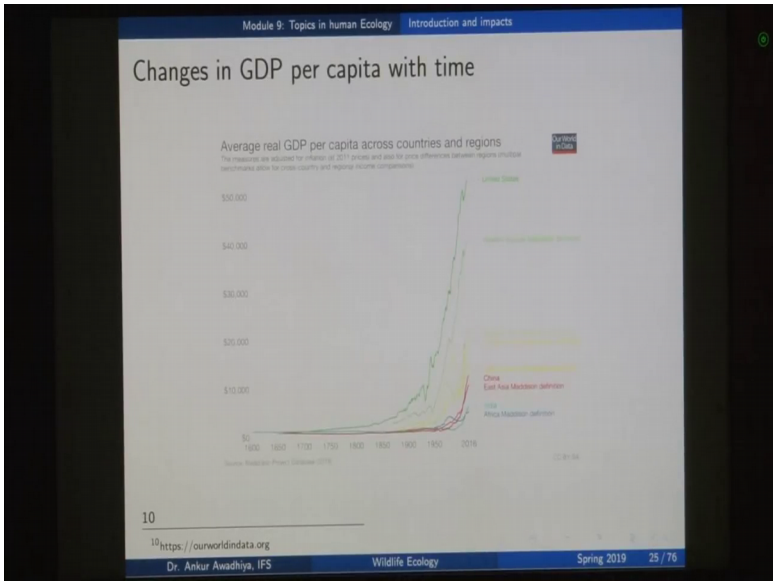
(Refer Slide Time: 47:00)

And even if you look at GDP per capita, now earlier we were looking at the density of population. Now we are talking about the GDP per capita now the people who are having more than GDP; the people who are having more amount of purchasing power, more amount of things, that they can use more access to resources they will also put up more

amount of impacts. So, in this case if we talk about the European countries or say the continent of North America or the continent of Australia.

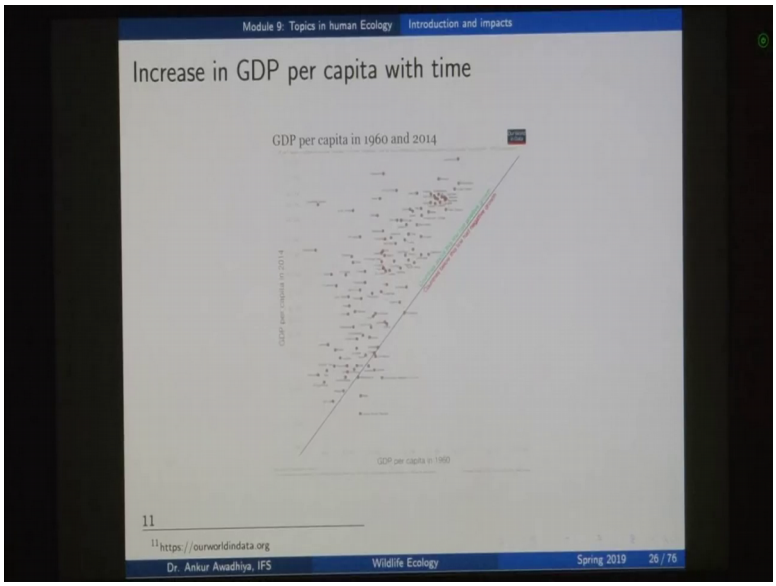
So, in these cases the amount of GDP per capita is very high or we can say that the amount of consumption per capita is very high. Now the more amount of resources that we are consuming the more is the impact on the environment that you will make.

(Refer Slide Time: 47:48)



And if you look at the changes in the GDP per capita with time, here also we can see that the GDP per capita has been increasing roughly exponentially in a number of areas. So, we can say that when we are talking about the affluence it is increasing with time.

