Regenerating the commons by building institutions

The case in rural India where peasants pool resources

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ABSTRACT

The increasing pressure of a growing population on commons has arisen as a major subject of concern. There is a need to move away from the deteriorating state of open access towards a more regulated state of common property resources. This has given rise to the study of village level institutions, which focus on collective action and peoples' participation, involving the weakest sections of the society. This is a process of institutionalization which can start from within the community by changing informal rules. This can be further supported by the government by changing formal regulations. However, the success of institutionalization depends crucially on the amount of participation of the members of the community.

This paper starts with a case study on a village institution in Bihar. In this case, where peasants pool resources as a contribution to the common, will be represented as a repeated prisoners' dilemma with changing payoffs. The fact whether they pool or not has an influence on their future payoffs. It will be shown how a certain exogenous change in the payoff structure will influence the equilibria for both peasants.

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1. Introduction

People have been living in harmony with nature for centuries. Only in recent times a process of environmental degradation has started. When one thinks of the environment, one soon refers to (tropical) forests, fisheries, pastural grazing lands, etc. These are also known as the commons, because it is not owned by one particular person. The owner will be the state, a group of fishers, a group of cattle-owning-villagers, etc. Sometimes the owners are not determined. This is the case of open access, where people can extract "unlimited" amounts of resources, while nobody is or feels responsible for its regeneration. Even when a few persons would prefer to maintain the quality of the common, they will be unable to do so.

This is exactly the problem I am concerned with in my present study: the management of the commons. Can it still be possible for the people to have open access to the common or should their access be limited? The common can be characterized as a common-pool resource as soon as some rules concerning ownership and extraction do emerge in the community. This is a process of institutionalization. In this context I will define institutions as rules of the society which structure the interaction between man and man. In that sense, institutional change can be thought of as a change in the operational set of rules. The common-pool institution structures the management of the common-pool resource for the user group by imposing rules on the members. Initially, these rules will be quite informal and they will be guided by the existing norms, values, taboos, traditions and codes of conduct. When the users will see improvement in the common and their returns increase or maintain, an incentive to improve the formulation of rules will be created. This can lead to a more formal structure of the common-pool institution, where the constitution, laws, and/or property rights will be adjusted.

This process of institutionalization at the village level is closely related to the concept of collective action and peoples' participation, where people (1) contribute to the development effort, (2) share in the benefits, (3) involve in decision-making as well as (4) in evaluation[1]. This is what I think the most crucial factor for common-pool institutions to develop fruitfully. Without participation, institutions will loose their value. The

1See for instance Lise(1995a).

interaction between people and common will move towards open access, mainly due to people losing interest in the process.

The major research question is to find those conditions under which the people can be moved and motivated to participate. The first component of participation, a contribution to the development effort, will be represented by the case where peasants have to choose repeatedly between either pooling land or labour or not. Once they have pooled some resources, they will be put continuously for the choice to either continue to pool or to withdraw their resources. The case where peasants pool or not was also analyzed in Lise (1995b) in a more static sense. Here I will extend the analysis by considering a more dynamic representation of the game. I will discuss the consequences on the value of the minimum required discount factor in section 3. The model will be supported with a case study in section 2. The existence of the minimum required discount factor is proved in the appendix in section 5. Section 4 concludes.

2. Chakriya Vikas Prenali in South Bihar[2]

Bihar is known for its green forests. Nowadays the existence of these forests is seriously threatened. There are several reasons why these forests disappear, like the increasing pressure of the local population, industrialization and the inability of the forest department to check this process of forest degradation.

As a voluntary response towards this degradation process, people in 30 villages of Bihar were motivated to pool resources in their own village. These resources would be regenerated under the system of 'Chakriya Vikas.' This circular system of development is based on the philosophy that once the initial investment has been made and when one round of the circle has been completed, it will become a self-regenerating and self-reliant process. The circle consists of planting short-term products like vegetables, medium-term products like bamboo, fruit-trees and fuel and fodder trees, and long-term products like timber-trees. All these products are planted on the land which is pooled by the participants. The quality of this land is low in general which makes it easier for the

[2]Earlier reference to this case can be found in Kadekodi and Lise (1994), Lise (1995a), and Sinha (1995).

people to pool. The quality of the land in the pool can be improved by constructing rain-catchment structures like tie-ridges, wells, tanks and check-dams. The arrestment of rain has prior importance in this dry region of Bihar, where the land only gets moderate rain during the monsoon period, which is less than three months in the year. That period is too short to complete a crop, while the nursery of tree-seeds and seedlings requires water throughout the year.

