Introduction to Environmental Economics
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Lecture – 14
Ecological Footprint-I

So, hello everyone today we will be discussing Ecological Footprint as an indicator of sustainability. As you understand that in the continuation of our sustainability model we have already discussed what is involuntary performance index. So, that there we discussed about that how this involuntary performance index is an indicator for measuring the sustainability.

So, along with that that we also discussed that how the second index that is the ecological footprint can also be used as a sustainability indicator or sustainability index. So, let us discuss in the context of sustainability what is ecological footprint, the very concept definition and how this ecological footprint as a concept it got origin.

And whether this is a static concept or it is developing or it has some evolutions itself. And after that we will be talking about what are the indicators of the ecological footprint. And lastly we will be calculating or how to calculate the ecological footprint itself.

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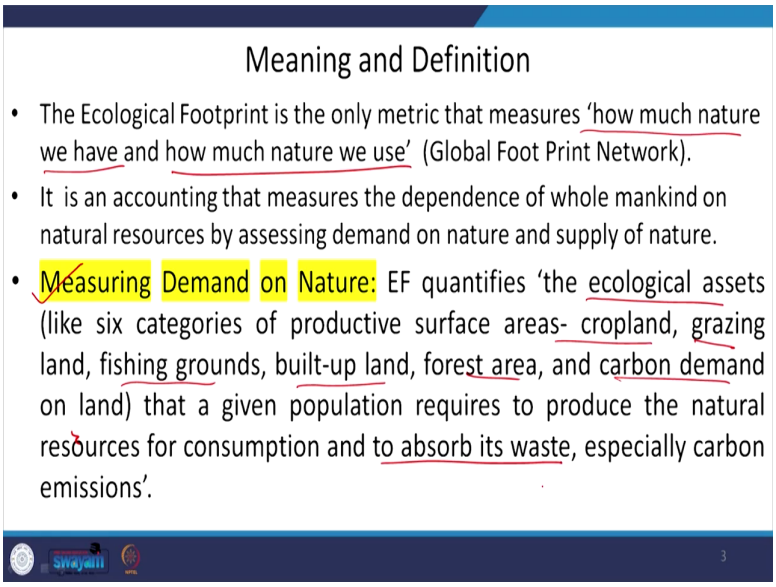

So, let us begin with the concept itself by taking some meaning the meaning of the very concept as well as the definition. So, what is the meaning of ecological footprint? So, as you understand we do have all of us we are having footprint right. So, what is your footprint? The area that you are taking the area that you are requiring for your own sustainability right.

And, so far the ecological footprint is concerned we are also measuring the same directions right. And in a in nutshell you can say where it is also a metric form or you can say it is a metric that measures two things. So, these two things takes into account both the supply and the demand factors so far the ecology is concerned.

So, by taking to account this demand and supply factors, in the ecology we are saying that this ecological footprint may be defined that how much nature do we have? And how much nature

we use. So, when you are saying that how much nature do you have, so when we are talking about the supply side factor that is how much nature do we have?

So, it means it actually signifies the very dependence of the human beings or the whole mankind on the natural resources. So, that is why we are depending on it or we are actually talking about how the nature or what is the quantity of nature that we are using. And the second one is the supply side factor that talks about how much nature do we have? So, it is again you start that what is the a productivity or bio capacity of the environment as well as the ecology is for sustaining the demand sides for catering to the needs of the demand factors.

So, this is how in a nutshell we can say that this ecological footprint can be measured by taking to account the demand for the goods and services from the nature yourself by taking to account or the all the summation all the demand of the human being. So, so as we need we are also measuring the supply side factor by taking to account what is the bio capacity of productive ability or productivity of the very ecosystems on which the human beings are depending.

So, in this case you are saying if you are measuring the demand side of the nature we are quantifying the ecological assets. And what are this ecological assets we are to quantify? We are categorizing into six different ecological assets. So, they are the crop lands, grazing lands, fishing grounds, built up lands, forest area, and the carbon demand on land.

So, these are the six categories of the ecologies or ecological assets we have taken into account. And we are demanding our very demands in terms of goods and services from this; from these categories of ecological assets. So, when you are saying that we are measuring the demand on nature we are taking to account all these categories. And we are finding how we are putting demands from all these categories of ecological assets or ecosystems you can say.

So, and again in the in measuring the demand on the nature we are also taking into account the absorption of waste, that how; the how because of our economic activities how the pollutions

or the externalities basically the negative externalities or unwanted output is being adsorbed in the nature itself.