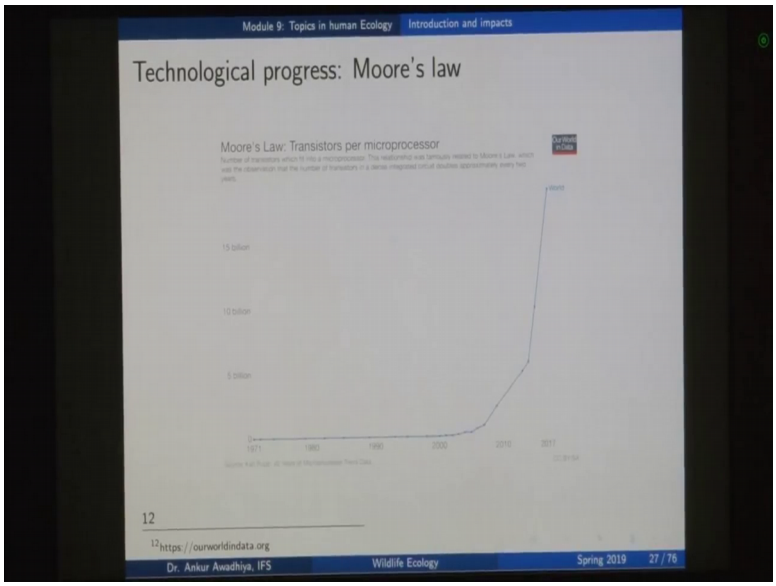
(Refer Slide Time: 48:13)



So, the population is increasing the affluence is increasing and if you look at this particular chart, here on the x axis we have GDP per capita in 1960 and here we have GDP per capita in 2014 for all these different countries. Now there are only a few countries for which the growth rate has not been enough. So, in which case the GDP per capita in 2014 is less than the GDP per capita in 1960, but for most of the countries we can say that the GDP per capita in 2014 is much greater than the GDP per capita in 1960.

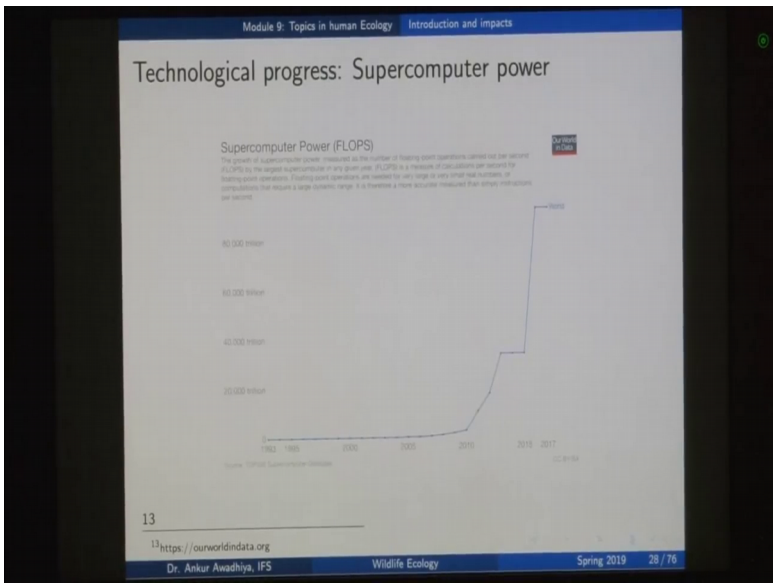
So, we can say that for a majority of countries in the world; the GDP per capita has been increasing, it is not the case for just a few of the countries. Now let us now talk about the third factor of impact which is the technology. Now what is the level of technological advances that we have been making?

(Refer Slide Time: 49:12)



So, we will look at a few case studies the first thing is the number of transistors that are there in your micro processors. Here again, you have on the x axis you have the years we have started from 1971 and here you can see that the number of transistors per capita it has been increasing exponentially; or we can say that at least in the field of computers we are having an exponential increase in the technological advance.

