AFRICAN ECONOMIC RESEARCH CONSORTIUM

Collaborative Masters Programme in Economics for Anglophone Africa (Except Nigeria)

JOINT FACILITY FOR ELECTIVES (JFE) 2010

JUNE – OCTOBER

ENVIRONMENTAL ECONOMICS I

First Semester: Final Examination

Duration: 3 Hours **Date: Tuesday, August 10, 2010**

INSTRUCTIONS:

1. You are required to answer **THREE** questions in total. All questions carry equal weight.
2. **Question 1** and **Question 2** are **COMPULSORY.**
3. You may **choose** between **Question 3** and **Question 4.**
4. Answers must be clear, structured, and concise

Question 1 [20 marks]

(a). Explain why market failure can lead to environmental degradation? **[5 marks]**

(b). Discuss the rationale for government intervention in the presence of market failure as well as the limits to such intervention in Sub-Saharan Africa. **[5 marks]**

(c). In the dynamic model of fisheries, we have seen that optimal management follows the so-called "fundamental equation of renewable resources".

$$r = f'(X) - \frac{\frac{\partial C}{\partial X}(H,X)}{p - \frac{\partial C}{\partial H}(H,X)}$$

where X is the stock of resources, H is the harvest, $C(H,X)$ is the cost of harvest, p is the market price of the resource, r is the interest rate and $f(X)$ is the resource growth function.

State clearly the intertemporal problem faced by a "present value" private property fishery as well as the usual assumptions of this model. Provide an economic intuition to this fundamental equation. Is extinction possible in this framework? **[5 marks]**

(d). Discuss, with a special reference to Sub-Saharan Africa, the importance of property rights in achieving (social) efficiency in the management of renewable natural resources. **[5 marks]**

Question 2 [20 marks]

Suppose the inverse demand curve of an exhaustible resource is: $p(t) = q(t)^{-\alpha}$

Suppose further that the costs of extraction are zero, that initial reserves are S and that the discount rate is r.

(a). Determine the price elasticity of demand. What is its key feature? **[2 marks]**

(b). What is the peculiarity of this demand function? **[2 marks]**

(c). Find the time-path of extraction for a competitive mining industry

(i) Write the problem of the mine owner. **[2 marks]**

(ii) Solve the dynamic optimization problem using the maximum principle. Provide an economic intuition for the co-state variable and its dynamics. **[5 marks]**

(d). Find the time-path of extraction for a monopolistic mining industry. That is, write the problem of the monopolistic mine owner and solve the dynamic optimization problem using the maximum principle. Provide an economic intuition for the co-state variable and its dynamics. **[5 marks]**

(e). Compare the results found in questions (c) and (d). Discuss the implications on resource extraction of market structure and demand. **[4 marks]**

Question 3 [20 marks]

Suppose the utility functions of two agents are given by: $U_1(x_1, G)$ and $U_2(x_2, G)$

where x denotes the private good, and G denotes the public good. The price of the private good is p_x and the price of the public good is equal to p_G. The agents' income levels are I_1 and I_2.

(a). Derive the general condition that describes the set of Pareto efficient allocations. **[3 marks]**

Now assume that: $U_1(x_1, G) = \sqrt{x_1}\sqrt{G}$ and $U_2(x_2, G) = \sqrt{x_2}\sqrt{G}$; is $p_x = 1$ and the price of the public good is equal to $p_G = 4$. Both agents have an income of Ksh 400, that is $I_1 = I_2 = 400$.

(b). Apply the Bowen-Lindahl, Samuelson optimality condition to this specific problem to solve for the efficient quantity of the public good G^*. **[2 marks]**

Now suppose both agents try to maximize their utility given the contribution of the other agent to the public good and their own budget constraint. That is, we want to find each agent's best response function.

(c). Write down each agent's utility maximization problem (remember she only has to pay for her private consumption and the part of the public good that she is providing). **[2 marks]**

(d). Derive agent 1's and agent 2's best response functions. **[4 marks]**

(e). Solve for the Nash equilibrium in this game of private provision of public good and draw the response functions of each agent in a well-labeled graph. **[3 marks]**

(f). Show graphically and mathematically, that each agent contributing half of the efficient amount of the public good is a Pareto-improvement over the Nash equilibrium payoffs, but that this is not a Nash equilibrium. **[4 marks]**

(g). Explain why the Nash Equilibrium is not Pareto efficient. **[2 marks]**

Question 4 [20 marks]

Consider a simple model of bio-economic equilibrium in an open access fishery in which resource growth is logistic and is given by:

$$\dot{S} = G(S) = \gamma\left(1 - \frac{S}{S_{max}}\right)S$$

$$H = \alpha ES$$

$$\frac{dE}{dt} = 0$$

where H is fish harvests, S is the fish stocks, γ is the intrinsic rate of growth of fish, S_{max} is the carrying capacity of the ecosystem in which the fish is found, and α is the fish catchability coefficient. Each ton of fish is sold at a price p and each unit of effort is purchased at c units of money.

(a). Derive the values of the equilibrium fishing effort, fish stocks and harvests under the assumption of static open access. **[8 marks]**

(b). How would the values found in question (a) change when the cost of effort and the price of fish decrease? Explain the economic intuition for each equilibrium value. **[4 marks]**

(c). Suppose the growth and the harvest functions for the fishery were the same as the above, but instead the fishery is managed by a single profit maximizing unit. Derive the equilibrium fishing effort, fish stocks and harvests under the assumption of static private property. Compare the open access and profit maximizing equilibrium stocks. **[8 marks]**