So, that is we are we can say we are talking about the absorption quality or absorption capacity of the nature to assimilate the waste. And especially it is in terms of the carbon emissions. And on the supply side as well as we understand that we are talking about the bio capacity of a particular area or particular geography a geographical location. Let us say we are talking about a particular state, a region, or nation, or some international boundary (Refer Time: 05:56) taken into account the continents. So, this kind of bio capacity of these regions represents the very productivity of the ecological assets.

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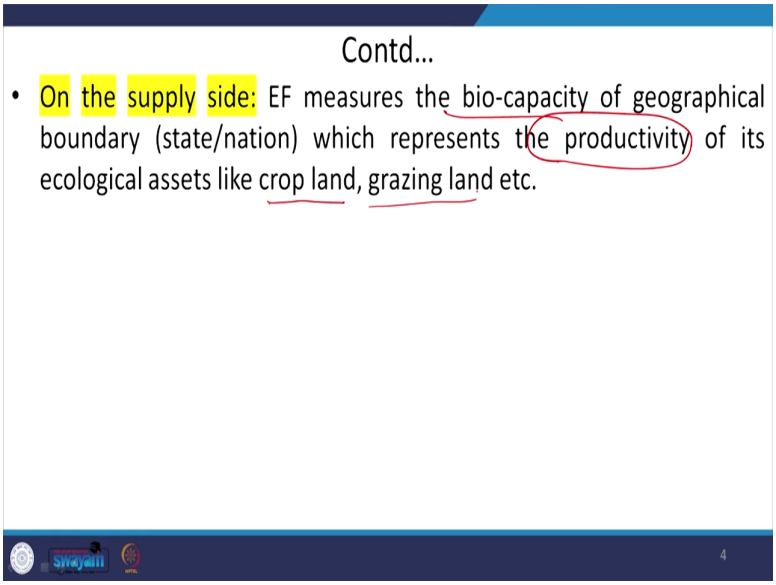

So, what are those ecological assets? That we have already talked about, these are six categories of ecological assets. So, we are talking about what is the productivity of cropland

or what is the productivity of forest land or what is the productivity of grazing land and likewise.

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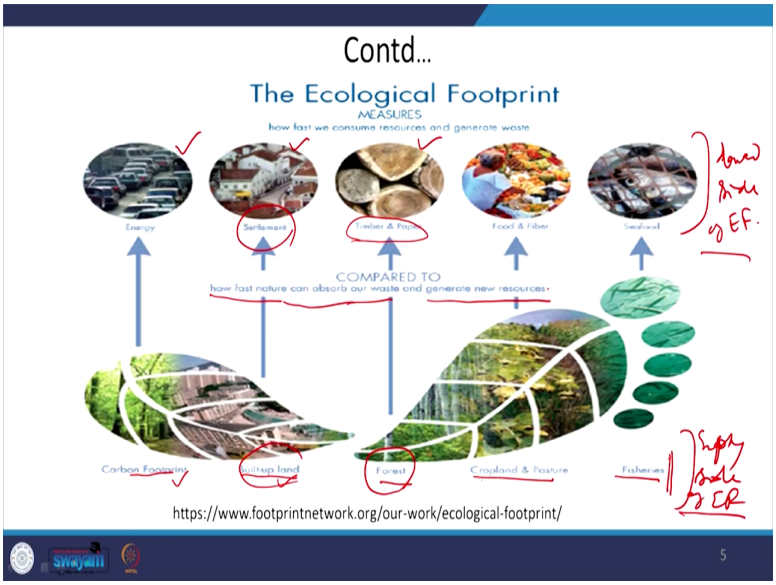

So, how do you understand this ecological footprint? Because, we are talking about both the demand side and supply side. And we have taken into account these categories of parameters like your built up areas, your forest lands, your carbon, carbon land, cropland, and the pastures, your fisheries right.

So, these actually gives us the picture of different categories of ecological assets and how we are depending, how the human beings they are depending on these ecological assets. So, let us say we are talking about the built up land. So, means we are we are depending on this built up land in terms of different kinds of infrastructural settlement, in terms of settlement itself.

And when we are talking about the forest how the human beings they are depending on the forests forest ecosystem or forest ecological assets we are here. So, the demand we are placing on forests in terms of the timber paper products. And the other products that we are getting from the very forests ecological systems, and likewise the other so on.