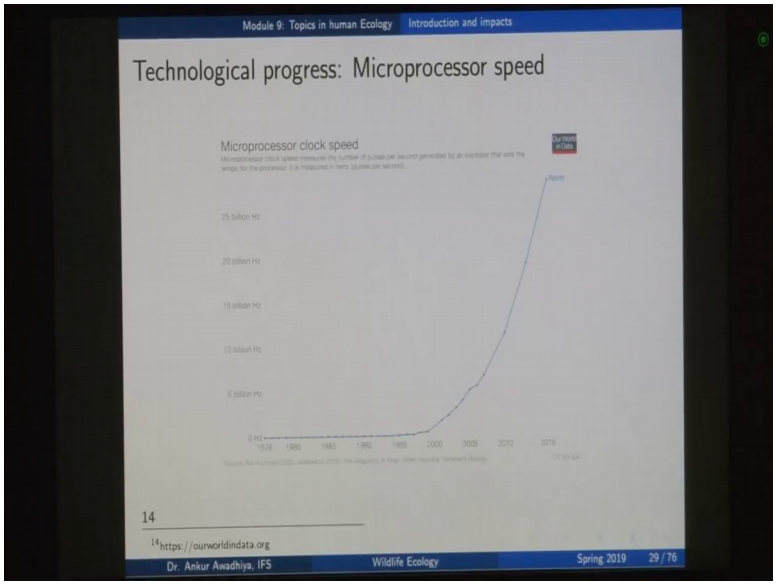
(Refer Slide Time: 49:36)



Same thing with the amount of super computing power that you have, how many number of floating point operations you can perform per seconds in the supercomputers? And

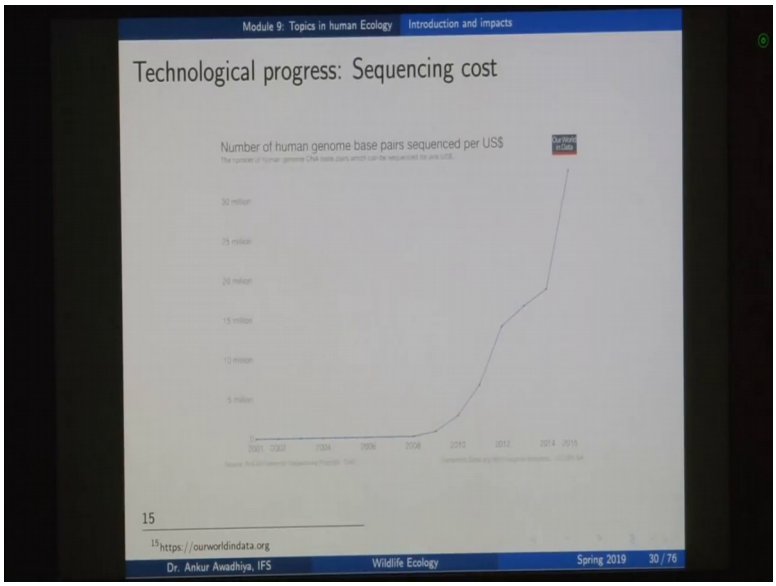
here again from 1993 to now it has now we can see that it has been increasing exponentially; or things like microprocessor speed it has been increasing exponentially.

(Refer Slide Time: 49:58)



Now, not only is this technological advancement, limited to the computing sector.

(Refer Slide Time: 50:08)



If we look at say sectors like biology, what is the cost of a sequencing a particular portion of genome? So, in this case we are asking the reverse question for 1 dollar how many number of base pairs in the genome can you sequence?

So, if you can sequence more number of base pairs per dollar it means that your technology has been increasing they are becoming more and more efficient. And here again on the x axis you have the years from 2001 till 2015 and here again you can see that the increase has been exponential.

