Random Allocation in the Local Commons Management

Akihiko Kawaura

Abstract

When the word "tragedy of the commons" gained prominence as a warning against inevitable environmental destruction of common pool resources, the proposed solution was to abandon the commons. Its economic interpretation was either government regulation or privatization. Subsequent anthropological and sociological studies, however, found that many local communities have successfully avoided the "tragedy of the commons" with traditional institutions that emerge spontaneously among themselves. In these local communities, common pool resources are often divided in small units, and randomly distributed across community groups with such mechanisms as lottery and draw. This paper presents a simple two-period model that identifies the condition under which the random process generates incentives for voluntary environment protection. A somewhat counter-intuitive implication of the model is that random allocation facilitates conservation when environmental neglect leads to substantial degradation. It is also observed that the number of groups within the community should remain small in order for the random allocation rule to be an effective protection mechanism.

1. Introduction

When Hardin (1968) coined the word, "tragedy of the commons", in his seminal article to discuss the population and environment problem, the only solution that he envisioned was to abandon the commons. Its economic interpretation was either government regulation or privatization. Subsequent anthropological and sociological studies, however, demonstrated that many of the traditional institutions that emerge spontaneously in local communities were effective in avoiding the environmental degradation of the commons, while meeting the demands of the local people for resource use. In these local communities, common pool resources were often divided in small units, and randomly distributed across community groups with such mechanisms as lottery and draw.

In the area of common land management, McKean (1982, p.71) reports that, in some rural communities in Japan, land is divided and assigned by lot for temporary use by community members with reassignment every 2-3 years. Ura (1993) describes Bhutanese grazing communities where pasture land is divided and distributed by lottery among groups of herders for a grazing season. Examples of forest products management with random allocation include Swiss villages, in which communal forest trees are allocated by lottery among teams of households for annual cutting (Netting 1976, p. 142). McKean (1982, p. 75) also observed that a Japanese village, Hirano, used a lottery mechanism to distribute fodder gathered on village-owned lands. The random allocation is also adopted in fishery resources management. Matthews and Phyne (1988, p.167) report that communities in Grate's Cove, Fermuse and Twillingate, in Newfoundland, Canada, use an annual lottery to assign best fishing grounds among fishermen. A similar system exists in Alanya inshore fishery in southern Turkey, where fishing sites are divided for daily rotation from September to May and fishermen draw lots to decide the starting fishing site (Berkes 1992, p.170).

The purpose of this paper is to offer a simple model of random allocation which highlights the incentives that are conducive to protection of the local commons. The next section presents the model in a two-period framework. The concluding section discusses the model's implications.

2. The Random Allocation Model

Consider that the local common pool resources, such as pastures and fishing areas, are divided and distributed among N groups of community members for one period. The allocation is determined through a random process such as lottery or draw. Distributed resources are returned to the community at the end of the period, and another set of allotment is decided. The payoffs derived from utilizing these N divisions of resources to their full capacity in one period are $\{ P_1, P_2, P_3, \ldots, P_N \}$ with P* being their average. Full utilization of the resource capacity, however, results in environmental degradation. In order to avoid damages to the commons quality, maintenance is necessary. The maintenance cost is m, and is identical across N zones ($m < P_i$ for $i=1,2,\ldots, N$). The maintenance cost either takes the form of explicit outlays to recover the environmental quality, or represents payoffs forgone by abstaining from full utilization to avoid degradation. If a distributed resource zone is fully exploited without any maintenance, its payoff in the next period will be lower by Fm, where F represents the repercussion factor of environmental neglect.[1] The model adopts a two-period framework since a group's decision in the first period affects its own expected payoff in the following period.

A group has two options as it utilizes the commons zone allocated to it in the first period, i.e., maintenance and neglect options.[2] With the maintenance option, it engages in environmental protection by incurring cost m. Its expected payoff in the first period (EM1) is:

$$E_{M1} = P^* - m.$$

The group has its conjecture about the probability, w, that each of other N-1 groups conducts environmental maintenance in the first period, and the expected payoff in the second period (E_{M2}) depends on it. As the number of other groups that maintain the commons quality in the first period, j, could take the value from zero to N-1, E_{M2} would be expressed as:

$$E_{M2} = \sum_{0}^{N-1} {}_{N-1}C_j \cdot w^j \cdot (1-w)^{N-1-j} \cdot \left(P^* - \frac{N-1-j}{N} \cdot Fm\right).$$

Among the possible outcomes is the first period complete conservation (j=N–1), which is observed with the probability w^{N-1}, and leaves the average payoff for the second period at P*.

Under the neglect option, a group's expected payoff in the first period (E_{N1}) is:

$$E_{N1} = P^*$$

since it can fully exploit the resource capacity. Its expected payoff in the second period (E_{N2}) again reflects other groups' choice in the first period, and is specified as:

$$E_{N2} = \sum_{0}^{N-1} {}_{N-1}C_j \cdot w^j \cdot (1-w)^{N-1-j} \cdot \left(P^* - \frac{N-j}{N} \cdot Fm\right).$$

Full degradation (j=0) occurs with the probability $(1\text{-}w)^{N-1}$, in which case the average payoff for the

[1] From the protection effort side, the factor F can be interpreted as the "reward" in the form of avoided decline in payoff.

[2] The model depicts a group's decision before the commons assignment in the first period is determined, i.e., prior to the first lottery. Reformulating the model to begin after the first period distribution is decided does not change the implications of the model.

second period becomes P*– Fm.

