Environmental and Resource Economics
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Natural Resources Economics and Dynamic Optimization Part - 1

So welcome once again, today, we will discuss we will start our discussion on Natural Resource Economics. If you recall, the course title is environmental and Resource Economics. So, so far we have discussed some portion from environmental economics and the other part of this course is basically from Natural Resource Economics and today onwards we are going to start about our discussion on that. So, this is Natural Resource Economics.

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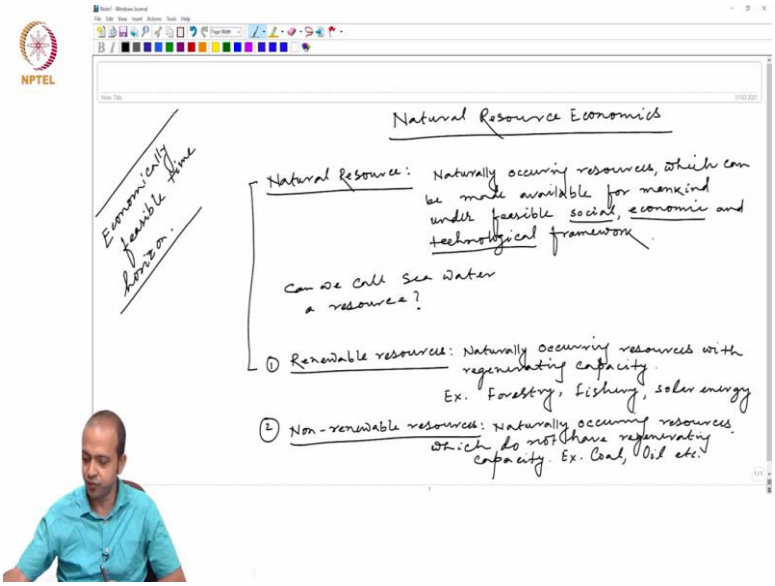

Natural Resource Economics or simply you can say Resource Economics by resource we mean only natural resource. So, first of all before going to talk about economics and all what is the natural resource? Natural resource that we need to understand first. So, do you have any idea on natural resource you can think about it. So, basically economists what they define as naturally occurring resources, which can be made available for mankind under feasible, social, economic and technological framework.

So, this is the definition of natural resource economic; natural resource. So, these resources are naturally occurring and this if is some of these naturally occurring resources can be made available for mankind under feasible, social, economic and technological framework. Now, the question is why we are mentioning three frameworks here social, economic and technological.

Now, I will give you some example, let us say that at present time, we are facing water resource crisis all over the globe more or less human being we are facing some kind of crisis for water, safe drinking water and safe water for other purposes. Now, an alternative we can think of seawater as an alternative to this to solve this water crisis, we can actually desalinate seawater and use it for drinking and other purposes.

Now, the question is can you say that the sea water is a resource? Can we call sea water a resource? So, again, it should be made available for mankind under social, economic and technological framework. First of all, if we desalinate that water, if we desalinate sea seawater, first of all societies should accept that that means societies should perceive that after desalinating sea water it is that to be safe to use. If society does not accept, we cannot call that as resource.

Secondly, there should be available technology for the desalination purpose. So, desalination requires a huge amount of energy also which will remove the salt content from the seawater and transform that the safe drinking water. So, do we have technology which will convert that seawater into drinking water, if the technology is not available, then we cannot call seawater as resource because we cannot extract that.

And thirdly, it should be feasible under economic framework also, that means, it should be cost effective, if the desalination process, the technology that is required for this desalination if it is too costly, then human being we cannot afford for such water, that is why all three conditions social, economic and technological framework, all three conditions must be satisfied if we call some naturally occurring resources as natural resource.

So, this is the definition or we are going to use throughout this course, for natural resource. Naturally occurring resources which can be made available for mankind under feasible, there should be social feasibility, society must accept that, there should be technological feasibility, we should have appropriate technology to extract that resource and it should be economically feasible. So, that means the process should not call involve too much cost.

Now, there are two types of natural resource, two types; one is called Renewable Natural Resource, Renewable resources. So, renewable resources basically naturally occurring resources with regenerating capacity. What is the example? The example is forestry, fishery or you can think of let us say solar energy, these are all renewable resource.

So, even if you extract for example, even if you extract some portion of the forestry some trees if you cut then the forest it has its own regenerating capacity to fill up whatever resource you have extracted, similarly, that is true for fisheries and solar energy. And second type of natural resources, Non-renewable type naturally occurring resources, which do not have regenerating capacity, for example, you can say that coal, oil etc.