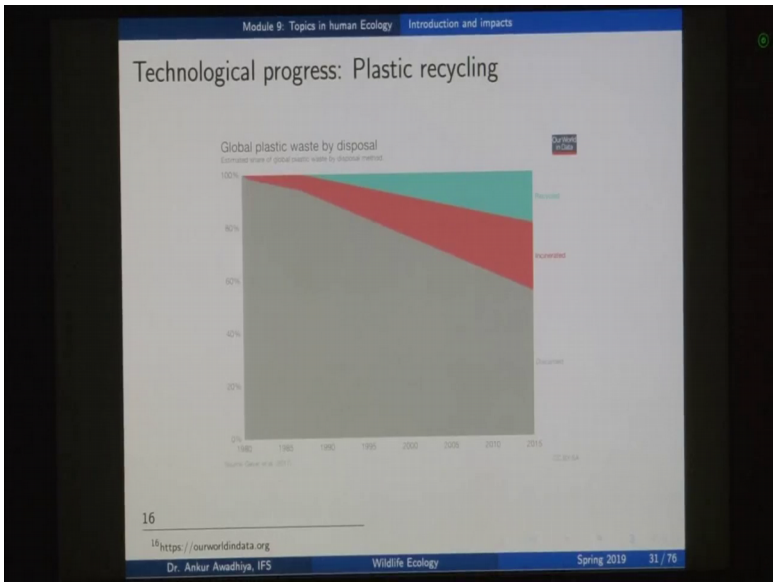
So, in all these cases the increase in technology has been more or less exponential; it has been increasing. Now if impact is population into affluence into technology population is increasing, affluence is increasing, technology is increasing what will happen to impact? The amount of impact will also increase.

So, which is why; now we can understand why the impact of human beings has been increasing with time. Now what are the ways available with us? How can we reduce our impacts? Well one thing would be to say that we should try to reduce the amount of population that we have, but then reduction of operation will take a huge amount of time. So, that is not something that we can do say in the next 2 3 5 10 years. So, this will take say100 years or say 200 years.

So, now this is not something that we can change very fast, if we talk about affluence if you try to reduce the affluence, what you will be saying is that more and more people should be converted into poor people. They should have less access to resources which is not something that we as a society can agree to. What about changes in the technology? Should we say that we should stop making any technological advances even that is not possible because we need access to more and more technologies.

So, if this is not possible this is not possible this is not possible and how are we going to reduce the impacts? Now in this case we can play with the technologies that we have; we can make use of such technologies that are able to reduce the impacts on the environment now one good case study is that of plastics.

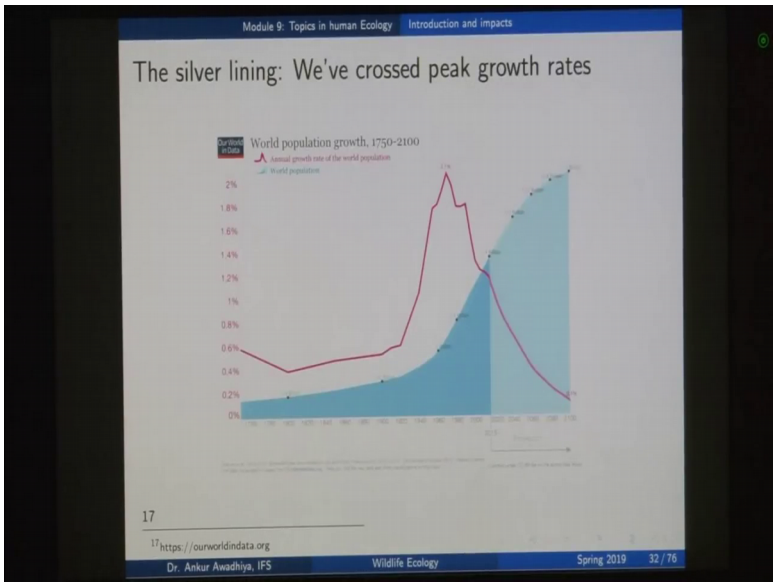
(Refer Slide Time: 52:44)



Now, here on the x axis we have the years from 1980 till 2015. And we are looking at the global plastic waste by the modes of disposal, now of the 100 percent plastics that were produced in 1980; the amount that was recycled or the moon that was incinerated to produce energy was practically 0, but then if we talk about 2015; we can say that say around 10 percent or 15 percent of the plastics is getting recycled.