So, really in one hand in the in this side, so it depicts its depicts the supply side of ecological footprint and here as you are measuring the very demand of humankind. So, it is depicting the demand side of ecological footprint. So, in any sense you can say when we are comparing the demand side factor with supply side factor, what we are doing we are doing? We are actually analyzing or comparing. How fast nature can absorb our waste and regenerate new resources by taking to account this demand and supply factors. So, now after having a brief knowledge brief idea about this ecological footprint let us understand what is the very origin and the development of the same concept.

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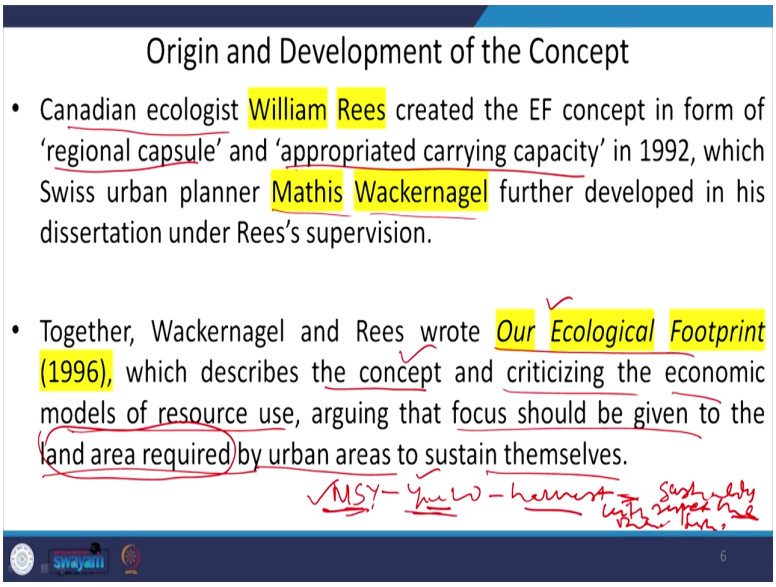

So, when you are saying that this is this ecological footprint it is an index for sustainability. So, first of all this fellow this Canadian ecologist William Reese he created the concept and although he understood what is the meaning of this ecological footprint. He has not actually used this concept by this name ecological footprint rather by some other terminologies.

So, here he used for the first time in order to understand this ecological footprint, he used this concept regional capsule and appropriated carrying capacities. So, these are the two terms that this fellow William Rees, he used these concept in order to understand this ecological footprint. How about while working with and the his PhD student that is Mathis Wackernagel.

So, for the first time he they talked about this concept that is ecological footprint. And he wrote this ecological footprint or he coined this ecological footprint in his in their book that is Our Ecological Footprint it was published in 1996.

So, this book in a nutshell you can say it describes the very concept. And this concept was developed because to criticize the economic model of resource use the kind of harvest, the kind of yield. Arguing that the focus should be given to the land area required by the urban areas to sustain themselves. So, earlier what happened in economic models of resource use we are talking about maximum sustainable yield or yield and harvest.

And by using this terminologies we found that what is the sustainability with respect to; with respect to that particular resource. Let us say fishery or forestry, so how much the fishery or how much forestry can be extracted, but still it will be sustainable. So, we need to think about this maximum sustainable yield and harvest a yield by using this three concept, we understood what is the economic models for resource use.

But, these two fellows in this in the in his in their book they first of all criticized this economic models of a harvesting for sustainability. What is the point? The point is that you need to think about the land area required to required by this areas to sustain themselves. So, what is the amount of land area that is required for maintaining all this lifestyle, or maintaining all this all these demands that the human beings are having.

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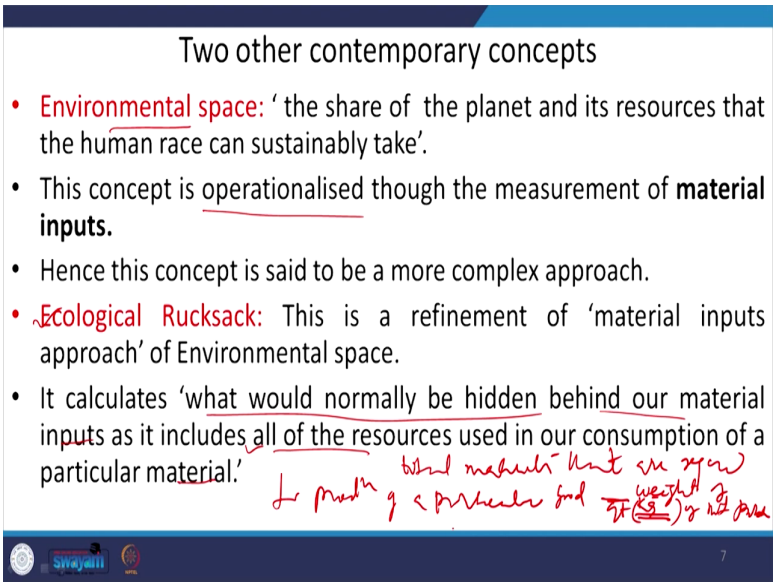

