Environmental & Resource Economics
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Dynamic Optimization and Renewable Resources Part - 5

So, welcome once again to our discussion on Natural Resource Economics and in our last class yesterday we are talking about optimum extraction for a non-renewable resource to derive the price path what should be the optimum price for a non-renewable resource extraction and we said that price should be equals to marginal cost plus something additional which we have defined as marginal user cost in this case.

We said that this is the shadow price the rho t what we are talking about the shadow price and then in the process after doing the mathematical optimization of our objective functional we arrived at a condition wherein we say that total benefit of preserving the resource if I do not preserve the if I do not extract the resource today and preserve it for tomorrow, then we are going to get two types of benefits, one benefit in the form of capital gain, so, the price of the resource will increase tomorrow.

And then secondly, the other benefit what we also enjoy, but by preserving the resource for tomorrow is the stock effect on the marginal cost of extraction, more is the stock, less would be the cost of extraction, these are the two benefits and these two benefits if we sum it up, then that should be equals to the total interest that I would earn if I extract the resource today and put the money or revenue generated from that resource extraction in bank and bank gives interest at the rate of r. So, total benefit then r into rho t should be equals to rho dot capital gain plus del c dot del x t that is what we discussed yesterday.

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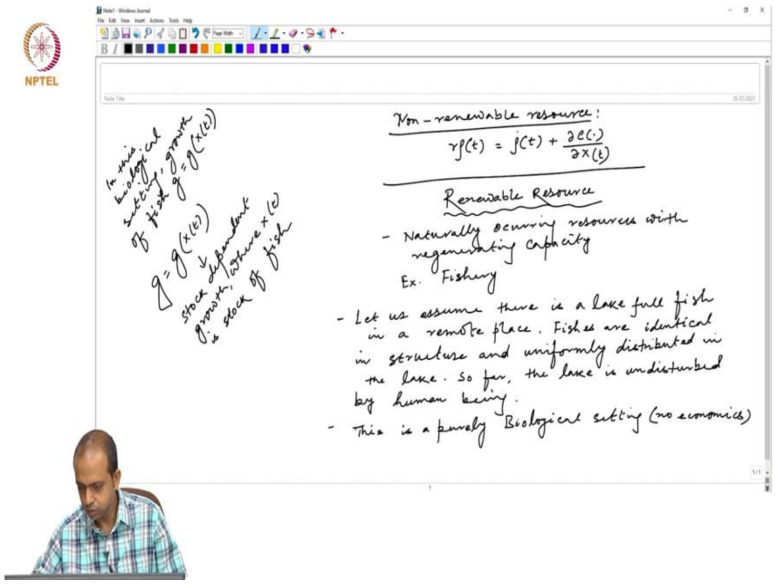

So, that means the condition what we are talking about this is in the context of non renewable resource. So, the condition that we have derived is total benefit r into rho t should be equals to rho dot t capital gain plus del c dot del x t that is the total benefit that will get tomorrow. Now, today what we are going to discuss is the price path or deriving the condition for optimum extraction of a renewable resource is going to be today's discussion.

Today's discussion will be on renewable resource and what is renewable resource we have already defined these are naturally occurring resources with regenerating capacity and for an example we can take fishery. So, what is the context let us assume there is a lake full of fish and in a remote place.

So, fishes are identical in structure and uniformly distributed in the lake and since the lake is in a remote place so far the lake is undisturbed by human being since it is not disturbed by the human being that means economics is not involved in this context so, we say that this is a purely biological setting no economics.

So, in this biological setting what we do that in this biological setting growth of fish denoted by g equals to g of x t. So, this g equals to g of x t this is called stock dependent growth where x t is stock of fish. So, this is purely a stock dependent growth that we are talking about.