Now when we are talking about regenerating capacity please keep in mind, we are talking about possibility of regeneration within a economically feasible time horizon. If somebody says that this coal is also going to regenerate after 1000 years, if some earthquake or something happen that 1000 years is actually beyond an economically feasible time horizon. So, that we have to keep in mind this concept, economically feasible time horizon.

10 years, 15 years, 20 years, 25 years these are all economically feasible time horizon but 200 years, 500 years, 1000 years these are all beyond economically feasible time horizon. However, it is very difficult to exactly define the length of an economically feasible time horizon.

So, keeping economically feasible time horizon is in mind we are basically defining this renewable and non-renewable resources. Renewable resource has regenerating capacity within this economically feasible time horizon while non-renewable resources do not have regenerating capacity within this economically feasible time horizon.

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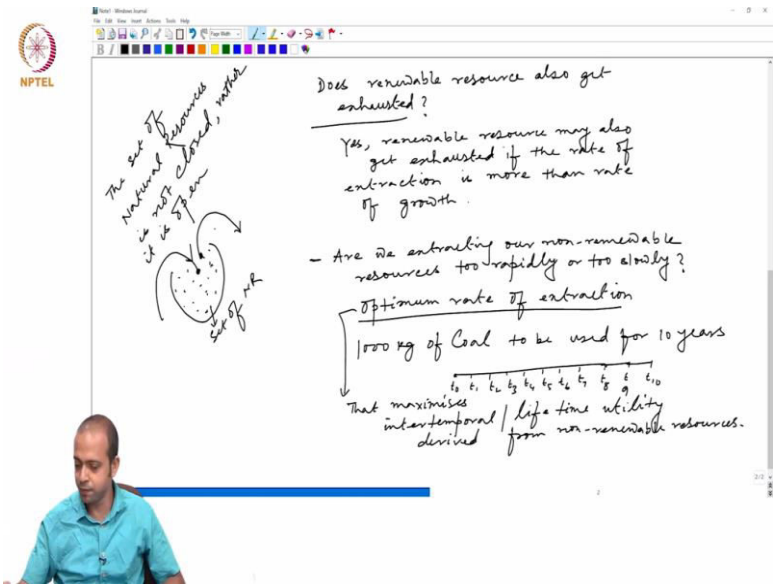

Now, when you are talking about renewable resource then apparently we may feel that if resources renewable type then there is no possibility of that type of resource getting

exhausted. So, exhaustion is not possible for the renewable type but actually that is not true. So, that means this type of question may arise in our mind.

Does renewable or resource also get exhausted? This type of question. Yes, it is possible. Yes, renewable resource may also get exhausted if the rate of extraction is more than rate of growth. So, the rate at which we extract the renewable resource, if that is much larger than the rate of regeneration then the renewable resource may also get exhausted that is purely based on rate of extraction. Similarly, sometimes what happens is that climatic condition may also prevent the proper growth of some species because of some anthropogenic activities.

Because of some human activities or anthropogenic activities, the climatic condition may favor appropriate growth of some species and they may get, they may get extinct or eliminated from the world. So, that is why there is no reason to believe that just because some resources, renewable type it will never get exhausted it may get exhausted if the climatic condition does not favor their appropriate growth and if rate of extraction is more than a rate of growth.

Then secondly, when you are talking about non-renewable resource, then this question comes to our mind; are we extracting our nonrenewable resources too rapidly or too slowly? So, when we have non-renewable resource, so apparently, we may think that we should extract at a very low rate, but economists they will not suggest even the slower rate of extraction. Economists they will always talk about optimum rate of extraction.

Now what is the optimum the rate of extraction? The rate of extraction that maximizes the intertemporal benefit derived from such non-renewable resources. For example, we have let us say 100 kg of coal or 1000 kg of coal and then this 1000 kg of coal we are going to utilize to be used for 10 years. So, here let us say this is the entire time horizon, entire time horizon t0, t1, t2, t3, t4, t5, t6, t7, t8, t9 and t10.

So, what should be the rate of extraction at each and every time period, so, that the intertemporal benefit derived from this 100 kgs of coal is maximum that means, the rate of optimum rate of extraction is that, that maximizes intertemporal or lifetime utility derived from non-renewable resources. So, it is not about maximizing utility at one point or two points rather we will collect the utility derived from each and every time period and summation of that should be maximum.

So, that means, it is not a static optimization, rather it is a dynamic optimization at each point of time we need to decide about the optimality and that is called optimum rate of extraction, which will maximize the intertemporal or lifetime benefit or utility derived from such resources. So, this is what we call about natural resource. Now one thing we have to keep in mind the set of natural resource, natural resources is not closed, rather it is open. What does it mean?

