UNIT 9: ECONOMICS OF NATURAL RESOURCES - ll

UNIT STRUCTURE

9.1 Learning Objectives

9.2 Introduction

9.3 Renewable Resources

9.3.1 Renewable Vs Non Renewable Resource Economy

9.4 The Biological Growth

9.5 The Growth Curve

9.6 Sustainable Yield

9.6.1 Maximum Sustainable Yield

9.7 The Economically Optimum Rate of Harvest

9.8 Let Us Sum Up

9.9 Further Readings

9.10 Answers to Check Your Progress

9.11 Model Questions

9.1 LEARNING OBJECTIVES

After going through this unit you will be able to,

- define renewable resources
- distinguish between renewable and non renewable resource
- explain the 'sustainable yield'
- know the economical as well as biological efficient yield
- determine the optimum rate of harvest for the renewable resource.

9.2 INTRODUCTION

All means of satisfying human needs at a given point of time and place are called resources.The natural resources are those resources which occur naturally. They cannot be produced.Natural resources can be classified in different ways. On the basis of origin it can be categorized as biotic and abiotic. On the basis of distribution it can be categorized as ubiquitous and localized. On the basis of ownership it can be categorized as individual, community level, national and

international. On the basis of the stages of development it can be said as potential, actual, reserve and stock.On the basis of renewability there are two important types of resources i.e. **Renewable resources** and **Non Renewable resources**.Resources from a human use perspective are classified as renewable only so long as the rate of replenishment or recovery exceeds that of the rate of consumption. In this unit we will discuss the renewable resource.

9.3 RENEWABLE RESOURCES

Renewable resources are those which have regenerative capacity within an economically reliable time horizon. They are capable of self reproduction and interactive in nature. This is in the sense that the size of these resources are determined and influenced by the biological forces and human activities. If the biological forces is small or renewable resources are over used, then there is a chance of exhaustion of these resources.

But the line dividing the distinction between exhaustible resources and renewable resources is always not clear. However renewable resources are different from exhaustible resources because they are naturally regenerated on a time frame that is relevant to human exploitation. Like the exhaustible resource, renewable resource cannot be reproduced. Hence along with the intervention by human activities, the stock of the renewable resource depends on the population dynamics of a stock. The essential feature of renewable resource is its capacity to regenerate itself, its stock may increase or decrease on a time frame that is related to human exploitation. All varieties of exploited plants and animals are common examples of renewable resources.

9.3.1 Renewable vs. Non Renewable Resource Economy

The economic analysis of renewable resource differs from that of non renewable resource in two ways,

- It is not concerned with the finite availability of the resource and the time when a resource industry ceases to exist. A renewable resource can remain productive indefinitely, although it may be drawn down to extinction if it is over exploited.
- The issue of market structure and the potential for cartelization is not a prominent feature of renewable resource literature: market power is prone to being competed away by the close substitutability between one resource stock to an another.

CHECK YOUR PROGRESS

Q 1: What is meant by the term 'resource'? (Answer in about 20 words)

Q 2: Define natural resource. (Answer in about 20 words)

Q 3: What do you mean by Renewable resource? (Answer in about 30 words)

Q 4: Will the renewable resource exhaust? Give arguments. (Answer in about 60 words)

9.4: THE BIOLOGICAL GROWTH:

Catching a fish or cutting a tree does not reduce the population of fish or tree in any period. But if through human activities or by some other reasons the population is drawn down below the critical threshold, the species will become extinct. Therefore biological population belong to a class of renewable resource is called interactive resource, where the size of the resource stock (population) is determined jointly by the biological considerations and by actions taken by society. The size of the population in turn determines the availability of the resource in future. On the other hand, the stock of the renewable resource will decrease if the rate of exploitation exceeds the natural growth rate. The stock of the renewable resource is generally affected by two factors i.e. biological and manmade factors. The biological forces of affecting the size of the renewable resource are endogenous factors. The exogenous factors like the human activities can also affect the size of the fish stock. The biological factors influencing the stock of a renewable resource such as a fish are birth rate, death rate, in migration of the new fish to the habitat and outmigration of the existing fish from the old habitat. The biological growth of the renewable resource can be explained with the help of Figure 9.1.

Figure 9.1: …….

