Sustainable Materials and Green Buildings
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Lecture 1 - Introduction and Planet Equivalent

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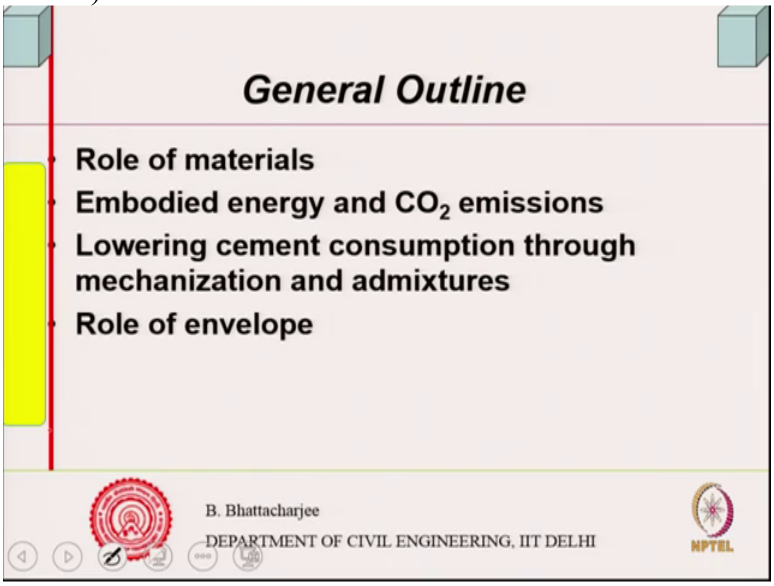

Good Morning. So we start with lecture one, and generally, the outline of this particular lecture, first we will talk about role of materials, followed by something called embodied energy, carbon dioxide emissions and lowering of cement consumption, et cetera. So we will see that later on.

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So, basically if you look at it, global population is increasing, right. And therefore consumption is also increasing very fast. So if you look at world resource institute in, this is of course when I say 15 years this is not now, because the data is a little bit old, 2010 may be, right, so 15 years say 1995 to 2010 production wastes have been increasing in spite of increasing the efficiencies.

So this is happening and there is something called the living planet report, so we consuming around 20 percent of the resources than earth can produce. I will explain this actually. This was, 20 percent was much earlier, now it must have gone up far more higher.

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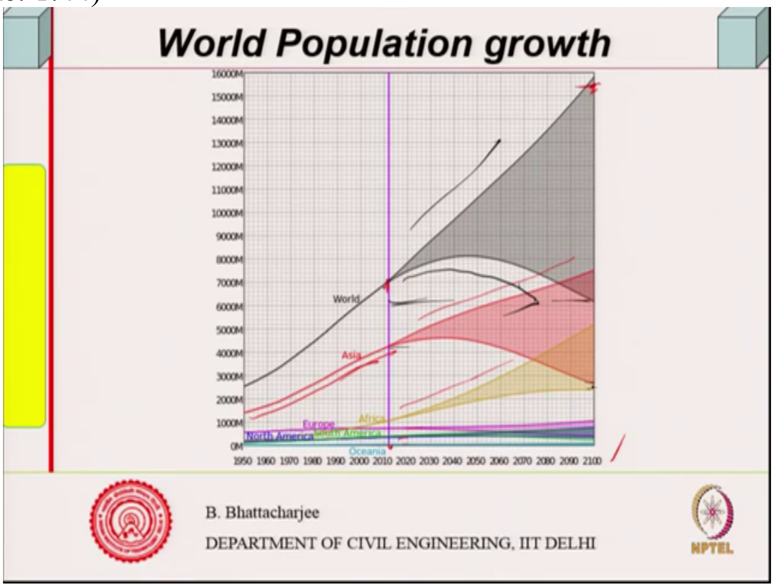

So, if you see world population growth, this is of course the projected world population growth. So world population at 2010 was somewhere there let us say 7,000 million and increasing in this manner 2100 it will go somewhere, you know, this is the rate. Obviously, your consumption of world resources increases together with this. Out of this if you see Asia, rate is very high and this is what is projected if you continue to grow in the same manner.

Africa, also very high; Latin America, North America, Europe, Oceania, practically is all stabilized. So, this is the scenario, if population is growing in the current, you know, in the current rate, right. But if it is controlled somewhat then it can come down, come down to the level of, some level of 2010 or something of that kind, particularly with respect to Asia and Africa. So these are the continents where population is growing at a very fast rate, right. And therefore human being for their sustenance needs resources, energy, food, water, everything, right. And earth of course has got a limit to produce. It cannot produce infinitely. It has got a limit, we will look into that.

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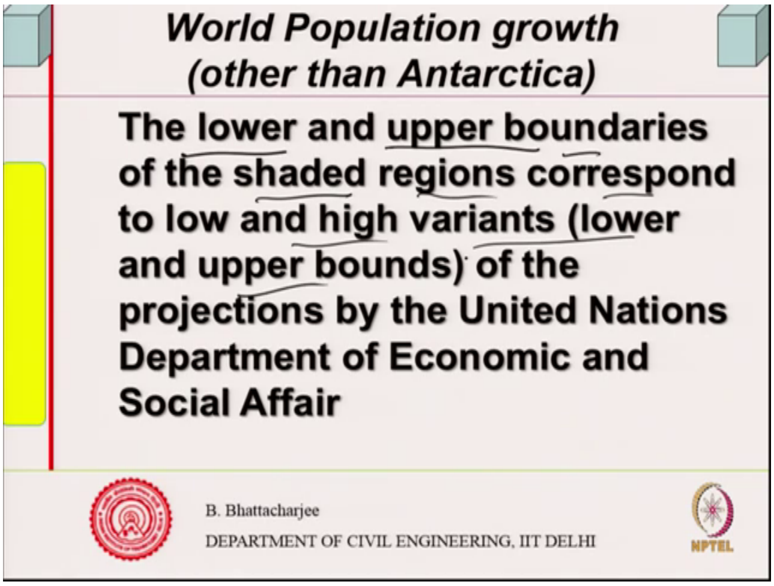

In fact, if you see the population growth, I have another diagram when I will come to it; it was practically not increasing at any very great rate till possibly about 17th century or so. But, with the advent of modern science coming in, the medicine coming in, child birth rate has reduced, I mean, child mortality rate has reduced, you know, death at birth and things like that were reduced. So population started increasing actually exponentially.