This process of investment in environment has been started by P. R. Mishra in 1987 who was also the main responsible person to change the attitude of the villagers in Sukhomajri[3], such that they refrained from free grazing. The nearby common could regenerate, due to full protection of the villagers by stopping the process of free grazing by goats and cows. They changed their focus to buffalo-rearing with a focus on the production of milk. The feed teir buffaloes with grass which they can collect from the common. The growth of fodder and babbar grass is even declining due to the increase in the number and size of the trees.

3. A **dynamic game representation of the pooling situation**

Let us consider the case-study in a more abstract manner. Assume that two peasants are taken arbitrarily from a certain community. Due to the effort of the local non-governmental organization are they repeatedly put for the choice to either pool a part of their private resources like labour, land, water, cattle, etc. or not. Once they have pooled some resources, they can consider the possibility to either continue pooling or to withdraw their resources.

When one peasant pools, while the other does not pool, the single pooler has to do all the work for the common, while the other can focus his attention on other work, while he is still able to use the common. Hence, he can free-ride. Finally, when both do not pool at all, they will leave their waste land barren and it has a marginal utility for whatever is left as grazing land. Nobody will take care for the regeneration of the common. Then the free-rider problem is most severe. This is the situation of the prisoners' dilemma.

[3]See for instance Chopra et al (1991).

Let us formalize this as a symmetric 2-person 2-strategy noncooperative repeated game $\Gamma = (S, \delta, R, P, g)$ in the following manner.

a) Let $i \in I = \{1, 2\}$ be the set of players.

b) The possible actions of all players are as discussed. Hence, their strategy space does always consist of two strategies: S^* is either {pool, not} or {continue pooling, withdraw}. This will be abbreviated as {P, N} and $\{CP, W\} = \{s^1, s^2\} = S_i$ for all $i \in I$. Then the joint strategy space is given by $S = \sum^2_{i=1} S_i = S^* . S^*$. Let s_{it} be the action of player i at time t, then $s_t = (s_{1t}, s_{2t})$, is the vector of actions at time t chosen by all players.

c) This game is repeated infinitely. The importance of the future of the players is expressed with the following discount factor $\delta = (\delta_1, \delta_2)$.

d) It is assumed that a players' payoff does not only depend on the actions, but also on the amount and quality of the natural resources R in the common. At time t, $R = R_t$ is a real non-negative number, $R_t \in [0, \infty)$. Notice here that R_t crucially depends on all past actions and therefore summarizes the history in a single numerary.

e) For all $s_t \in S$ and for all $R_t \in [0, \infty)$, $P_{it}(s_t, R_t)$ denotes the payoff of player i at time t when all players selected their action according to s_t, where the resource level is R_t. Hence, R_t changes endogenously, dependent on the past choices of the players and has as such an indirect effect on the payoffs. Under discounting the net present value of players i's payoff will have the following structure: $P_i = \sum^T_{t=0} \delta^t_i P_{it}(s_t, R_t)$. $P = \prod^2_{i=1} P_i$ is the aggregate payoff set.

f) Let $g_{it}(s_{it-1})$[4] be the state for player i at time t when (s)he played strategy s_{it-1} in the last period. This will lead us to the following rules:

   i) g_{it}: {P, CP} -> {CP, W};

   ii) g_{it}: {N, W} -> {P, N}.

   Hence, in every period, we have to deal with 2x2 game, only the possibility of choosing a strategy depends crucially on his/her last strategy.

I will use the concept of subgame perfect equilibrium throughout this paper.

[4] g_{it} only depends on the value of the last action. This makes it a Markovian function.

Consider the following representation of the pooling game, which is a symmetric bimatrix game.

Game Γ = (S, δ, R, P, g):

2 / 1	Pool (Continue Pooling)	Not (Withdraw)
Pool (Continue Pooling)	$x(R_t)$, $x(R_t)$	$b(R_t)$, $a(R_t)$
Not (Withdraw)	$a(R_t)$, $b(R_t)$	$y(R_t)$, $y(R_t)$

Here $P_{1t}((P,P),R_t) = x(R_t)$ denotes the payoff to player 1, when both decide to pool, at resource level R_t, at time t. $a(R_t)$, $b(R_t)$ and $y(R_t)$ can be described analogously. In the case of the prisoners' dilemma the payoffs have the following ordering:

$$a(R_t) > x(R_t) > y(R_t) > b(R_t) \tag{1}$$

We can find a credible threat in the case of the prisoners' dilemma when we apply the following trigger strategy where both peasants will continue to pool until one or the other deviates for the first time. After that both will refrain from pooling for ever.

$$\sigma_1 = \begin{cases} \text{Pool} & \text{as long as no defection took place;} \\ \text{Not} & \text{otherwise.} \end{cases}$$

This trigger strategy will give the following restriction on the discount factors of both players. On the left side of the inequality is denoted the payoff when both will continue to pool. On the right side we can read the payoff where one defection took place at time τ.

$$\sum_{t=0}^{\infty} x(R_t)\delta^t > \sum_{t=0}^{\tau-1} x(R_t)\delta^t + a(R_\tau)\delta^\tau + \sum_{t=\tau+1}^{\infty} y(R_t)\delta^t \tag{2}$$

However, this formula is not solvable and it will not be possible to get an explicit expression for the critical discount factor.