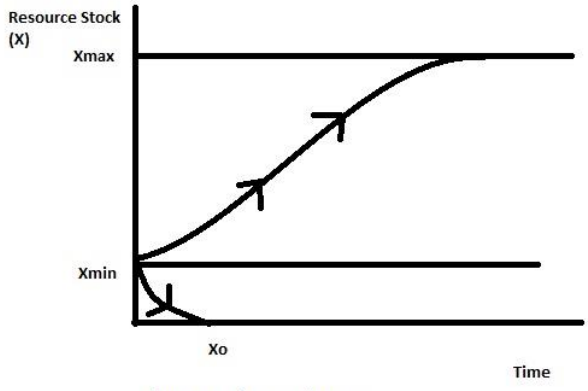


Figure 9.1: The Growth Curve

For simplicity, to understand the phenomenon we take the example of a single fish species which is a renewable resource. The growth in any natural biological event (a natural fish stock or forest) will depend on the stock of the event. Thus the increase in the fish stock in a natural water body depends on the initial stock of fish in the natural water body. For a hypothetical fish stock the growth rate will follow a cumulative growth shape by assuming the size of the stock as a function of time. In figure the curve G (X) shows the size of the stock as a function of time. At low levels of the stock the fish multiply, but as they begin to compete for food their rate of growth slows down and eventually the stock converges on some maximum level Xmax. This is the economy's carrying capacity for a particular species (Fish) in the absence of human interventions. This cumulative curve thus takes the general logistic shape with at first successively large increments, then successively smaller one. The growth curve begins at Xmin which is known as the 'critical minimum level of population'. If the size of the stock falls below this level then there is a possibility of extinction of the species leading to Xo. The natural biological growth rate of the resource will not be able to increase the size of the stock once again, if the stock once falls below the critical minimum level of population. In that case the species will become eventually extinct.

CHECK YOUR PROGRESS

Q 5: Why the renewable resources are called interactive? (Answer in about 20 words)

Q 6: State whether the following statement is True (T) or False (F)

The biological forces of affecting the size of the renewable resources are exogenous factors. (T/F)

Q 7: What is the shape of the biological growth curve of renewable resource? (Answer in about 70 words)

Q 8: What is the carrying capacity? (Answer in about 50 words)

Q 9: Define critical minimum level of population. (Answer in about 50 words)

9.5 THE GROWTH CURVE

Again, the optimal depletion for renewable resource can be analysed with the concept of growth function of a renewable resource, for example, a fish. The growth of a resource stock is a function of the size of the stock itself in the absence of any change in the ecological characteristics of the ecosystem. This is known as 'density dependent growth' and can be illustrated as a logistic function.

If the initial stock of fish in a natural water body in a given time period is ‘X’, then the growth of the fish stock ‘G’ in water body may be functionally expressed as,

$$G = G(X)$$

This implies that the growth is a function of the initial resource stock. The nature of growth can be shown with the help of Figure 9.2.

Figure 9.2: …….

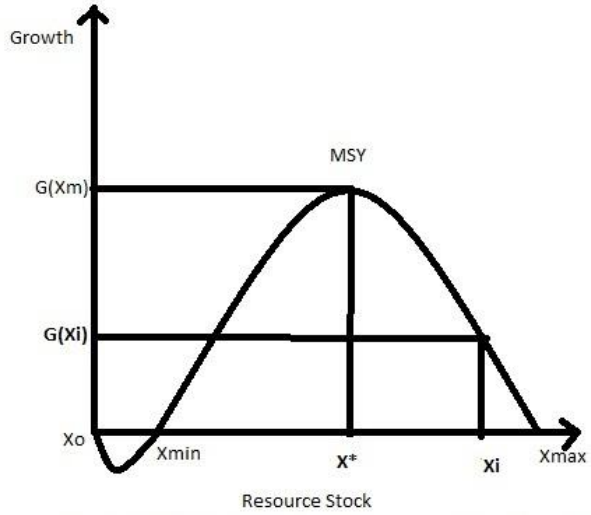


Figure 9.2: Relationship between Resource Stock and Growth

In the figure we measure the size of population on the horizontal axis and the growth of the population on the vertical axis. The growth curve suggests that there is a range of population size (Xmin to X*) where population growth increases as the population size increases and a range (X* to Xmin) where initial increase in population size lead to eventual declines in growth of the population. Xmax is known as the natural equilibrium. In the absence of any human intervention and left to the nature alone, any renewable resource stock like a fish will have some population which is known as natural equilibrium. This is a ***stable equilibrium*** point. This is stable because any reduction of the stock of resource due to some factors like mortality or outmigration from that particular habitat will exactly offset by the new birth and in migration of population from a different habitat to that particular habitat.