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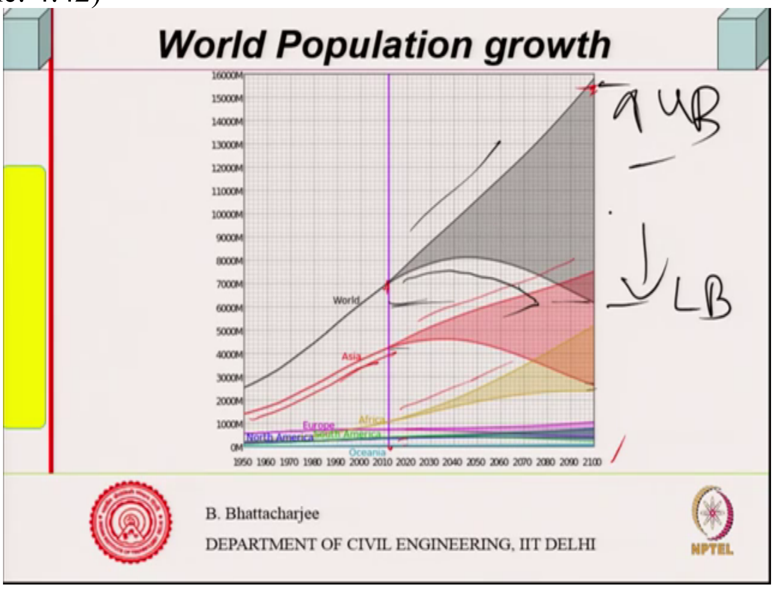

So, now in the previous diagram lower and the upper boundaries of the shaded regions corresponds to low and high variants, lower and upper bounds, as I showed. The extremities, you know, the previous diagram if you look at it, there are the upper bounds and lower bounds. So depending upon how you control the population this is the bounds, lower bounds, this is the upper bound. So somewhere in between, we are likely to be in any case.

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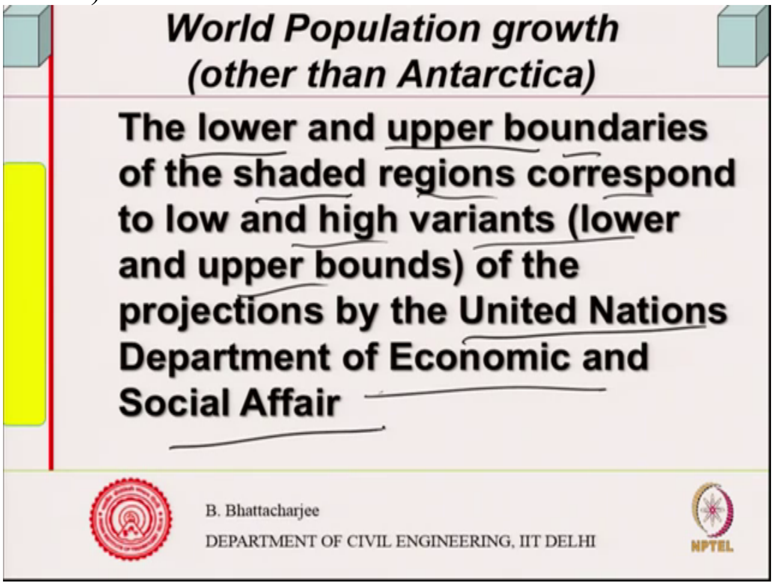

So, that is what it is. You know, this is the projection by United Nations Department of Economic and Social Affair.

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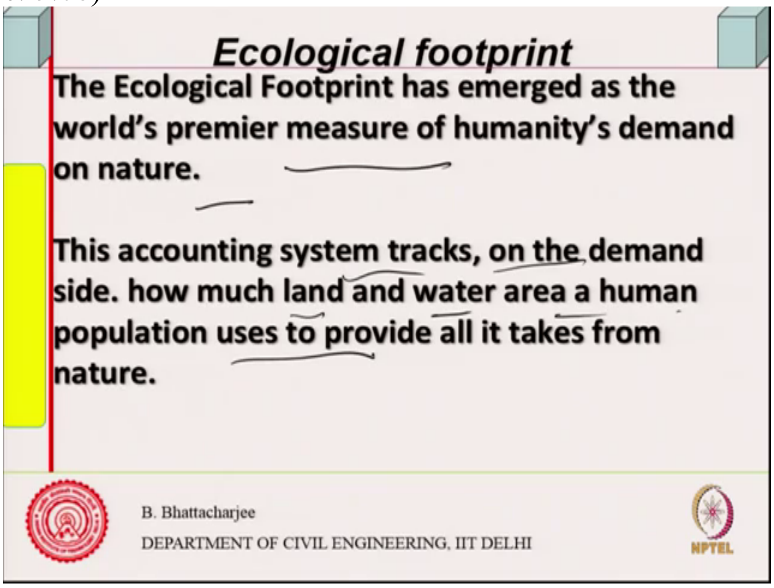

Okay. Ecological footprint is another terminology we use, so this is one issue, we will come to the, you know like something more related to this population growth and sustainability and things like that. Ecological footprint is a measure, you know, it is a measure of humanity's demand on nature, how much you are demanding on nature. Population is increasing, how much you are demanding on nature?