So, we have developed technologies through which we can reduce the amount of plastics that needs to be thrown out into the environment. Now of course, if we look at the 100 percent in 1980 that was much less than the 100 percent that we have today, but then at least we have started moving in this direction. So, technologies can be made use of to reduce the impacts of the human beings on the environment.

(Refer Slide Time: 53:54)

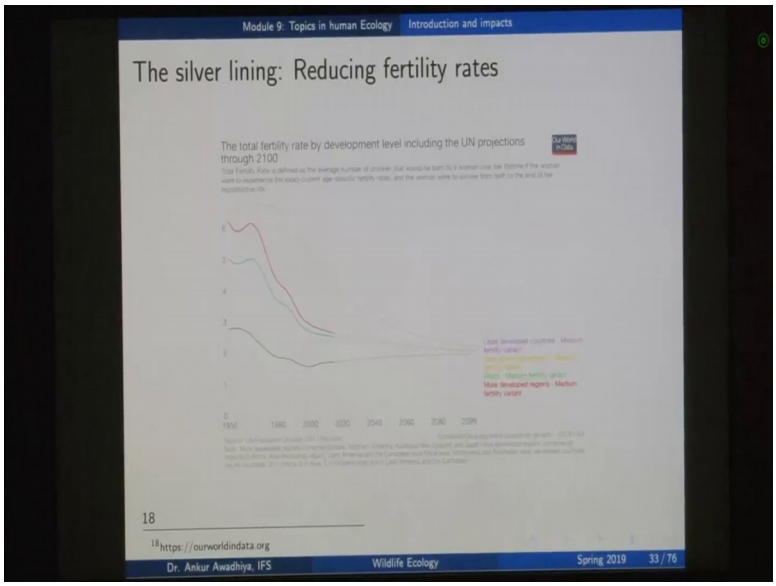


The second thing is, even in the case of populations when we are saying that there has been an exponential increase in population; if we look at the growth rate of the world population it peaked somewhere in the 1960s.

So, here you have a peak growth rate of 2.1 percent every year, but then now if we look at the growth rate of population it is close to around 1 percent or say 1.2 percent every year. So, the world population it has not started decreasing, but at least the rate of increase has reduced. And if this reduction continues then after a short while we will have case in which the world population will start behaving more and more steadily.

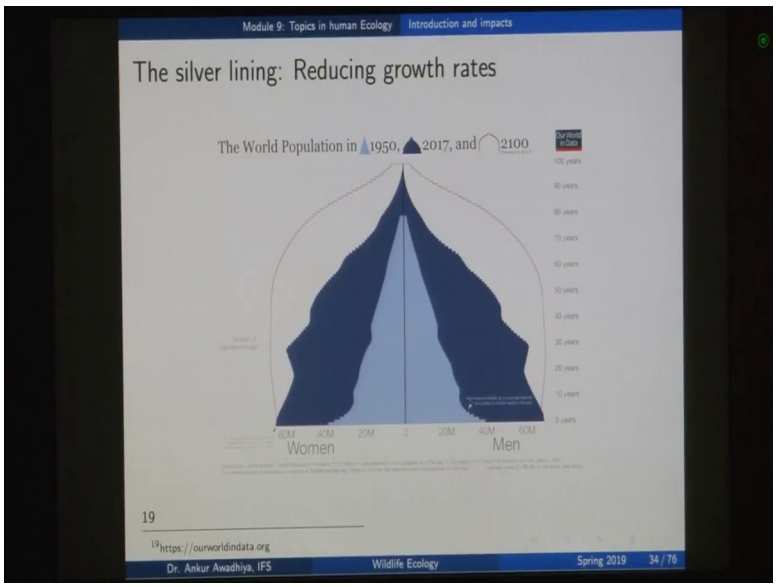
So, we will have reached some peak. So, in this case the world population has been increasing so far, but then because the growth rate has been reducing. So, now, we are seeing that it is now becoming a bit more flatter. So, that is another silver lining so even in the case of the population you can say that we can reduce it or we have already started to reduce the population or started to put brakes on our rate of increase, but then it is going to take some more time.