A stable equilibrium is one in which movements away from equilibrium stock level set forces in motion to restore it.

If any forces tend to reduce the population stock below the natural equilibrium Xmax for some time, it will restore itself once again along the growth curve G(X) due to the new birth and in migration. Again, if the size of the population exceeds the natural equilibrium for a short period of time, then it will cross the limit of that particular habitat. The excess stock will have competition among themselves for food and space. Hence some will die and others will

migrate in search of new habitat by keeping the natural equilibrium as stable.

There is another point which is unstable. This point is known as minimum viable population. This is unstable because the size of the population will not sustain at that point for a longer period of time. If the size of the population increases beyond this, then the stock will increase by following the path of the growth curve G(X) and will reach the natural equilibrium Xmax. Again if because of some reasons, the size of the population reduces below this level, then the species will reach the point Xo and will become extinct in one day. Hence the population will not continue for a long period of time.

CHECK YOUR PROGRESS

Q 10: What is density dependent growth? (Answer in about 20 words)

Q 11: State whether the following statements are True (T) or False (F)

(a) Natural equilibrium point is stable. (T/F)

(b) Minimum viable population is stable. (T/F)

9.6 SUSTAINABLE YIELD

With human intervention when catch (yield) level equals the growth of the stock, it is known as sustainable yield. In the sustainable yield, the stock size, the growth rate and hence the catch, all remain constant. It is sustainable resource stock depicted in diagram as G(Xi) for the resource stock Xi.

9.6.1 Maximum Sustainable Yield

On the other hand, the particular stock size at which the growth rate of the resource stock is maximum is known as the maximum sustainable yield (MSY). MSY is the largest perpetual yield that could be obtained from the resource. Beyond the MSY, the growth rate of the resource stock will decline. MSY is depicted in the diagram as X*.

The size of the resource stock can be maintained for a long period of time, if the catch or yield level of the resource is at MSY. The resource stock can replenish itself over a long period of time at this level. If it takes one year to regenerate, MSY can be harvested in each year. Harvesting the resource stock at MSY can be considered as economically optimum harvest level. The biologists say that we can go up to the maximum sustainable yield. But the economically optimum or efficient sustainable yield is less than the biologically maximum sustainable yield. This is because biologists are concerned only in stock and yield of the resource. But the economists are concerned

with the marginal cost of harvesting or catching also. The marginal cost of harvesting rises as the level of yield increases. As a result, economically optimum sustainable yield is less than the maximum sustainable yield.

9.7 THE ECONOMICALLY OPTIMUM RATE OF HARVEST:

After determining the maximum sustainable yield, the main concern is to determine the optimum rate at which harvesting can be made. Allocation to be efficient, it has to equate the marginal costs of harvest with its marginal benefit i.e. the maximum net benefit.

The level of harvest or yield depends on 'effort'. Effort is the resource and time devoted to harvesting the resource. It is expressed as,

$X = Y/ E$

Or alternatively,

$E = Y / X$

The bigger the effort (E), the larger the proportion of the stock (X) that would be harvested (Y). Rewriting the equation,

$Y = EX$

The rate of harvest can be shown in the following diagram. For simplicity, we merge the point Xo to Xmin of the above diagram. The choice of effort (E) will determine the equilibrium harvest (Y) and the stock level (X). This in turn will determine the characteristics of the growth curve. Hence, EX = G(X).

Figure 9.3: …

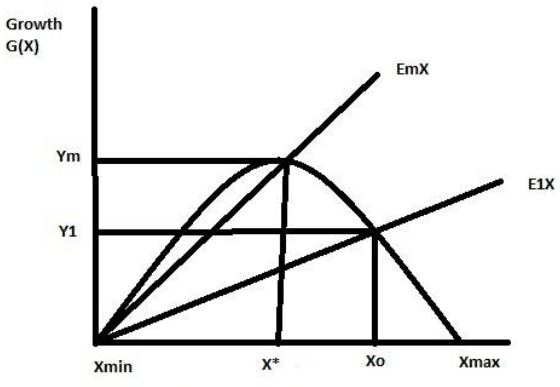


Figure 9.3: Effort Yield Curve

In the above diagram the growth of the resource stock G(X) as well as harvest (Y) is represented in the vertical axis and the size of the stock (X) is represented in the horizontal axis. For any resource stock the effort will determine the amount of harvest as well as the remaining stock of the resource.