So the accounting system tracks on the demand side, how much land, water, area, human population uses to provide all it takes from nature, right. So that is ecological, that is how we define ecological footprint. So, that is basically, it is a measure of humanity's demand on nature and this accounting system, so ecological footprint may be even for a process or something of that kind. So, it is basically demand on the nature and this is essentially an accounting system, try to calculate out how much, right. You know, how much on the demand side, how much land, water, and everything put together you use from the nature?

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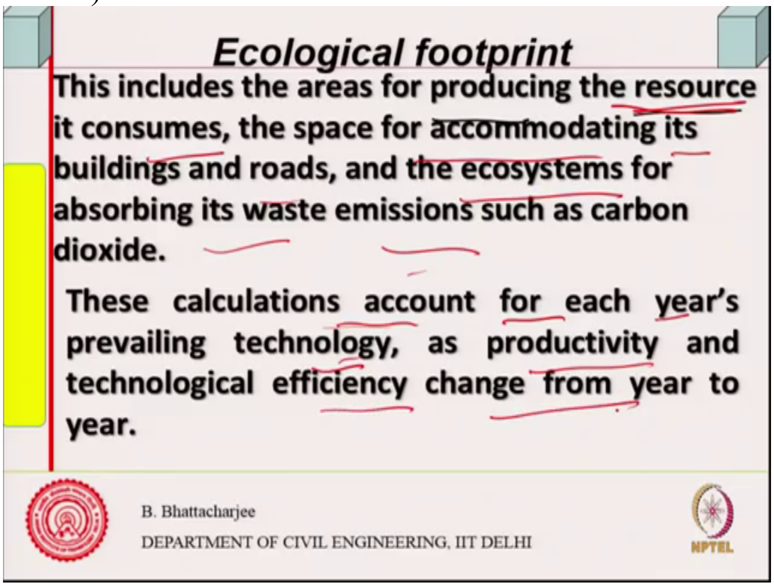

So, this therefore includes areas of producing resources, you know areas of producing resources that is consumed, the space for accommodating, the buildings, roads, the ecosystem for absorbing the waste emission such as carbon dioxide is one of them, there are other waste, so this is it. So, this calculation account for each year's prevailing technology because technology changing, is changing. So whatever we have been using, you know controlling earlier waste, whatever we are possibly making waste, we might reuse some of them with a newer technologies. So it has to, it is a dynamic thing. This is a dynamic thing and will change with time.

So the calculations of each year's prevailing technology, so currently prevailing technology according to that this accounting is done, as productivity and technological efficiency change from year to year, so that is what it is. So that is the idea. Since it changes from year to year, therefore ecological footprint calculated is calculated on yearly basis because your technology changes every year.

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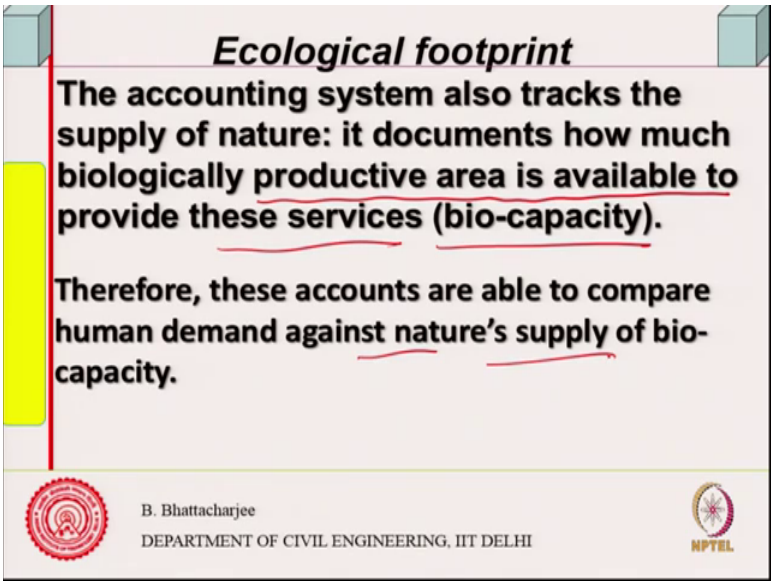

Well, it tracks also supply of nature. For example, how much biologically productive area is available to provide the services? For example, food. Whole of the land cannot provide, is not biologically productive to give us food, therefore there is a bio-capacity. So, these accounts are able to compare human demand against nature's supply of bio-capacity. So, ecological footprint is in this context we define something like this.

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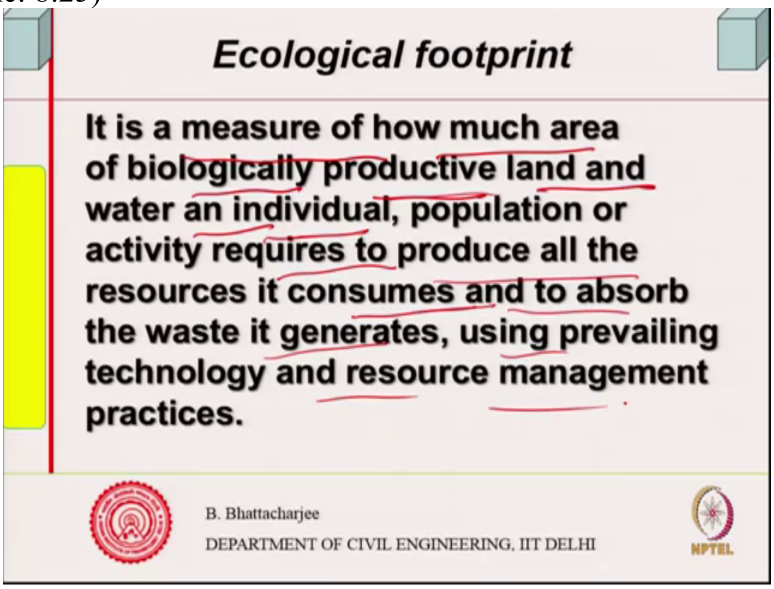

So therefore formal definition will be 'it is a measure of how much area of biologically productive land and water an individual or population or activity', so you can say ecological footprint of cement production, that is an activity. Ecological footprint of India as a country or maybe Delhi as a state or city, so one can look into that. So to produce all the resources it consumes and to absorb the waste it generates, so therefore also, so this is the how much area of biologically productive land and water an individual or process or certain area, population consumes and the absorb, you know basically measure how much of the waste generated is absorbed, right, so using prevailing technology and resource management practices.