(Refer Slide Time: 55:14)



Next if we look at the fertility rates or the number of children that every woman had. So, in the 1950s here we see that there were a number of countries in which you had this fertility rate of as high as 6 or 7, but now if we look at the current scenarios we have only a few countries in which you have a fertility rate as high as 4 and in a number of countries it has now even come to less than 2.

(Refer Slide Time: 55:53)



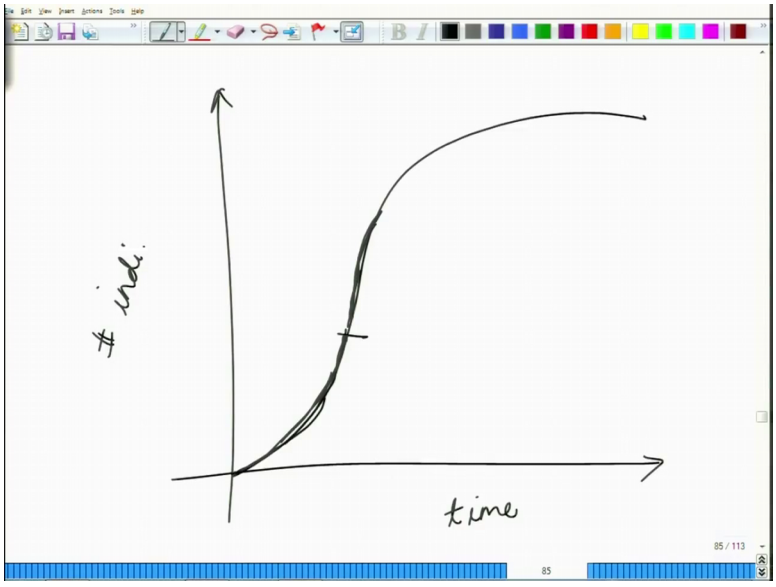
So, per couple we are having even lesser number of children or if you look at the population pyramids with time; if we see this population pyramid that was there in the

year 1950. So, in the 1950 in this population pyramid we can see that there is a large sized base, which tells us that more and more number of children were being born in this time. If you look at the current population pyramid now the amount of more children that are being introduced into the population that has reduced as compared to the adult population.

So, now we are having say, lesser number of children per adult as compared to in the 1950; and in the case of the projected growth per population pyramid in the case of the year 2100 we will be having lesser number of children, that are being born as compared to the number of adults that we have. This is also another you can observe that in this particular equation I is equal to P into A into T, we are now developing more and more technologies that will reduce the impacts that we have on the environment.

The affluence is going to increase with time because this is not something that we would want to put our brakes on, but then in the case of population is build we are now seeing signs that the population will start reducing the population growth rate has already reduced, but then in a short time will start moving towards a period of stability.

(Refer Slide Time: 57:25)



So, if you remember the case of the population growth curves here also we said that the number of individuals in a population versus time, it will show a sigmoidal pattern. Now in the case of the human population we have so far been in this area. So, there has been an exponential increase till this point which is why because this area is the rock phase.

But then, now we are entering into this area in which we are seeing that the population growth rate has started to reduce.

So, in this particular lecture we looked at the importance of looking into human ecology what are the kinds of impacts that we are making into the environment? And those impacts have now become so, huge that they are now eclipsing any other impacts by any other causes. Such as say natural changes in the radiation of the sun; that has been much more eclipsed by the climate change. Or the natural rate of extinction that has been much more eclipsed by the, but the anthropogenic extinctions that are happening in the environment.

Or natural levels of habitat change that they have been very much eclipsed by the amount of habitat changes that we are bringing into the system. So, that is making a study of human ecology more and more relevant in the case of human ecology we look at the impacts of human beings on ecology. And we also look at the applications of ecological principles on to the human beings.

So, in this current anthropocene era so, when we say anthropocene it means, that this is a geological time scale, this is an epoch in which the human beings are having a relatively very huge impact on the geology on the ecology on the biosphere and so on. And we look at these topics in more detail in the next lecture so that is all for today.

Thank you for your attention [FL].