For the resource stock Xo, with the effort level E_1, Y_1amount of harvest can be made. This is the sustainable level of harvest. If effort is made beyond this level, then more harvesting can be made. This will reduce the availability of stock in the habitat. Remember, sustainable yield is where harvest equal to growth rate. Again if the effort is less than the sustainable yield, then the resource stock will grow to reach the sustainable yield.

If the effort level is more than E_1, then maximum harvesting can be made out of that habitat at the effort level E^*.

Now, the effort yield curve can be illustrated into costs and revenue. If we assume that effort is only factor of production, then the total cost (TC) will be equal to the level of effort times the price of effort, which may be taken as the wage rate. Assuming a constant wage rate and a constant price, total cost can be shown as a linear function. Total revenue (TR) is,

TR = P X Harvest

And thus harvest curve becomes TR curve. Optimum sustainable yield corresponds to level where marginal cost of harvesting is equal to marginal revenue from harvesting i.e. MC=MR. This means that the slope of TR should be equal to the slope of TC. So, the efficient or optimum level of effort is achieved when the vertical distance between benefits and costs is maximized.

Figure 9.4:

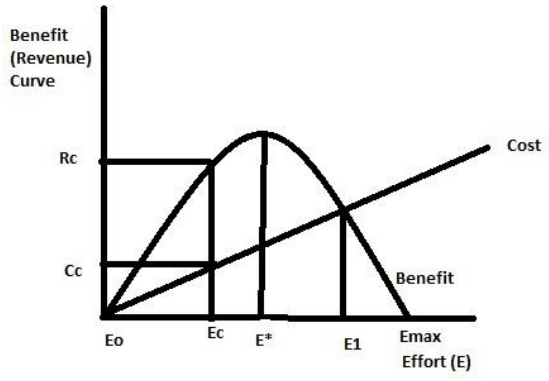


Figure 9. 4:The Efficient (Optimum) Sustainable Yield for a Rnewable Resource (Fishery)

As sustainable levels of effort are increased, eventually a point is reached E* where further efforts reducethe sustainable catch (yield) and revenue for all years. This point is the maximum sustainable yield.The net benefit is depicted as the vertical difference between the benefit and costs. The efficient (optimum) level of effort is Ec, where the vertical distance between benefits and costs is maximized. Here MC = MR. This efficient level of effort determines the efficient level of yield. This is the static efficient sustainable yield.

CHECK YOUR PROGRESS

Q 12: Define sustainable yield. (Answer in about 30 words)

Q 13: What is meant by maximum sustainable yield? (Answer in about 20 words)

Q 14: How the allocation becomes efficient? (Answer in about 30 words)

Now from the above information, we can come to the conclusion that maximum sustainable yield is not efficient. The maximum sustainable yield would be efficient, if the marginal cost of additional effort were zero. Since this is not the case, the efficient level of effort is less that necessary to harvest the maximum sustainable yield. Thus static efficient level of effort leads to a larger fish population than the maximum sustainable yield of effort and hence maximum sustainable yield does not appear to be a socially desirable objective to strive for. Thus, what is economically efficient sustainable is not maximum sustainable yield and efficient sustainable yield is less than the maximum sustainable yield.

9.8 LET US SUM UP

- The natural resources are those resources which occur naturally. They cannot be produced. Natural resources can be classified in different ways on the basis of origin, distribution, ownership, development and renewability.
- Renewable resources are those which have regenerative capacity within an economically reliable time horizon. They are capable of self reproduction and interactive in nature.
- Renewable resources are different from exhaustible resources because they are naturally regenerated on a time frame that is relevant to human exploitation. Like the exhaustible resource, renewable resource cannot be reproduced.