And this is changing quite a bit if you see. For example, if you go to, let me give you an example like I was just mentioning some time earlier that possibly in a sport now started using crumb rubber for property enhancement as well as using some waste material. Similarly, in rigid pavement system you no longer use the Ordinary Portland Cement alone. In concrete pavement it is almost a regulation practice to use lesser flyers or similar sort of thing to control heat of hydration and so on. So you can use some of the waste, right. So resource management and handling the waste, both are accounted, taken care of in this ecological footprint.

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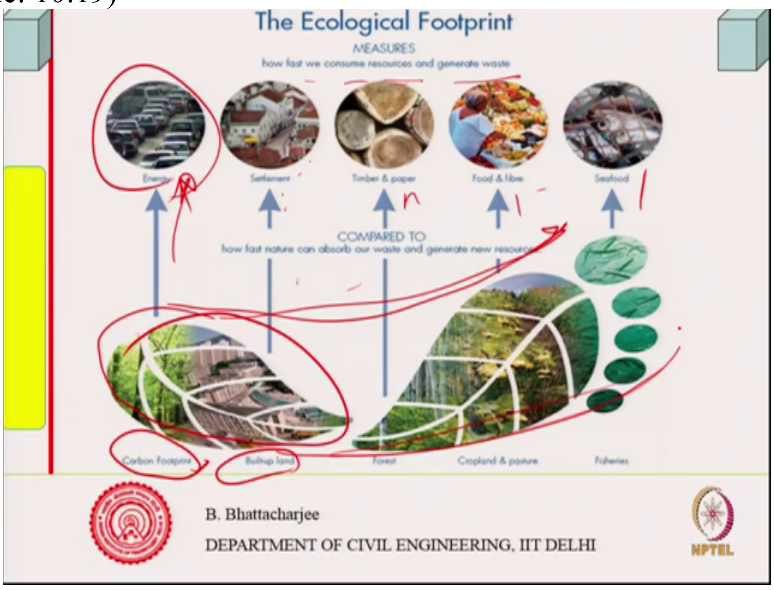

So if you see ecological footprint well, you know it measures how fast consume resources and generate waste. It is a measure, high ecological footprint would mean that you are consuming lot of resources and possibly generating lot of wastage, so accordingly that. So basically there is something called carbon footprint as well, right. And so basically you can see, so energy is used up in transportation, vehicular transportation, as you can see, also in you know like this might, this essentially might be coming from the fossil fuel, which is nothing but the deposits of the plants and animal remains which gets converted into, some of them gets converted into fossil fuel. Then food build up that occurs, so we also do build the food, so from that it goes and then therefore timber we use, so food and sea food, everything, so this already has got a footprint.

So all this has got a ecological footprint, ecological footprint you know the transportation that you are using, then all kind of industry or building sector or anything of that kind, the timber you use, the food that you produce, seafood that you produce all has got a ecological footprint or a part of it is carbon footprint as well. So carbon footprint is related to carbon, right. So ecological footprint is related to all this, alright.

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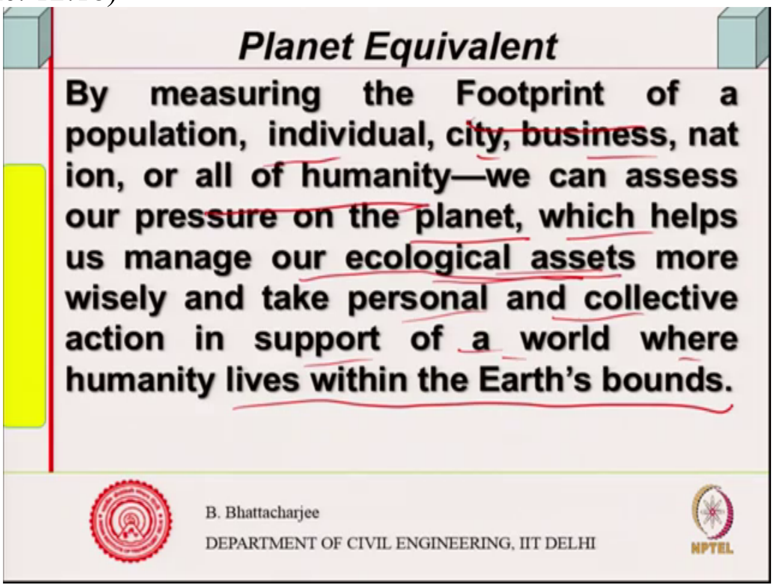

So, we can then measure something called a planet equivalent. So what we have looked so far? We said that world population is growing. Then we said to take care of, to understand how much of natural resources human being is using we can have an accounting system, in which we can calculate out the ecological footprint which will take care of the resources that you are using and the waste you are generating, waste you are generating, right. And that is what it is. So our overall activities like transportation, building system, food, everything has got a link to the ecological footprint, right.

Now something called, we define something called planet equivalent, planet equivalent, now you see, the amount of resources the earth can generate is fixed. Because, two things are fixed. Once its surface area is fixed and also the energy it receives, it mainly receives the energy from the sun. So sun gives us energy and it is a periodic thing. Whatever you get every year, most of it is dissipated out also, right. By and large, although, you know, the concepts of global warming is coming, which we will look into later on, so it actually receives and dissipates it out. That means, that budget is fixed.

Whatever you are receiving is fixed. Every year it is fixed, unless you have an artificial science, artificial sun, hydrogen energy is come by, create an artificial sun somewhere, from water you convert deuterium into helium and all that fusion process, till that time, but that will be still very small compared to the energy that you get from the sun.