I am simultaneously in this similar almost contemporary time to other concept they were developed in order to understand the similar meaning, so far the resource use is concerned. And the sustainability in order to understand the sustainability concept. The first concept is the environmental space, and the second one is environmental rucksack. So, sometimes it is also said ecological rucksack.

So, what is environmental space itself? So, here this environmental space is defined as the share of the planet and the planets resources that the human beings they can sustainably use sustainably take. And still the same resources and the same share of the planet can be left behind for the future generation. So, that is what the sustainable sustainably use or sustainable take a concept is used here. And again how to operationalise this concept of environmental

space because it is expressed in terms of the share of the planet and the share of the resources of the planet that the human being and they are using.

So, this concept is again operationalised through the measurement of material inputs. So, what exactly; what exactly the amount of materials and material inputs they are used in constructing or in building a particular product for making a product particular product. So, in that way they are defining this environmental space. And hence because we are talking about so many immaterial inputs for the production of so many goods and services. Then it will be giving a kind of very complex approach in defining this environmental space.

Because, say if you are talking about any kind of manufacturing products. And in any kind of manufacturing products we are actually using like n number of manufacturing products. Then how do you actually a measure this material inputs that for x that is let us say pencil for production of this pencil, what is the material inputs we are using or it has been already used for the productions.

So, because of this and this problem because we do have many demands for in terms of goods and services, and when these measurements is in terms of material inputs. Here is the very concept of environmental space is a complex affair. So, that is why it actually could not be, so much popular, so for understanding the sustainability in concept. And the second one is the ecological rucksack and again this environmental sorry the ecological rucksack is a refinement of these material, inputs, approach.

Because as you understand that we just talked about it is a complex affair to express every goods and services demanded or produced in terms of material inputs. So, that is why some refinement was necessary at that point of time. So, it led to the conception or kind of this ecological rucksack. So, what exactly is the ecological rucksacks, or how you are using or how you are measuring these ecological rucksacks?

So, to define it what would normally be hidden behind our material inputs as it includes all of the resources used in our consumption of a particular material. So, what is the meaning of this

all this the sentence and that defines the ecological rucksacks. It means the, what is the total amount of materials that is used for the production of a particular good?

So, total materials that we are requiring that are required for production of a particular good. So, that means, this amount of material is being removed from the planet minus what is the weight or quantity in terms of some units let us say kg in terms of kilograms of that particular product.

So, in this way you can find out what is the ecological rucksack; that means, what is the total materials that is that are being removed from the planet? Because in order to produce this product minus what is actual amount of or what is the actual weight age weight of that product after its final set final manufacturing process.

So, the difference is nothing but your ecological rucksack, so it means that again it is somehow related to the material inputs. Then let us say for production of exports we are extracting we are remove removing in terms of materials that is 10 kgs of xyz materials minus and when the production is in its final stage it is in a final product stage. So, what is the weight of that particular good? So, by finding this differences we can define what is the ecological rucksack.

So, what is where if; obviously, the product will be less than the materials used? And when you are saying this is the less amount of the in terms of words then it signifies that where these amount of loss or what exactly the amount and loss amount where it is it has gone. So, in order to show this because, if you believe in ecological processes we are saying that matter and energy they are in a cycle.

So, if you are extracting some kind of materials for the production processes the same must be recovered from here right. And if it is not so, then there is a problem somewhere it must be in terms of os or in terms of the externality. So, in order to understand this concept ecological rucksack were was developed. But, again this could not be, so popular concept in that point at that point of time because of again complexities involved in this concept and in understanding.

