Midterm Exam

You are required to answer the FIRST question. Pick two out of the remaining three questions to answer. Your answer should be in full sentences and reflect full grasp of the material. All questions are equally weighted. If you answer all questions only questions 1 to 3 will be graded.

1. Liberia is endowed with human capital, physical capital and natural capital assets. One of the important natural capital assets for its economy is the available fish stock. Assume that the fish stock is open access to any Liberian citizen. Also assume that a significant portion of the population did not finish secondary education. Note that more educated populaces tend to have less violence and are more cooperative. Finally, their physical infrastructure is not deteriorating and is expanding.
   a. If we wanted to obtain a measure of economic growth in Liberia, what measure could we use? Explain at least one drawback to this measure. If we wanted to obtain measures of sustainable development in Liberia, what measures can we use?
   b. Give an example of how weak sustainability, strong sustainability and environmental sustainability can be achieved given the three main assets in the economy.
   c. The Liberian government wants to achieve sustainable development. Explain how sustainable development can be achieved given the assets of the economy.
   d. The precautionary principle can be used to regulate pressures on the fish stock. What does the precautionary principle say with regards to protecting the fish stock? Explain one drawback of using the principle from a policymaker’s point of view.

a. Economic growth refers to changes in national income or output. Gross domestic product (GDP) or gross national product (GNP) are classic measures for a country. There are several drawbacks with using GDP or GNP as a measure of economic welfare: (1) it does not say anything about allocation of output to the populace (income distribution) and (2) does not fully capture all assets of the economy such as natural resources. There are also several drawbacks as a measure of economic growth as well because of problems with comparability across countries due to the exchange rate problem and differences in purchasing power. Sustainable development encompasses welfare that encapsulates economic, social and environmental aspects. Therefore, some measures of sustainable development include measures of poverty, income inequality, freedom, governance, health, literacy, corruption, fish stocks, water quality, participation in the policy decisions, etc.

b. 
   a. Weak sustainability – The aggregate value of the assets of the economy has to be non-decreasing. In this case, the value of fisheries can go down as long as the value of human capital and value of physical capital stock compensate for its decline.
Strong sustainability – Individual value of each asset in the economy must not decline. This implies the value of the fishery stock does not decline, the value of the human capital does not decline and the value of physical capital does not decline.

Environmental sustainability – Physical flow of environmental assets need to be maintained. In this case, the amount of extracted fish is less than or equal to the amount of new growth of fish.

c. In order to achieve sustainable development, economic welfare has to be maximized subject to a sustainability criterion. To maximize welfare, deadweight loss needs to be reduced. There is deadweight loss in the market for extracted fish because it is open access. There is deadweight loss in the human capital asset market because of positive externalities from education. One way to reduce deadweight loss in the fish market is to enforce property rights of the government and implement a fee structure of extracting fish. Because of the positive externalities in education, one can subsidize going to school. Implementing both regulations will increase economic welfare (through a reduction in deadweight loss), increase environmental welfare because of improved fish stock management, and improve social welfare because more low income families will receive better access to education. The next step is to make sure a sustainability criterion is achieved as outline in part (b). So for example, if I pick strong sustainability, I have to ensure that the value of the fish stock does not decline, the value of human capital stock does not decline and the value of physical capital does not decline.

d. The precautionary principle states that any uncertainty should be interpreted toward a measure of safeguard. In this case, if the benefits of protecting the fish stock are not fully realized then the precautionary principle implies that policies should be made to prevent the extinction of the species. Unfortunately, even though it gives direction to policy, it does not tell us the magnitude of such a policy. In this case, we are not sure how much of the fish stock should be preserved.

2. The depletion of the ozone layer is attributed to the emission of Chlorofluorocarbons (CFCs). Before 1990, the use of coolants in refrigerators such as Freon released a significant amount of CFCs.
   a. Given the above scenario, is the equilibrium level of refrigerators produced prior to 1990 in the market “too much” or “too little” compared to the social optimum? **Explain why this occurs.** Support your answer by drawing the private and social, marginal cost and marginal benefit curves for refrigerators. Identify the deadweight loss if any exists.
   b. Identify a regulation that the government can use to achieve the socially optimal level of refrigerators. Explain how this regulation works.
   c. Explain how the Coase theorem could hypothetically work to achieve the optimal level of CFCs emissions in this context. Enumerate at least one major drawback that hinders the creation of a market for CFCs without any third party regulators in the real world.
   d. Assume that the marginal savings for refrigerator producers is unknown. If the marginal damages from CFCs rises very rapidly, would an environmental standard (quota) or a tax be a better option? **Explain** and prove your answer with a graph.
a. Too many refrigerators were produced relative to the socially optimal level. In the refrigerator market, there is one externality: a negative consumption externality when using the refrigerator. Since these effects are not internalized in the market, production and pricing of the good are based only on the private marginal cost and marginal benefit curves which do not coincide with the social marginal benefit curve. Damages from the externality are not considered so too much of the good is produced resulting in a deadweight loss equal to the area abc below:

![Market: refrigerators before 1990](image)

b. A tax on the consumer can internalize the effect of the externality. To avoid paying the tax, less output is consumed. Note that the tax rate should be equal to marginal external benefit which is the distance from b to c. A quota equal to Qs could also remove the deadweight loss.

c. Coase theorem states that if there is full information, there are low transactions costs and property rights are well defined, interested parties, i.e. those that emit CFCs and those that are hurt by CFCs, will be able to bargain to arrive at the socially optimal solution. This leads to a formation for a market for CFCs. In reality, transactions costs are not minimal. It will take time and money to get refrigerator owners together along with refrigerator manufacturers. Also, it is not clear who has de facto rights over clean air.

d. An environmental standard or quota is more preferable in this case because the deadweight loss with this type of pollutant is lower than the deadweight loss with an environmental tax. See graph below. This is because if you know when the marginal damages will suddenly rise, it is best to put a quota before this happens to ensure that the critically threshold will never be reached. With a tax, you can miss if you do not know true MS.
3. The table below shows the marginal benefits from clean air for the only two people in Quahog. Since Peter has asthma, his value for clean air is higher. Clean air is a public good. Solve for the Social Marginal Benefit (MB^S) at each quantity by filling in the table. Assume that the marginal cost of filtering air to make it clear (either through planting trees or reducing air pollutants) is always $7.50 per unit metric ton of clean air.