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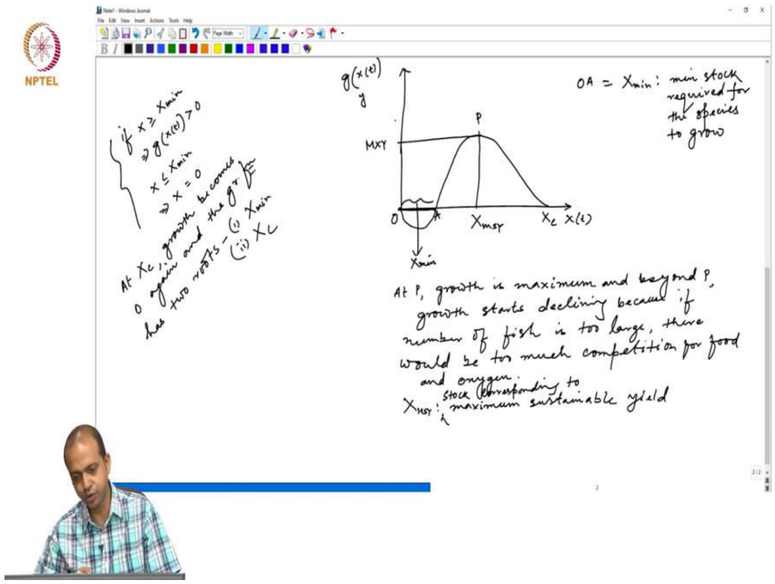

Now, if we plot this growth path diagrammatically let us say that in the x axis we are measuring stock. And in y axis what we are measuring is growth which is g is a function of x t. And also the rate of extraction sorry, not rate of extraction rather I will say that yield, y is yield then the typical growth function looks like this.

So, that means growth first starts with negative then it touches here and then it is going up and again going down. So, here the idea is if x the stock of fish is greater than X min what is the X min? This is called X min. So, how is this X min defined X min is minimum stock required for the species to grow.

So, this is the minimum amount let us say this is O and let us say A let us say this is P and let us say this is Xc. So, OA is indicated by X min the amount of stock indicated by OA if x is greater than X min. So, that means stock of the face is more than the X min then only will see a positive growth if x then that will that indicate g of x t is positive and if x is less than X min then that would imply x equals to 0 this is what we have to mind.

So, that means at any point of time, if the stock falls below this minimum level then we will say that the species will not grow and ultimately it will get exhausted. So, OA is the amount which is X min amount of resource required minimum stock required for the species to grow. So, what is happening here at point P growth is maximum and beyond P growth starts declining because if number of fish is too large there would be too much competition for food and oxygen that is all. So, beyond P if grows if the number of fish grows beyond P then there would be too much competition among them for food on oxygen. So, as a result of which the growth will come down and we assume that corresponding to this P this is called X msy is called maximum sustainable yield. This is called msy.

So, we say that X msy is maximum sustainable yield that is the maximum stock which is sustainable, maximum sustainable. So, rather than calling it X msy is maximum sustainable yield I would say that stock corresponding to maximum sustainable yield because sustainable yield we are measuring here in the y axis, x is simply denoting the stock.

So, x is that level of stock which produces maximum sustainable yield denoted by m xy this is not sustainable yield, this is stock. Now at Xc growth becomes 0 again and the growth function has two roots. What are the two roots, two roots are X min this amount this is the point X min and secondly Xc at X min the function is touching x axis and an Xc again the function is touching the x axis that is why you say that this function is having two roots.

So, this is purely a biological setup, human beings they could not locate that lake that is why the lake is undisturbed by the human being. And obviously we can understand if it is undisturbed by the human being if they are not catching the fish. So, it is purely a biological setup and we are considering a biological growth path. And that growth has two roots.

One is that X min which indicates minimum amount of stock that is required for the fish to grow and P indicates the maximum growth happening beyond which if the fish still grows, they not will happen there would be too much competition among them for food and oxygen and growth will decline.

And once again at Xc it will touch the x axis and as a result of which the function has two roots. So, the stock corresponding to maximum growth is called maximum stock related to maximum sustainable yield and sustainable yield is measuring in the y axis is corresponding to the peak of this growth path.