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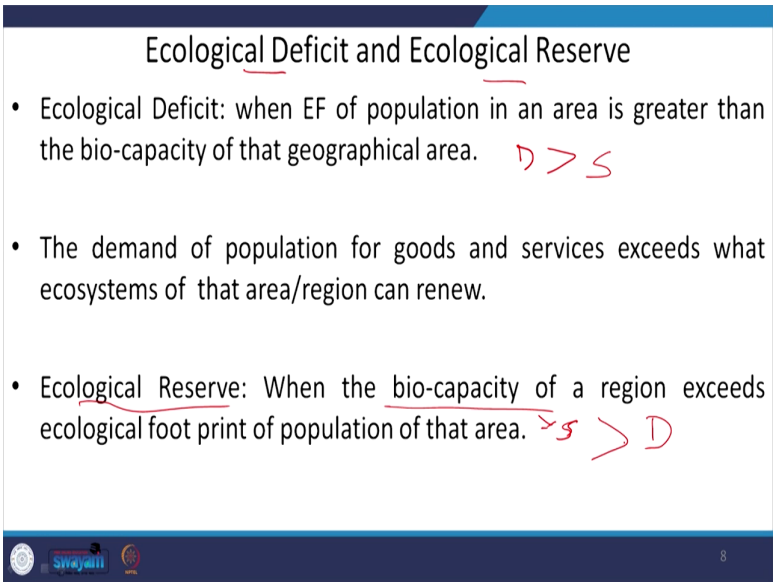

And as a result ecological footprint sent to me a dominating concept in understanding the sustainability and sustainable development concept. So, in understanding this ecological footprint another two forms or sub categories of ecological footprints you can say. Or other concepts that needs to be understood in order to understand the ecological footprint they are the ecological deficit and ecological reserve.

So, what is the ecological deficit? As you understand that we are in ecological footprint we are talking about both the demand side and supply side factors, so supply minus demand. So, if the supply is greater than the demand then; obviously, will be in a positive surplus side or reserved side. And if this the demand is demand on the systems or on the ecological assets it is exceeding the supply or the bio capacity of that the ecological system then; obviously, we will be having the problem of deficit or scarcity.

So, by understanding this demand and supply concept this ecological deficit is defined when ecological footprint of population in a particular region it is greater than the bio capacity of that particular region. Then we are facing the problem of ecological deficit or that particular situation is known as the ecological deficit.

So, here simply you can say here the demand on the ecological system or ecological assets are greater than the supply. And, so far this ecological reserve is concerned, here it is defined as the bio capacity of a region or area, it is exiting the ecological footprint of the particular population of that area.

Then, it means that here the bio capacity is representing your supply side factor or the supply in terms of your ecological systems in terms of crop lands in terms of your of forest lands. So, this supply of ecological assets is greater than the demand from the human things in terms of different goods and services on the system itself.

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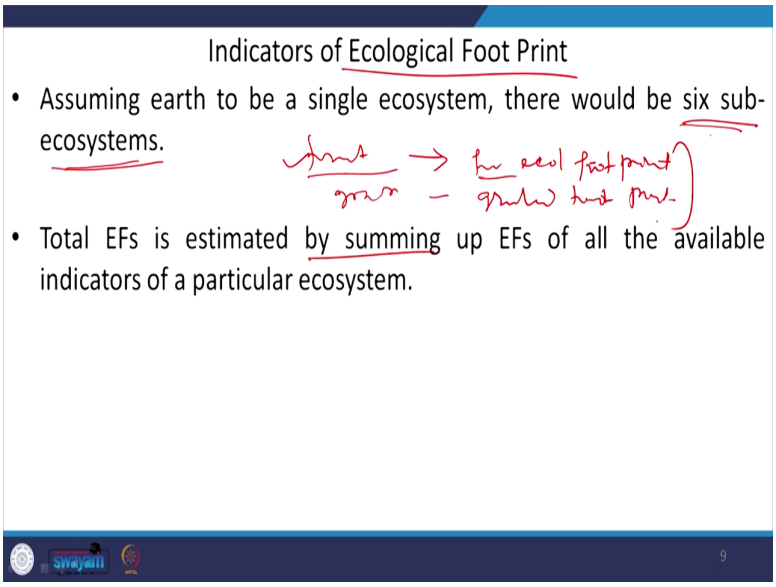

And together they stood two concepts it gives the idea of ecological budget that whether it is giving from this ecological footprint. We can get to know what is the budget ecological budget in terms of whether we are in deficit, or we are in surplus and as you understand that this ecological footprint is concerned about the population in a particular region, particular nation, or a particular area, then by this it will be easily find out. It will it will be easily found out whether the particular nation or state or a particular city is having the ecological deficit or ecological surplus. So, far this demand; so far this demand and supply concept of ecologists are concerned.

So, after discussing these now, let us understand how do you find or what are the indicators that must be taken into account in order in order to find in order to calculate the ecological footprint concept? So, from the very beginning we talked about the six categories, or six

subsystem, or six sub-ecosystems to define to understand the very ecological footprint. So, what are these; what are these six sub systems?

