The Tragedy of the Commons and the Decision-Maker

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Background and Problem Statement

In 1968, Garret Hardin wrote an article in *Science*[1] titled "The Tragedy of the Commons." The article had a significant impact, and the issues it presented were much debated in the fields of ecology, law, philosophy, and psychology. An excerpt of the article that defines the problem follows:

> The tragedy of the commons develops this way. Picture a pasture open to all. It is to be expected that each herdsman will try to keep as many cattle as possible on the commons. Such an arrangement may work reasonably satisfactorily for centuries because tribal wars, poaching, and disease keep the numbers of both man and beast well below the carrying capacity of the land. Finally, however, comes the day of reckoning, that is, the day when the long-desired goal of social stability becomes a reality. At this point, the inherent logic of the commons remorselessly generates tragedy.
>
> As a rational being, each herdsman seeks to maximize his gain, Explicitly or implicitly, more or less consciously, he asks, "What is the utility to me of adding one more animal to my herd?" This utility has one negative and one positive component.
>
> 1. The positive component is a function of the increment of one animal. Since the herdsman receives all the proceeds from the sale of the additional animal, the positive utility is nearly +1.
>
> 2. The negative component is a function of the additional overgrazing created by one more animal. Since, however, the effects of overgrazing are shared by all the herdsmen, the negative utility for any particular decision-making herdsman is only a fraction of -1.
>
> Adding together the component partial utilities, the rational herdsman concludes that the only sensible course for him to pursue is to add another animal to his herd. And another, and another . . . But his conclusion is reached by each and every rational herdsman sharing the commons. Therein is the tragedy. Each man is locked into a system that compels him to increase his herd without limit — in a world that is limited. Ruin is the destination toward which all men rush, each pursuing his own best interest in a society that believes in the freedom of the commons. Freedom in a commons brings ruin to all.

The article continues with the moral, legal, and philosophical implications of the dilemma. While these discussions are beyond the scope of this exercise, you are encouraged to read the entire article.

Questions

You and four other farmers lease land from the government to graze your cattle. The land can support 100 healthy cows, where a healthy cow weighs 500 lbs. (For the sake of simplicity, assume that a cow cannot exceed 500 lbs., and that the entire 500 lbs. is meat available for market). For every cow (above 100) added to the field, each suffers a 10-lb. reduction in weight. Further, assume a cow cannot survive (or is not marketable) below 300 lbs. The government believes in a self-policing policy — you and your fellow farmers must manage your herds on your own. Then answer the questions on the next page.

[1] Hardin, Garrett. "The Tragedy of the Commons." *Science* (December 13, 1968): 1243–1248.

1. Graph the weight of each cow as a function of the number of cows in the field.

2. How many cows will cause the commons to collapse (i.e., at what point does the field fail to support any cattle)?

3. Each farmer (you and the four others) has 20 head of cattle. Develop a spreadsheet that shows the "payoff" or "profit" (your payoff = the number of pounds of cattle) that results from your decision to add or not add one cow vs. every one of the other farmers' decision to add or not add one cow each (the payoff should be in total pounds for each farmer's herd). As an example, the payoff for no one adding more cattle would appear as follows:

You add:	Others add:	Your payoff:	Others' payoff:
0	0	10,000	10,000

Repeat for two and three cows.

4. As a profit-maximizing farmer, do you add cattle? What do the other profit-maximizing farmers do?

5. Now, assume that the other farmers come to you with a plan to share the payoff or profits of a common herd (assuming all five farmers). Show, on a spreadsheet, the results of your decision to add or not add one cow vs. every one of the other farmers' decisions to add or not add one cow.

6. What stands in the way of implementing the plan in Question 5?

7. What other agricultural and industrial systems might be prone to the "Tragedy of the Commons" problem?

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Industrial Engineering
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For the Instructor: Teaching Note on "The Tragedy of the Commons and the Decision-Maker"

Purpose

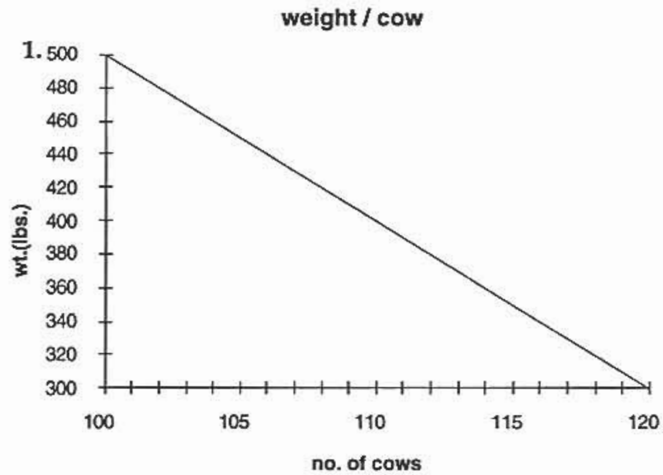
Increasingly, decision analysis techniques are being applied to decisions outside the traditional engineering and business spheres. This exercise is designed to show students that decision analysis is an effective tool for complex environmental issues.

The accompanying article, "The Tragedy of the Commons and the Decision Maker," investigates the failure of the rational decision model under certain resource allocation conditions. Students step through a decision matrix quantitatively showing "the tragedy of the commons." Further questions investigate social systems that can be employed to reduce the impact of the "tragedy."

This material was designed for inclusion in an introductory decision analysis course in industrial engineering; it is also appropriate for MBA students. Students should be familiar with the basic concepts of expected value and decision matrices.

Answers

1.



2. The Commons collapses with 120 cows.

3. Using theses formulae, where y=you and x=others:
your payoff = (20 + y)(500 - 10(y + 4x)),
and if all others add cows, and you don't,
their payoff = (20 + x)(500 - 10(y + 4x))

You add:	Others each add:	Your payoff:	Others' payoff:
0	0	10,000	10,000
1	0	10,290	9,800
0	1	9,200	9,660
1	1	9,450	9,450
0	0	10,000	10,000
2	0	10,560	9,600
0	2	8,400	9,240
2	2	8,800	8,800
0	0	10,000	10,000
3	0	10,810	9,400
0	3	7,600	8,740
3	3	8,050	8,050

4. As a profit maximizer, you and the other farmers will add cows until the commons collapses.

5. Using the formula individual profit = $((100 + y + 4x)(500 - 10(y + 4x)))/5$ where y=you and x=others, the following results:

You add:	Others each add:	Your payoff:	Others' payoff:
0	0	10,000	10,000
1	0	9,898	9,898
0	1	9,568	9,568
1	1	9,450	9,450

6. To succeed, the common herd plan must be accepted by all farmers. If one farmer breaks the agreement, s/he makes profits at the other farmers' expense (as is evident in Question 3). Further, this system hints of socialism—an idea that has its own problems. Generally, the problem must become bad enough to encourage participants to adopt the mutual system.

7. Some examples include:
   - groundwater (industrial use vs. drinking water)
   - breathable air
   - timber
   - fisheries

The matrix at the end of this compendium's Resource List indicates eight books and articles on decision analysis and industrial engineering.

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