A group's choice between maintenance and neglect options depends on the relative size of their expected payoffs in terms of the present discounted value. Denoting the discount rate as r, the present value of the maintenance option payoff is:

$$E_{M1} + E_{M2}/(1+r)$$
$$= P^* - m + \sum_{0}^{N-1} {}_{N-1}C_j \cdot w^j \cdot (1-w)^{N-1-j} \cdot (P^* - \frac{N-1-j}{N} \cdot Fm)/(1+r). \quad (1)$$

Similarly, the present discounted value of the payoff from the neglect option is:

$$E_{N1} + E_{N2}/(1+r)$$
$$= P^* + \sum_{0}^{N-1} {}_{N-1}C_j \cdot w^j \cdot (1-w)^{N-1-j} \cdot (P^* - \frac{N-j}{N} \cdot Fm)/(1+r). \quad (2)$$

A group voluntarily and unilaterally maintains the commons quality if (1) exceeds (2), i.e.,

$$P^* - m - P^* + \sum_{0}^{N-1} {}_{N-1}C_j \cdot w^j \cdot (1-w)^{N-1-j} [(P^* - \frac{N-1-j}{N} \cdot Fm)/(1+r) - (P^* - \frac{N-j}{N} \cdot Fm)/(1+r)] > 0.$$

This condition can be rearranged to:

$$\sum_{0}^{N-1} {}_{N-1}C_j \cdot w^j \cdot (1-w)^{N-1-j} (Fm/N)/(1+r) > m,$$

which is further rewritten with the binomial theorem as:

$$(w + (1-w))^{N-1} (F/N)/(1+r) > 1,$$

and finally as

$$F/N > 1+r. \quad (3)$$

This is the condition for the random allocation rule to motivate environment conservation. As long as this inequality holds, a community member group has an incentive to assume responsibility in preserving the quality of the assigned part of common pool resources. This incentive holds regardless of its conjecture about the probability that other groups maintain their allotted zones in a good condition.

3. Implications of the Model

One somewhat counter-intuitive implication of the model is that random allocation facilitates environment protection when non-maintenance leads to substantial degradation. Confronted with large F, individual groups weigh the potential costs of neglect on themselves in the event of being assigned to the same zone through the random allocation process, and choose to engage in conservation. This in turn requires that the allocation system be sustained without any interruption. If the system is temporarily disrupted and incentives for protection are reduced, a large part of common pool resources may be lost before an alternative institution for resource management emerges.

It is also observed that the number of groups within the community should stay small in order for the random allocation rule to be an effective protection mechanism. A small N would cause a group's payoff in the second period to become more dependent on its own decision in the first period.[3] The model thus supports the view of Seabright (1993, p.114), who argued that the local commons problem was the "small-numbers problem" and distinguished them from global commons issues.

A numerical example highlights the danger of a rise in the number of groups. A discount rate (r) of 0.1 in the community of 4 groups (N) would

[3] One should note, however, that the advantage of small N depends on the assumption that shirking is absent within each group. Reducing N in a community with fixed population results in larger group size, which may tempt individual group members to engage in opportunistic behaviors and hence make the assumption untenable. This is most evident when N is unity, which transforms the random allocation issue into the total collective decision problem for the entire common pool resources.

require that the repercussion factor (F) exceed 4.4. If another group is admitted to use the common pool resources, the minimum repercussion factor jumps to 5.5: More grave consequences from the environmental negligence are necessary to generate conservation incentives. Berkes (1992, page 180) observed that the problem with lottery institution lies in "the difficulty of keeping down the numbers of participants from within the community", and failure to restrict the number could make random allocation ineffectual as a local commons management system.[4]

The condition (3) thus illustrates potential fragility of the local commons even where random allocation has successfully contributed to environment protection. The communities' achievement may be the result of an accidental combination of variables such as F and N, which are subject to change as communities experience various shifts in conditions surrounding them. It is thus important to further examine traditional local commons management mechanisms, and to learn means to avoid their breakdown. The proposal for privatization could come after this effort is exhausted.[5]

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[4] One example of the traditional institution to limit the number of participants that use common pool resources is the lobster (harbour) gang of the fishing community of Maine. They exclude outsiders from catching lobsters in their territory around a harbour. See Brown (2000) and Acheson (1985).

[5] Actually, the proposal for privatization may be viewed as an effort to overcome the "small number" problem. Assuming that the random process determines the commons allocation in the first period, privatization implies that each group continues to use the same zone in the second period. A group's expected payoff in the first period with the maintenance option is $E_{M1} = P^* - m$, which is the same with the original (non-privatization) case. The expected payoff in the second period (E_{M2}), however, becomes P*, as the group can now reap the benefit of its own first-period conservation by itself. The present discounted value (PDV) of the maintenance is:

$$E_{M1} + E_{M2}/(1+r) = P^* - m + P^*/(1+r). \qquad (1)'$$

In contrast, the payoff from its neglect option is $E_{N1} = P^*$, which reduces its expected payoff in the second period (E_{N2}) to P*-Fm. The PDV of the neglect option becomes:

$$E_{N1} + E_{N2}/(1+r) = P^* + (P^* - Fm)/(1+r). \qquad (2)'.$$

Privatization results in environmental protection if (1)' is greater than (2)', and this condition can be expressed as $F > 1+r$. Thus, N is dropped from the condition, and the "small number" is no longer necessary for environment protection. The commons are, however, abandoned in the process.