So, this is what we represented in terms of this graphical figure and there we explained that how this different six subsystems they are giving a picture of this ecological footprint. And while talking about because we are talking about six sub categories of ecosystems then; obviously, when we are talking about let us say the a forest land. So, it will be giving for forest land it will be giving us the metric of forest ecological footprint or forest footprint right.

So, likewise when we are talking about the grassland, so it will be giving us and we are measuring the footprint it will be called as the grass grassland footprint. And so for the ecological footprint is concerned we will be taken off the summation of all these footprints because we do have six different categories of sub ecosystems.

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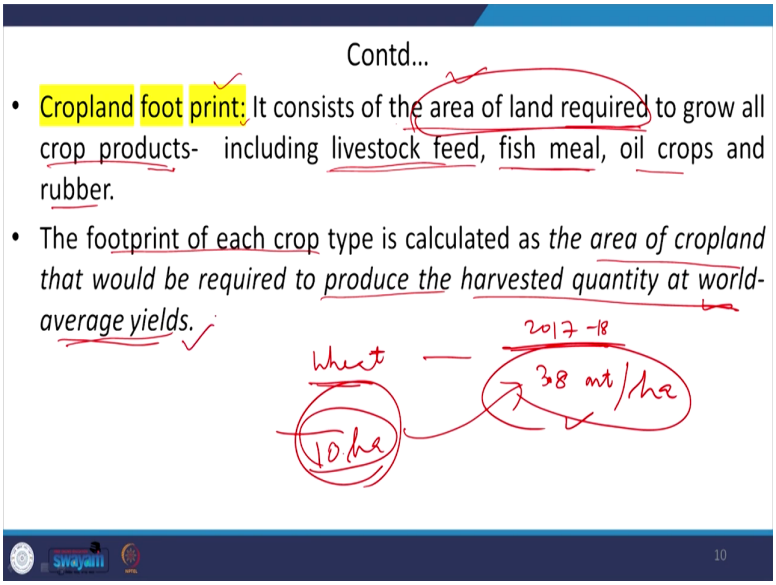

So, when let us talk about this first sub ecosystem that is the crop land footprint. So, how we are measuring, or what are the components that needs should be taken into account, or how this what is the meaning of this cropland footprint.

So, the cropland footprint we can get this crop cropland footprint. If we are taking into account the required land, or the area of the land which are required through all to grow all types of crop products that we are requiring. So, it also includes the livestock feed, fish meal, oil crops and the rubber. It is not only that the crops that we are requiring for our own consumptions in terms of food, but also food to our life stocks to the different occupations like maintaining the fishery occupations, or oil crops, or rubbers.

So, in cropland footprint we are taken into account the area of land that we are requiring for maintaining all these to grow crop products as well as the crop products for maintaining our life stocks. Our some different types of live hood concepts like fishery. And as you understand here we are saying that this crop land footprint is expressed in terms of the land required for all these crops to grow.

So, the footprint of each type of crop is calculated as the area of crop land that would be required to produce the harvested quantity at world-average yields. So, what is the meaning of this? That how we are saying because, how you we are going to find this crop land footprint. Because, we are having n number of crops then in that case how for preparing the footprint for each of the crop it will be tedious job again, and again how to sum it up?

So, that we can say that it is the integrate integrated form or the wholesome form of the cropland foot footprint. So, for that reason we need to calculate the area of the cropland in that particular crop, or cropland that would be required to produce the harvested quantity at world average yields. So, that means let us say we are talking about that what would be the a cropland footprint of a particular crop let us say wheat.

So, in order to find out the cropland footprint of wheat we need to take into account the harvested quantity at world-average yield. So, what is the harvested quantity of wheat at

world's average yields? Let us say we are talking about 2017-18. So, as per 2017-18 data so the average world average yield of a wheat is 3.8 metric ton obviously per hectare.

So, that means for finding out the footprint crop footprint especially for the wheat footprint we need to find out that what is the area of the cropland that would be required for producing the average world average yield of this particular wheat. So, if say that we are requiring 10 hectares of land for producing 3.8 million ton; of million ton wheat.

Then, we are saying that this is the footprint 10 hectares is the footprint for this wheat crop, and likewise for other crops we need to find out the requirement of the particular land area for producing this particular crop. And this particular crop will be always measured in terms of the average world average yields.