<table>
<thead>
<tr>
<th>Quantity of clean air (metric tons)</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peter’s Marginal Benefit ($/metric ton)</td>
<td>10</td>
<td>7.50</td>
<td>6</td>
<td>4.50</td>
<td>1</td>
</tr>
<tr>
<td>Chris’s Marginal Benefit ($/metric ton)</td>
<td>7</td>
<td>5.50</td>
<td>4.50</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Social Marginal Benefit (MB^S)</td>
<td>17</td>
<td>13</td>
<td>10.5</td>
<td>7.5</td>
<td>1</td>
</tr>
</tbody>
</table>

a. Plot the Social Marginal Benefit curve and Marginal cost curve on a graph. Label the graph completely. Identify the deadweight loss area.

b. What is the socially optimal number of clean air for Quahog? If we let the market work on its own, how much air would Peter want filtered and clean? How about Chris? Explain why there is a difference between the socially optimal level of clean air versus how much a free market would provide.

c. Identify one government regulation that can be used to achieve the socially optimal level of clean air. Explain how this can work.

d. How is sustainable development achieved by Quahog in this scenario?
a. The socially optimal level of clean air is 4. Peter would only buy 2 and Chris none. There is a difference between the socially optimal level and what the market provides because with a public good, there is an incentive to free ride. This means that there are individuals who would benefit from the public good even without paying for it. This creates an underprovision of the good. An alternative way of explaining this is with externalities. Given the non-excludable and non-rival nature of a public good, there is a positive externality. If there is a positive externality, the private marginal benefits are lower than the social marginal benefits. The resulting equilibrium quantity is lower than the socially optimal level.

c. One option is for the government to provide subsidies for purchasing clean air filters or planting trees. For every cubic meter of clean air created, the government subsidizes the cost of funding it. This would reduce the marginal cost of production.

d. Sustainable development implies (1) maximization of welfare subject to (2) meeting a sustainability criterion. To achieve part (1) one must recognize that free riding is occurring or a positive externality exists leading to a deadweight loss. The government can provide a subsidy to get closer to the socially optimal level of clean air and reduce the deadweight loss. Implementing this would lead to an increase in economic welfare (because of the reduction of deadweight loss), improvement in environmental welfare because of an improvement in air quality and an improvement in social welfare especially if the poor have a higher value for clean air. To achieve (2), one can employ the weak sustainability criteria. As long as the value of all capital assets (including clean air) is not decreasing in the economy when maximizing welfare, we will achieve strong sustainable development.
4. In Amazonian Ecuador, government-owned forestland was opened to claimants who can establish ownership through use. Here, any Ecuadorian citizen could clear as much forestland as they need and claim it as long as they use it for agricultural production for crops such as corn or soybean.

a. Given the above scenario, is the level of agricultural production “too much” or “too little” or equal to the social optimum? **Explain why this occurs.** Support your answer by drawing the private and social, marginal cost and marginal benefit curves for agricultural production. Identify the deadweight loss area if any exists.

b. Explain the concept of the tragedy of the commons in this context. What will likely happen to the stock of forestland without any regulation? Explain why.

c. Identify a regulation that the government can use to achieve the socially optimal level of agricultural production. Explain how this regulation works.

d. How is sustainable development achieved by the country given that the forestland is easily accessible by any Ecuadorian citizen?

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a. Too much agricultural production occurs. In this scenario, the stock forestland is an open access resource for Ecuadorian citizens which means it is rival and non-excludable. There are private costs to planting agricultural produce, which citizens consider in their decision making process such as the cost of the seeds, the labor cost, the cost of fertilizer, etc. But there is also a cost to one input not paid for: the cost of the forestland. This leads to a difference in private and social marginal cost and over production of agricultural commodities. The deadweight loss is shown in area abc.

![Diagram of private and social marginal cost and benefit curves with deadweight loss area]

b. The tragedy of the commons in this case implies that since there is no single owner of the forestland, each individual will claim an amount of land that is relatively higher because they do not have to pay for it. Also, the cutting down of trees by one individual reduces the available forestland stock for other citizens. It is possible that the forestland will be depleted without a formal or informal regulatory mechanism.
c. One option is for the government to institute a tax depending on how much forestland is cleared. Alternatively, a quota can be used identifying the maximum number of forestland that each household can clear.

d. Sustainable development implies (1) maximization of welfare subject to (2) meeting a sustainability criterion. To achieve part (1) one must recognize that a deadweight loss exists because of the open access nature of the resource. The government regulate use of the common pool resource through taxes or quotas. Implementing this would lead to an increase in economic welfare (because of the reduction of deadweight loss), improvement in environmental welfare because of a prevention of the depletion of the forestland and an improvement in social welfare especially if the poor have a higher value for access to such land. To achieve (2), one can employ the strong sustainability criteria. As long as the value of the forestland stock is not decreasing and the value of agricultural production is not decreasing in the economy when maximizing welfare, we will achieve strong sustainable development.