That means the set is like this, these are all the elements, this is a set of natural resource or let us say NR. Why it is called open? Because over a period of time some element may get exhausted. So, that element let us say this element may go out of this set or over a period of time some new element which was not there earlier can be added also, look at this. So, this element is getting added this element is getting eliminated.

For example, let us say uranium which was not there in the state of natural resources, let us say 100 years back, but now, now, within the economically, technologically and social framework, uranium has become a part of natural resource because that is available to be utilized for mankind. Similarly, some natural species which were there earlier in this set, let us say dinosaur over a period of time or some trees which are there 200 years back may no longer be there in this set. So, it could it is out of the set.

So, that is why the set of natural resource is actually open. New element can be added some of the existing element can be eliminated, may get exhausted that is why we say that the set of natural resources is not closed, it is an open set that is the meaning, that is the meaning.

Now, if you think about this natural resource, the main question that we are going to address throughout this course is optimum rate of extraction or rather we can say that optimal path of extraction that means, if we have optimum rate at each point of time and connect that we will get path in instead of getting one rate at a particular point. So, we are trying to understand a path of extraction. So, what should be the optimal path of extraction for this type of non-renewable resources that is what we are going to discuss.

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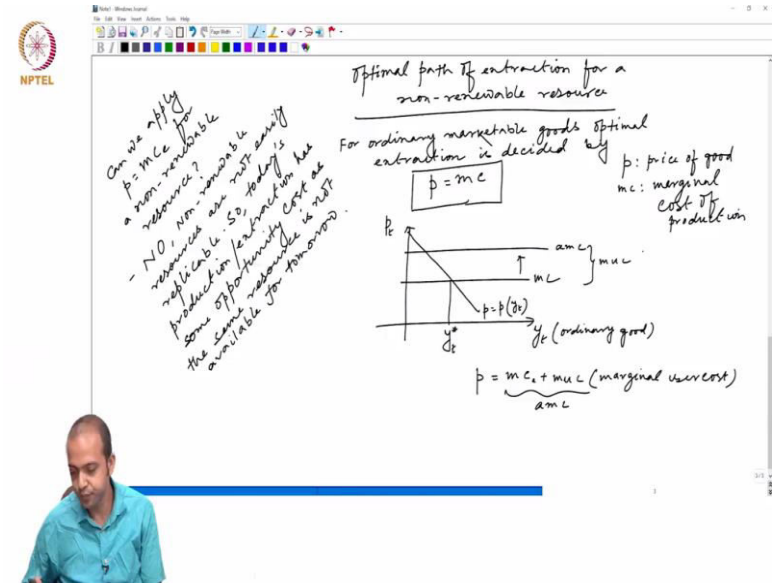

So, this is optimal path of extraction for a non-renewable resource. Now, for ordinary marketable goods, how do you decide extraction? Price for ordinary marketable goods, optimal extraction is decided by p equals to mc condition where p is the price of the resource or price of the good I will say and mc is cost of production or rather I will say marginal cost, marginal cost of production rate.

Let us say that we have a simple diagram let us say this is pt and here we are measuring yt, yt is ordinary good, ordinary good and this is basically the demand which is given by p equals to p of yt and this is let us say marginal cost of production. So, optimality at any point of time is this which is yt star. This is the optimal rate of extraction or optimal rate of production whatever you may call it.

Same condition now, the question is can we apply the same condition in the context of a renewable resource price equals to marginal cost of extraction instead of marginal cost of production, we can say that marginal cost of extraction. So, can we apply p equals to mc let us say e marginal cost of extraction for a non-renewable resource and the answer is actually no. The answer is no, we cannot apply marginal cost pricing for non-renewable resources.

Why this is so, because for non-renewable resource; non-renewable resources are not easily replicable. So, today's production or extraction has some opportunity cost as the same resource is not available for tomorrow. So, that means, we cannot simply apply marginal cost pricing over and above this marginal cost of extraction or production, we need to add this opportunity cost.

And if we add something on that, then actually this marginal cost curve will shift upward, the marginal cost will shift upward which is called Augmented Marginal Cost or AMC. Augmented Marginal Cost or AMC that means price should be equals to marginal cost of production or extraction plus this marginal user cost and at these two component taken together is called AMC.

So, that means these, the difference between this mc and AMC these differences actually MUC Marginal User Cost, that is why the marginal cost pricing which is applicable for ordinary marketable goods for optimal production or extraction whatever you may think of the same is not applicable for the non-renewable type resources, because it has some opportunity cost if we use the resource today, same amount of resource is not available for tomorrow's use. So, that means it has some opportunity cost.

So, what over and above this mc marginal cost of production or extraction we need to add that. And that is basically known as the gap between mc and AMC is marginal user cost. So, mce plus marginal user cost taken together it is called Augmented Marginal Cost.