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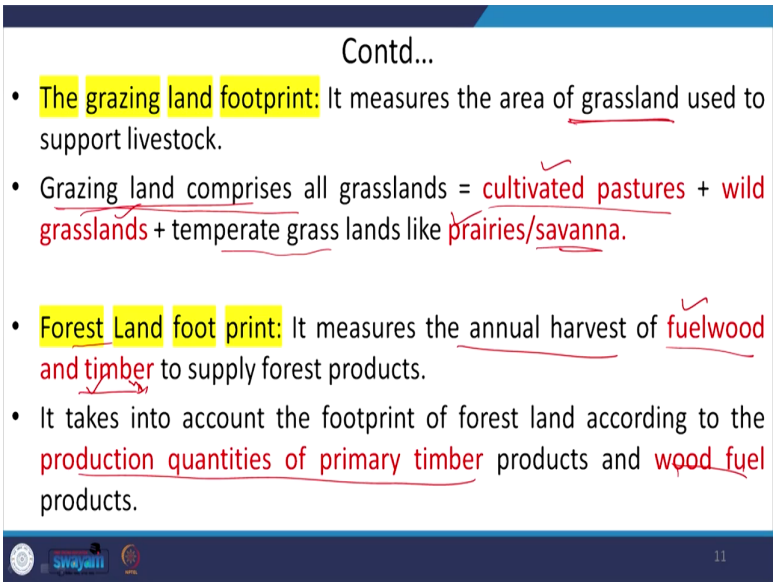

And the second sub ecosystem or subsystem is the grazing land footprint. So, how to measure this grazing land footprint? So, as you understand that when you are saying grazing land footprint it measures the grassland. But, apart from this grassland the grazing land also comprised of the cultivated pastures wild and grasslands along with the temperate grass.

So, the for example, the term in under this temperate grass we can take the case of savanna and all these grassland systems they must be taken together. So, along with the cropland because you understand that from the cropland also some portion of the crops are being used as a fooder; as a fooder.

So, along with this one we need to take into account this grazing land concept which is comprised of all these three in order to measure the grazing land footprint. So, the third one is the forest land footprint, how to measure it? Or what are these the items that must be taken into account?

So, for this for forest land footprint we need to take into account the annual harvest of fuel wood as well as the timber. So, both these things both this these two things that is fuel wood and timber they are representing the supply side of the products forest products.

So, in finding out this forest land footprint we need to take into account the production quantities of primary timber. Because, this is the timber here we are taking as well as the food wood fuel that we are extracting from the forest system itself. So, that is what is taken into account for finding the poor the forest land footprint.

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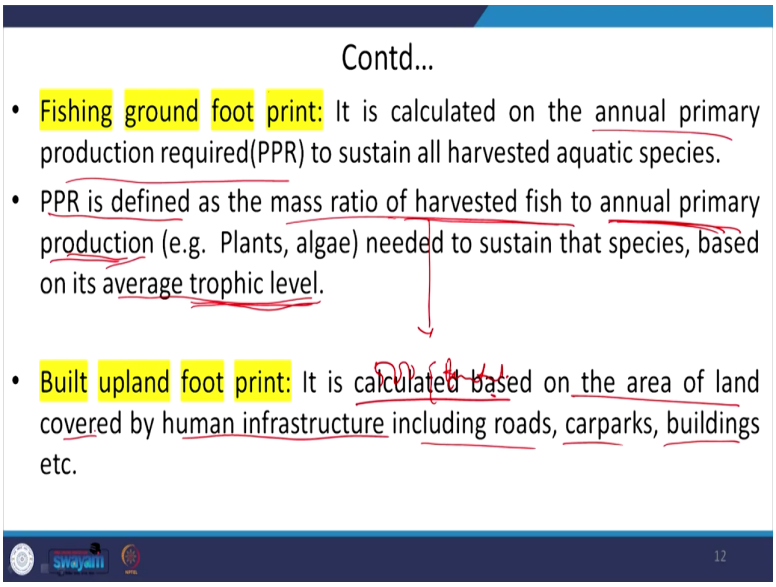

So, the other system that we are also taking into account for the ecological footprint is fishing ground footprint. So, how we are calculating this fishing ground footprint? So, we are taking into consideration the annual primary production requirement. So, this annual primary production requirement should be able to sustain all harvested aquatic species.

So, what is this are this annual primary production required or the primary production required per annum? So, this is again a biological concept that is defined as the mass ratio of harvested fish to annual primary production. So, what is this mass ratio of harvested fish? Let us say they have the mass ratio of harvested fish is 500 quintals to the annual primary productions that is generally in expressing this and there is primary productions we take into account the trophic level the concept of trophic level and we do have five different trophic level.