So every year's energy budget is fixed, area is fixed. Therefore, what planet can give in a year is fixed, right. What planet can give in a year, if we assume that all the energy that you are getting from the sun, you efficiently trap it, but you cannot trap everything. It is not possible thermodynamically because there will be, you know in any process you will have some, you cannot have 100 percent efficiencies. So whatever energy you are getting and the land, both are fixed.

So therefore, you can talk in terms of what is called planet equivalent. Now, what is planet equivalent? By measuring the footprint of a population, individual, city, business, et cetera, nation, or all of humanity, everybody, all humanity, we can assess the pressure on the planet. Because economic footprint means you are consuming and generating waste, right. So whatever you are consuming, that has to come from the mother earth. Now this consumption will be in need of energy, energy and obviously the land area as well.

So, how much a planet can generate in a year, that you can actually compute out. I mean it is a large accounting, but one can do that. So, you can measure, this of course helps in managing the ecological assets and more wisely taking personal and collective action, support a world where humanity lives within the earth's bounds. So we should be actually consuming that much what earth can produce in a year. Otherwise, we are actually, we are kind of withdrawing from the resources already it has generated over the years.

For example, the fuel that you get, fossil fuel you get, it is generated from millions of years, so you are actually withdrawing from there. The reserve that has been created over the years, you are withdrawing from there. And if you go on doing that, you might finish all of them and nothing will be left for the future generations at some point of time. So, that is it, so earth's bound. The planet equivalent is related to that. Okay, we will come to that.

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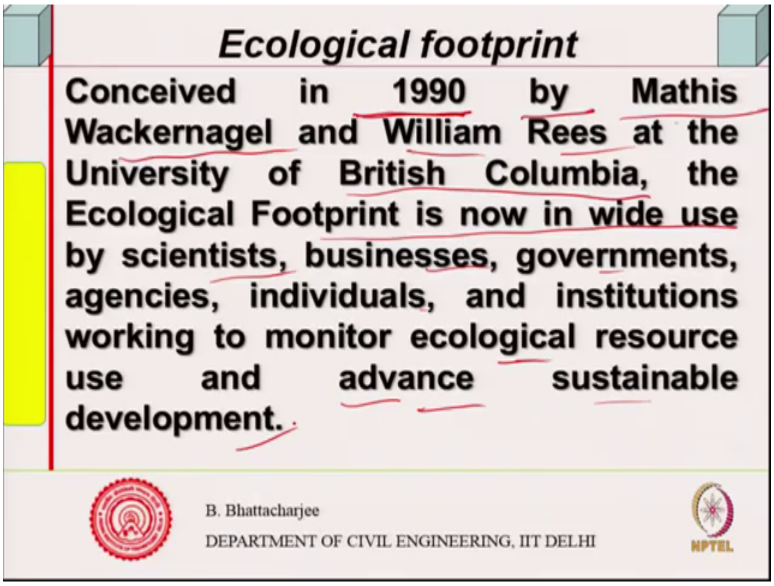

So, ecological, you know this is basically from based on ecological footprint and it was conceived in 1990 by Mathis Wackernagel and William Rees at the University of British Columbia, Canada. The ecological footprint is now worldwide used by scientists, businesses, governments, etcetera, etcetera, individual and institutions. Monitoring ecological, monitor ecological resources use an advance sustainable development. So this ecological footprint is used to advance the sustainable development or monitor the sustainable development, right.

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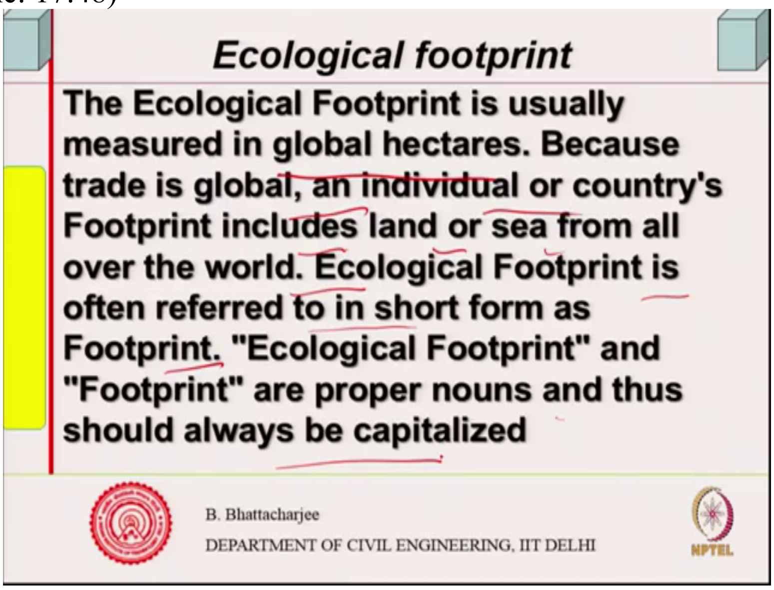

So it is unit is global hectares. Unit is global hectares, right. Global hectares, it is a measure of area, right. It is a measure of area. Because global, again for the whole world, because trade is global, individual or country's footprint includes land, sea from all over the world. Ecological footprint is often referred in short term as footprint. Quite often, people just say it as footprint and thus should you know, usually people use them, capitalize. So basically its unit is global hectares, global hectares, right. So global hectares, per person per capita you can think of.