- Biological population belong to a class of renewable resource is called interactive resource, where the size of the resource stock (population) is determined jointly by the biological considerations and by actions taken by society.
- The stock of the renewable resource is generally affected by two factors i.e. biological and manmade factors.
- The biological growth curve takes the general logistic shape with at first successively large increments, then successively smaller one. The growth curve begins at the 'critical minimum level of population'.At low levels of the stock the fish multiply, but as they begin to compete for food their rate of growth slows down and eventually the stock converges on some maximum level. This is the economy's carrying capacity for a particular species in the absence of human interventions.
- Natural growth rate is known as stable equilibrium and minimum viable population is known as unstable equilibrium.
- With human intervention when catch (yield) level equals the growth of the stock, it is known as sustainable yield. Again, maximum of the sustainable yield is maximum sustainable yield.
- The economically optimum or efficient sustainable yield is less than the biologically maximum sustainable yield. This is because biologists are concerned only in stock and yield of the resource. But the economists are concerned with the marginal cost of harvesting or catching also.
- Allocation to be efficient has to equate marginal costs of harvest with marginal benefit i.e. the maximum net benefit.
- The maximum sustainable yield would be efficient, if the marginal cost of additional effort were zero. Hence economically efficient sustainable is not maximum sustainable yield and efficient sustainable yield is less than the maximum sustainable yield.

9.9 FURTHER READING

(1) R. Bhattacharjee, *Environmental Economics*, OUP

(2) Hanley, Shrogram and White, *Introduction to Environmental Economics*, OUP

(3) G. Purakayastha, *Environmental Economics: Theory Problems and Solutions,* Kalyani Publishers

(4) Burhagohain and Das, *Environmental Economics*, EBH Publishers

9.10 ANSWERS TO CHECK YOUR PROGRESS

Ans to Q No 1: All means of satisfying human needs at a given point of time and place are called resources.

Ans to Q No 2: The natural resources are those resources which occur naturally. They cannot be produced.

Ans to Q No 3: Renewable resources are those which have regenerative capacity within an economically reliable time horizon. They are capable of self reproduction and interactive in nature.

Ans to Q No 4: The renewable resources are regenerated within an economically reliable time period.They are interactive in nature. Hence their size is determined jointly by the biological factors and human activities. If because of any forces the growth of the renewable resource is drawn down below the critical minimum level or more harvest is made by the human activities, then there is the chance of exhaustion of the renewable resource.

Ans to Q No 5: The size of the resource stock (population) of renewable resource is determined jointly by the biological considerations and by actions taken by society. Because of this reason renewable resource are known as interactive in nature.

Ans to Q No 6: False.

Ans to Q No 7: The biological growth curve follows the cumulative growth function by assuming the size of the renewable resource stock as a function of time. This cumulative curve takes the general logistic shape with at first successively large increments, then successively smaller one. After that it will reach some maximum level of population which is also the carrying capacity of the habitat.

Ans to Q No8: The carrying capacity of an eco system is the maximum population of a particular species that the eco system can sustain indefinitely by providing them all the basic needs for subsistence. It is the upper limit of the population of that species which can live in that eco system as comfortably.

Ans to Q No 9: Critical minimum level of population is the minimum level of population below which the stock of the population will decline and will extinct in one day.

Ans to Q No 10: The growth of a resource stock is a function of the size of the stock itself in the absence of any change in the ecological characteristics of the ecosystem. This is known as density dependent growth.

Ans to Q No 11: (a) True (b) False

Ans to Q No 12: Sustainable yield is the size of the catch or yield or harvest level of a renewable resource which is equal to the growth of the resource stock.

Ans to Q No 13: The maximum of the sustainable yield is the maximum sustainable yield.

Ans to Q No1 4: Allocation to be efficient has to equate marginal costs of harvest with marginal benefit i.e. the maximum net benefit.

9.11 MODEL QUESTIONS

Short Questions (Answer each question in about 150 words**)**

Q 1: Discuss the classification of the natural resources.

Q 2: Outline the differences between renewable resources and non renewable resources.

Q 3: Is maximum sustainable yield efficient? Justify your view.

Q 4: How can the optimum rate of harvest be determined for a renewable resource?

Essay type Questions (Answer each question in about 350 – 500 words**)**

Q 1: Describe the biological growth of a renewable resource.

Q 2: 'Economically optimum sustainable yield is less than biologically maximum sustainable yield'. Explain.

Q 3: Explain the concept of sustainable yield with suitable diagram.

Q 4: How the effort-yield curve can be derived from the growth curve?

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