So, here what in this case in order to understand is this primary production requirement. We are taking into account this the harvested fish along with this annual primary production that is expressed in terms of generally is expressed in terms of plants and algae. And again five your are saying they are the primary production because, they are producing their own food for their own consumptions.

So, that is why they are in the first level first trophic level. And in finding this footprint we are taking to account that this trophic level for that particular average trophic level for this particular spaces. And another category of for the footprint that we are also including in order to find this ecological footprint is the buildup plant or built up land footprint.

So, again this is calculated on the area of land that is covered by the human infrastructure maybe in terms of your buildings, maybe in terms of your parking area, your school area, roads and likewise. So, we are taken to account again all these infrastructures their footprint are expressed in terms of the land area required for the sustenance of this infrastructure.

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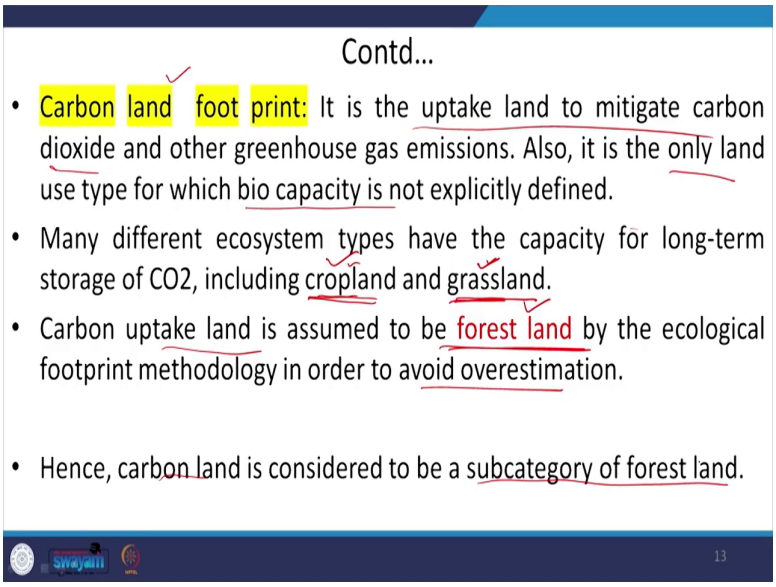

And the last but not the least generally we are saying this carbon land is not found because there is no stereotype land where you can reserve only for carbon. So, but; however, this ecological footprint takes into account the carbon land for finding this footprint. And here it is expressed as or it takes into account the uptake land to mitigate the carbon dioxides or other forms of gas emissions like your greenhouse gas emissions.

And if you take into account this carbon land then actually this is the only land use type for which the bio capacity is not explicitly defined. You cannot actually say that what is the productivity? Productive capacity of that particular system. Because, you do not know that what is the amount of land you need to actually store you need to actually give for storing the carbon.

So, that is why you do not know what is the bio capacity of that particular land which talks about the carbon plant. And again we can also argue that there are many different systems or land like your crop land or dry grassland they do have capability and to store the carbon as well. So, if this crop land and grassland they are otherwise or alternatively used, then obviously, it is very difficult to find this land for storing the carbon.

So, here in this context taken into account this difficulty this carbon uptake land, it is only assume assumed to be to be the forest land. Because, when you are saying that this two lands two different types of land like your cropland and grasslands that we have also included in the ecological footprint case. There also we talked about these two one these two indicators, but; however, that is very it is very likely that these two land use patterns can easily be changed. If these crop land and grassland they are converted into some alternative uses, then it will be very difficult to find out that what is the carbon land.

So, in order to avoid this kind of a difficulty because land use change are very frequent, these carbon land is especially calculated based on the forest land that how much carbon a particular forest land can observe. So, in order to avoid this over estimation this a carbon land is only taken into account the forest land. So, in a sense we can say this carbon land is considered to be a subcategory of forest land.

Because, we are expressing; in fact, we are saying when forest land is there, then we are saying that this carbon land is to be there even because the carbon can be observed in those forest area. So, in this lecture we discussed what is the ecological footprint, its meaning, its origin, and its deployment. Then we talked about what are the indicators to measure this ecological footprint. Then in the next class we will be talking about how to calculate this ecological footprint right. So, in the next class we will be we will be continuing with the same topic and we will be discussing how to calculate the ecological footprint itself.

Thank you.