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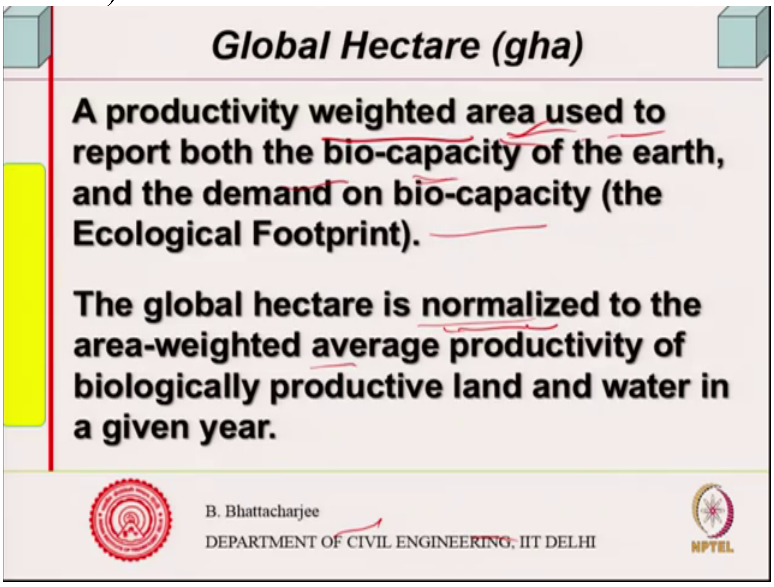

So this is basically a productivity weight, weighted actually area used to report both the bio-capacity of the earth and the demand on the bio-capacity. So global hectare is normalized to the area-weighted average productivity of biologically productive land and water in a given year. In the sense that, you see some land can produce lot more agricultural goods compared to another. So at desert land where you do not have irrigation really, its productivity is different than the one which is on the river basin, fertile areas and so on or irrigated areas.

So therefore there has to be some kind of weightage, right. Weightage has to be given. So one meter square is not, or one kilometer square or hectare is not same, so it has to be multiplied by that kind of weighted. So these are the weighted area, right, to look at the bio-capacity of earth. That means agricultural production, or if it is mining, then how much is the mining, so all extraction or any other kind of thing. So this is then you know area-weighted average productivity of biologically productive land, then that you can do like multiply by the area, divide by total area, you will get a normalized one. So that is what it is. Done?

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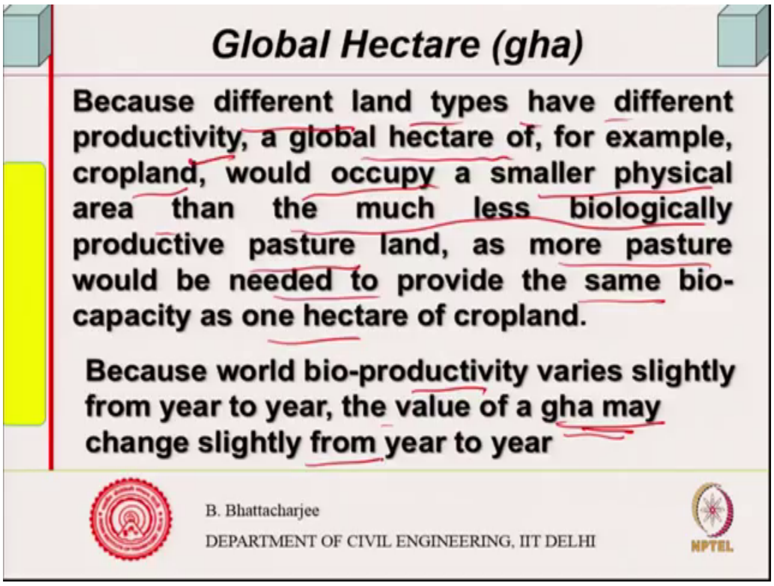

So as I was saying, because different land types have different productivity, so a global hectare of, for example, cropland, would occupy a smaller physical area than the much less biologically productive pasture land whose productivity is less, as more pasture would be needed to provide the same biological-capacity as one hectare of the cropland. Because world bio-productivity varies slightly from year to year, just digressing a little bit. I think it is beginning of the twentieth century a lot of people were thinking, because population started growing. So lot of people started thinking, can the society be stable as it is expanding now?

Malthus was one of them, whose idea is that you know the population increases in geometrical progression, right. So it is in GP series. Agricultural production was increasing in arithmetic series. Therefore this is not sustainable, you know in those days. But later on, technology changed. Productivity of the land increased. The agricultural science came forward, and therefore this theory never remain valid actually. This prediction or projection was not, I mean it did not serve any purpose because things started changing.

So therefore, technology can bring in certain changes, and therefore this may weighted, the weighting, weights that you are going to use, for the same area for agricultural production, might change depending upon what it is. So it is basically year to year changes and it is slightly from year to year because technological changes do occur.

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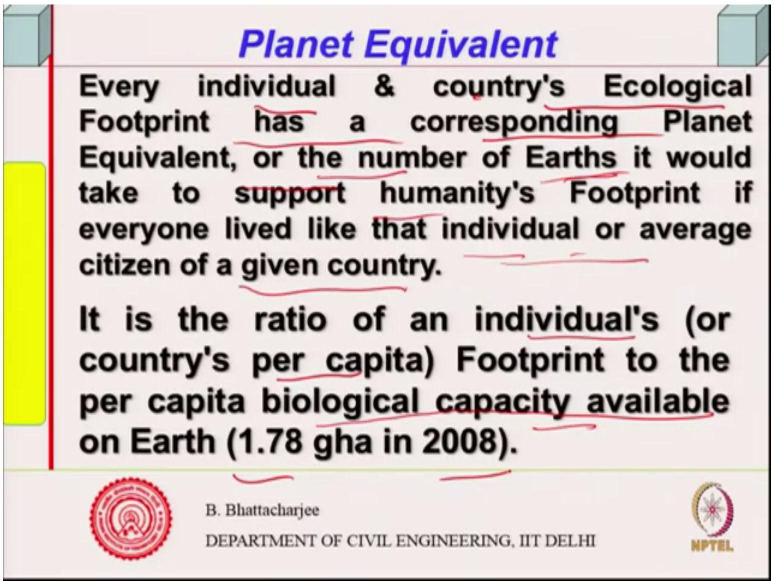

