AFRICAN ECONOMIC RESEARCH CONSORTIUM

Collaborative PhD Programme in Economics for Sub-Saharan Africa

COMPREHENSIVE EXAMINATIONS IN CORE AND ELECTIVE FIELDS
FEBRUARY 13 – MARCH 4, 2019

ENVIRONMENTAL ECONOMICS

Time: 08:00 – 11:00 GMT   **Date: Monday, March 4, 2019**

INSTRUCTIONS:

Answer a total of FOUR questions: ONE question from Section A; ONE question from Section B; and Two questions from Section C, which **must be either Question 5 or 6** and **either Question 7 or 8**.

The sections are weighted as indicated on the paper.

SECTION A: (15%)

Answer only ONE Question from this Section

Question 1

(a) Explain Hardin's (1968) "*Tragedy of the commons*" bringing out the intuition and the limitations.   **(7 Marks)**

(b) Can open-access harvesting drive the fish population to zero? Why or why not?
                                                                                  (8 Marks)

Question 2

(a) "Environmental issues involve questions of environmental values and tradeoffs". Explain using an example. What does this statement portend for the management of environmental resources?   **(8 Marks)**

(b) Explain the components of the total value of an environmental good.   **(7 Marks)**

SECTION B: (25%)

Answer only ONE Question from this Section

Question 3

Consider two nations A and B, whose activities individually contribute to the pollution of the common atmosphere. A reduction in pollution activities would benefit both parties.

(a) Using the basic prisoner dilemma game structure, argue that without any self-enforcing bilateral agreement, it is in the best interest of each not to reduce its pollution level.

(8 Marks)

(b) Why is such self-enforcing international agreement for climate change mitigation difficult at the global level? Arrange your arguments in the following order (i) the nature of climate change mitigation (ii) the constraints that must be overcome by a successful self-enforcing International Environmental Agreements (IEA) (iii) characteristics of a self-enforcing IEA and (iv) why this may be difficult to achieve in practice.

(12 Marks)

(c) Provide an argument to the effect that countries will individually prefer to invest in climate change adaptation over and above mitigation. **(5 Marks)**

Question 4

(a) Suppose a private polluter maximizes her net private benefits (NPB) to produce a commodity A, at a total cost equal to C_a. She sells the good at a price, P_a, causing an externality denoted as EC, to produced output Q_a. As a result, government decides to impose a tax as a pollution control policy. Solve the maximization problem to derive the optimal tax, t* as a pollution control policy. State and discuss the fundamental rule.

(7 Marks)

(b) **State** and **explain** the appropriate exact measure of welfare change to use in each of the following situations **and why**? Use equations where appropriate.

   (i) The government is _determined_ to raise fuel price with a view to reducing emission from vehicles but seeks to have a monetary measure of associated welfare change on consumers so as to come up with a relief package for "poor" households.

(10 Marks)

   (ii) The government wants to know whether allowing a factory that is likely to increase emission of gaseous substances in the environment in the course of its production activities, to locate in a given region will pass the _Hicks potential compensation test._

(8 Marks)

SECTION C: (60%)

Answer TWO Questions from this Section;
One of which must be EITHER QUESTION 5 OR 6
And
the other must BE EITHER QUESTION 7 OR 8

Question 5

(a) One of the policy options to ensure sustainable development in the use of non-renewable natural resources is development of innovations that support the substitutions of manufactured capital for natural capital. Looking at the following expression, evaluate how each of the conditions from (i) through (iii) supports or undermines achieving sustainability.

$$\sigma = \frac{\dfrac{d(K/R)}{K/R}}{\dfrac{d(Q_K/Q_R)}{Q_K/Q_R}} \text{ where } Q \text{ is constant}$$

where **K** is manufactured capital and **R** is a non-renewable resource and **Q** is output produced.

(i)   If $\sigma = 0$.   **(4 Marks)**

(ii) If $0 < \sigma < \infty$ **(4 Marks)**

(iii) If $\sigma = \infty$ **(4 Marks)**

(iv) Describe conditions (ii) and (iii) in the light of Hartwick's rule for sustainability and its policy implication using an example? Do you observe any link between Hartwick's rule and Hotelling's rule?   **(8 Marks)**

(b) The social discount rate is derived from intertemporal maximization of society's social welfare function and can be expressed in the Ramsey equation:

$$r = \rho + \theta g$$

Provide definition and economic interpretations of ρ, θ, and g.   **(10 Marks)**

Question 6

(a) In a two-period model of allocation of an exhaustible resource, the demand function is given by p = 10 – 0.2q in the current period and p= 30 – 0.5q in the second period. Assume that there is unrestricted supply and positive marginal extraction cost (MEC= 5 in both periods). If the discount rate is 8%, then:

(i) Calculate the efficient extraction rates. **(3 Marks)**

(ii) Calculate the net social benefits for each period. **(5 Marks)**

(iii) If firms adopt new technology for resource extraction where this technology reduces the marginal extraction cost, what would happen to the net social benefit and resource extraction plan? **(4 Marks)**

(b) The infinite-horizon forest rotation model is given by the following formula.

$$\Pi = \left[pS_{(t_1 - t_0)} e^{-i(t_1 . t_0)} - k \right] + e^{-i(t_1 - t_0)} \left[pS_{(t_2 - t_1)} e^{-i(t_2 . t_1)} - k \right] + \dots$$

Indicate how each of the following factors determine the rotation length **T** in an infinite-horizon forest rotation model:

(i) an increase in interest rate (i) **(3 Marks)**

(ii) an increase in net timber price (p) **(3 Marks)**

(iii) a fall in planting cost (k) **(2 Marks)**

(c) A society is rich in minerals (diamonds), forest resources and agricultural land. Minerals are exploited and sold at international markets; however, the production of minerals causes environmental damage. Hard wood is also sold on international markets but leads to depletion in stock of forest resources. Land is intensively used for agricultural purposes by a large majority of the population leading to soil erosion in many farming communities. During the accounting year, the government spent $4.6 million in programmes aimed at limiting the negative environmental effects of mineral extraction on local population and compensating affected families. The Net National Product of the country based on the UN System of National Accounts (SNA) is provided in the table below.

	US $ million
Output	5400
Input	1800
Gross product	3600
Depreciation (K_m)	-180
Net Product	3420
Of which	
Labour (commercial sector	1110
Farming income	1400
Communal sector	1090
Depreciation (Km)	-180

where K_m = man-made capital

(i) Suppose it is known that the depletion in the stock of forest resources for the year is 1 million tons; soil loss due to erosion is 6025/ha and mineral depleted is 50,000. Assume the market price for a ton of forest product during the year is estimated to be $65, the imputed cost of extraction per ton is $30; the value of soil loss to erosion is estimated at $620/ha; the average market price of diamond for the period is $350 while the marginal extraction cost is estimated to be 75% of selling price. Using this new set of information along with that provided earlier, extend the accounting calculations in the above table to derive the Sustainable Net Product and the distribution of income to the various sources. **(6 Marks)**

(ii) Assume the society (society A) extract 20% of its diamond resource annually. In contrast, another society (B) extracts 10% of its mineral reserves. Given a discount rate of 5% and assuming there is no new discovery in both societies, determine (using the user cost approach) what fraction of net resource revenue (resource revenue less extraction cost) each should reinvest to account for the depletion of mineral stock and comment. **(4 Marks)**

Question 7

Suppose that there are two towns linked by a four-lane highway built before both grew rapidly in population. The highway is frequently affected by severe traffic jams, and the government is considering three options for dealing with this problem.

Option **A**: simply build another four-lane highway between the two towns.

Option **B**: to do same as in option A but reserve one lane in each direction for specially built buses, with a view to reducing the emissions of CO_2 per person-mile travelled on this route.

Option **C**: build a new railway link rather than a new highway. It is thought that this could further reduce emissions and have less impact on wildlife and visual amenity.

Assume that the impact assessment has been done and produces the data shown in the table below.

Options for reducing traffic delays

	A (Highway)	B (Highway & Buses)	C (Railway)
Cost ($ million)	450	300	700
Time Saving (per year) (million hours)	7000	8000	6000
CO_2 Emissions 10^3 tonnes per year	600	500	200
Effect (cost) on Wildlife and Amenity (qualitative assessment)	Bad	Bad	Moderate

Now answer the following questions:

(a) Assuming we are to rank the various options using Environmental Cost-Benefit analysis (ECBA), what further information would be needed and in what way(s) can this (these) be obtained? **(6 Marks)**

(b) Explain Cost Effectiveness Analyses (CEA) as an environmental evaluation technique. Suppose, the government had decided that the minimum acceptable time saving for the project is 7000 million hours per year, rank the project based on this criterion and comment on your results. **(8 Marks)**

(c) Explain Multi-criteria Analyses (MCA) as an environmental evaluation technique Suppose that the government instead had attached the following weights to the following criteria of interest: Costs 0.25; Time Saving 0.35; CO_2 Emissions 0.25; and Wildlife and Amenity 0.15. Rank the projects using the weighted summation method showing all necessary steps. **(16 Marks)**

Question 8

(a) What are Integrated (Climate Change) Assessment Models (IAMs)? Explain the rationale behind such models. **(4 Marks)**

(b) Provide the basic structure and building blocks of the simplified DICE model. **(18 Marks)**

(c) What relevance do such models have for Sub-Saharan African countries? What are the limitations of such models? **(8 Marks)**