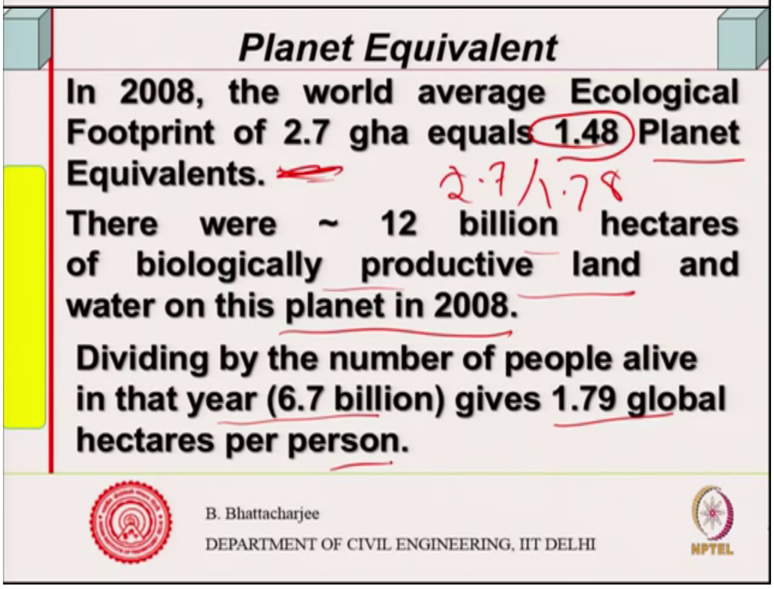

So followed from this is planet equivalent, which I just mentioned. For every individual or country's ecological footprint it has got a planet equivalent or the number of earths. Supposing I find out for a particular population the ecological footprint per person per capita for a given year, multiplied by the world population per person I found out world population, that will give you the planet equivalent of that particular area. But in overall planet equivalent to the whole world one can find out.

So that means, that many number of earths would be required if consumption rate is same as the population I have considered. So, if you look at total earth's population, you can find out a planet equivalent, because as I said, the total budget, area is fixed, energy is fixed and in the total global hectare, that is actually required that we can find out. So if everyone live like an individual or average citizen of a given country, first you calculate out for the whole country per capita, that is for the, then it becomes average for that country and everybody in the world lives for in a similar manner, then for the whole nation you can find out or the whole world.

So planet equivalent you can find out. So it is the ratio of individual's or country's per capita footprint to the per capita biological capacity available on the earth. So for the whole globe, it was 1.78 global hectare in 2008, right. So that means, currently the rate at which the kind of lifestyle they have, if they continue to have that kind of lifestyle, the total global hectare that would be required one can find out. So, basically you can make it as a kind of ratio footprint per capita to the biological capacity available. Capacity available for the same, right, because earth's capacity is known and what we require? Because we are consuming in terms of food, shelter, and things like that, transportation.

So therefore what is available to us, whatever we are spending we know and what is available to us is known. If I take that ratio, that gives me the planet equivalent. That gives me the planet equivalent. Right? Ratio. And planet equivalent means whole earth taken together, taking whole earth together. So it was for the whole earth the current rate of consumption, current rate of, current style of living let us say. In 2008, divide by the bio-capacity of the earth, it was 1.7 you know, it was 1.78 the capacity available and the world average ecological footprint was 2.7 global.

So consumption rate was 2.7 global hectare, because we can consumptions, we can calculate out how much area for the food production, how much area you need for to produce that kind of food, and all other resources. So it was 2.7 and 1.78 was the bio-capacity of the earth. Because 1.78 was the global hectare was the bio-capacity of the earth. So both can be measured in ecological footprint, the capacity and your consumption. Because consumption means the how much fossil fuel you are using, how much food you need, and correspondingly how much equivalent land area you need to produce the same with weightage.

For example, mining will have different weightage than agricultural and so on. So one can calculate out in this manner. So the ratio would be the 2.7 was what the consumption rate and available capacity was 1.78. So if you divide 2.7 by 1.78 or whatever it is, you get something like this. So that means, on that particular year by doing a total accounting, we would need 1.48 planet equivalent. Or in other words, we need 1.48 earth, right.

So there were 12 billion hectares of biologically productive land and water on this planet in 2008, right with all weightages multiplied. Dividing the number of people alive in that year, 6.7 billion gives 1.79 hectares per person. You know this is an accounting system. Take account of everything and that is what, that is what it is, right.

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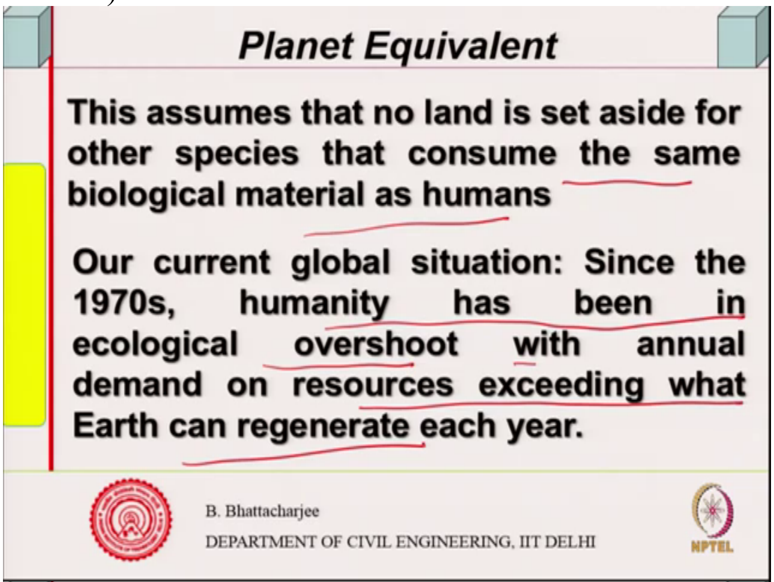

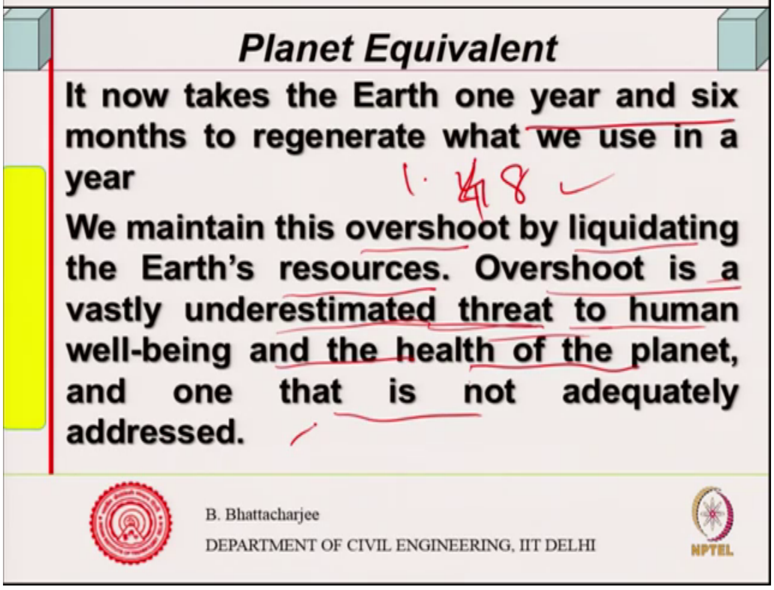

Okay. This assumes that no land is set aside for other species like other animals and things like that, that consume the same biological material as human. So that means you have used everything out and other species are simply are not there. Since 1970s, humanity has been overshooting with annual demand of resources exceeding what earth can generate each year. So, till 1970 it was balancing, and this you know, so now it takes earth one year and six months because 1.48. So 1.48, we have seen something of this order. So therefore you need one year and six months to regenerate what to use in a year because your land is fixed and you handle all your resources.

The energy required to produce, that is also fixed, the budget is fixed. So it is an interaction between land and energy all together and you need 1.48 earths. So we maintain this overshoot by liquidating the earth's resources, so reserved resources actually we are taking out, like fossil fuel which is a reserve resources. Also let us say, mainly this will be, this will be the one which we would be taking out from the reserve. Also the materials, some of the other materials that you are consuming. For example if you are producing, let us say, you are producing motor car, then you are obviously using steel as one of the major material.

Or if you are using the plastics, that means your again the petroleum products, so crude that you use, so therefore you are actually withdrawing from whatever is available to you. So overshooting therefore, overshoot is vastly underestimated, you know, overshoot is a vastly underestimated threat to human wellbeing so therefore, we do not you know this consciousness is needed. So that is what is being health of the planet, and one that is not adequately or currently it was not addressed, but people started becoming conscious. But it is not necessarily 100 percent, you know socio-politically 100 percent consciousness has come, as we can see gradually.

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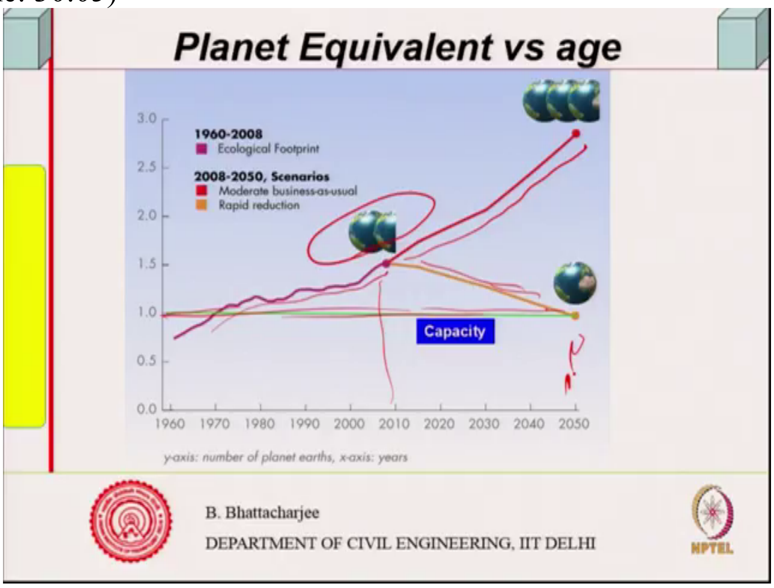

So that is what it is. This is the planet equivalent versus age diagram as we can give, as we can see. So, one planet is this is the capacity. All the land, all the waters, surfaces that you have, if you calculate out its capacity, bio-capacity as I was talking about, ecological, in terms of ecological footprint, all lands are not useful, so the weightages has to be given. And all the water, I mean that is also may not be useful for your production processes. So that weightage has to be given also. So, if you do that, then that gives you the capacity.

Also the energy that you get every year from the sun, from the sun because both are needed. Now energy right now you are taking from fossil fuel, supposing I am able to use efficiently, most of the energy from the sun, what is the possibility? So that would give you the bio-capacity of the earth. That is one earth. So that will be ideal that you do not extract anything from the mother earth, right. Use the sun's energy fully for all your purpose which is impossible anyway.

So that way bio-capacity, but how much you are using now, you can count, because how much fuel you are using, fossil fuel you are using, corresponding energy would be there. How much food you are using, right. So all this, it showed a trend in this manner in 2010. That means you needed one and a half, that is what I said, that 1.48 ratio of global hectare used up, 2.7 divided by bio-capacity and 7.48 and it would if it follows the same rate, it would require three earths by 2050.

So you know your planet equivalent can go to three times. Nearly three. But if we can control this, then we can even bring it back to one planet equivalent, if efficiently we use the system, then we can bring it to one planet. So that is the idea. So I think we will just break here.