Let us consider the following scenario:

Assumption 1: The common is preserved well until defection takes place. Hence, $x = x(R_t)$, $y = y(R_t)$, $a = a(R_t)$, $t < \tau$.

Assumption 2: After defection the common will be overdepleted. This will result in a decrease in the payoffs. Let α (<1) be the fraction of the last payoff, then: $x(R_t) = \alpha x(R_{t-1})$, $y(R_t) = \alpha y(R_{t-1})$, $a(R_t) = \alpha a(R_{t-1})$, $t>\tau$ or $x(R_t) = \alpha^{t-\tau}x$, $y(R_t) = \alpha^{t-\tau}y$, $a(R_t) = \alpha^{t-\tau}a$, $t>\tau$.

Under this set of assumptions it will be shown that it is possible to get an explicit expression for the critical discount factor of the dynamic (super) game. When all the values of the two assumptions are substituted in inequality 3, then the following inequality must hold in order to have (pool, pool) as a subgame perfect equilibrium.

$$x\sum_{t=0}^{\infty} \delta^t > x\sum_{t=0}^{\tau-1} \delta^t + a\delta^\tau + y\alpha^{-\tau}\sum_{t=\tau+1}^{\infty} (\alpha\delta)^t \qquad (3)$$

Rewriting this expression gives us the following polynomial expression, keeping in mind that $(1 - \alpha\delta) > 0$, since $\alpha<1$ and $\delta<1$.

$$p(\delta) = \alpha(a-y)\delta^2 - [\alpha(a-y) + (a-\alpha x)]\delta + (a-x) < 0 \qquad (4)$$

Based on the last inequality, the following theorem can be formulated:

Theorem 1: The parabola of condition 3 has exactly one real root in the interval between zero and one. This is exactly the lower bound of the discount factor for both players to have (pool, pool) as the subgame perfect equilibrium outcome.

Proof: See appendix.

From theorem 1 we know that a critical discount factor exists. It has the following value:

$$\phi = \frac{[(1+\alpha)a-\alpha(y+x)]\delta - \sqrt{[(1+\alpha)a-\alpha(y+x)]^2-4\alpha(a-y)(a-x)}}{2\alpha(a-y)} \qquad (5)$$

This critical discount factor can be compared with the result for the case where the payoffs were fixed. Then it can be proved that the critical discount factor ϕ under the present scenario is strictly smaller than the critical discount factor under fixed payoffs[5].

Theorem 2: $\phi < \phi_p = (a-x)/(a-y)$

Proof: See appendix.

[5]This critical discount factor can be derived by solving condition 1, using the notation from assumption 1. See also Lise (1995b).

4. Conclusions

The analysis of this paper shows that a dynamic game can lead to an explicit expression for the minimum required discount factor under which it is most beneficial for both peasants to participate. In an intuitively viable scenario the common would be preserved until defection, hence fixed payoffs, and will be overdepleted after that due to the trigger strategy which prescribes no pooling after a defection, then payoffs will decrease linearly. It has also been shown that the critical discount factor is strictly smaller than the critical discount factor under fixed payoffs. This approach is a first step towards a more general analysis of a dynamic game of the pooling situation. The application of this technique to Bihar can serve as a stimulation for other projects to use the same philosophy.

In this paper I have sketched a possible way to analyze village level institutions where voluntary action of the people can serve as a method to preserve the environment. Their environment is represented by the common from which the people of the village extract their resources like fuelwood, fodder and other grasses. The complete picture is far from given by this approach. However, it can also serve as a support for undertaking an empirical research in the field of management of the village commons. I hope that we can extend our knowledge by learning from the people at the grassroots in the nearby future.

5. Appendix Proof of theorem 1 and 2

The proof of theorem 1 will be given in three steps:

Step 1: I show that the discriminant is positive. This will imply two real roots.

The discriminant has the following value:

$[\alpha(a-y) + (a-\alpha x)]^2 - 4\alpha(a-y)(a-x) > 0.$

When we work out the square, we get the following expression:

$\alpha^2(a-y)^2 + (a-\alpha x)^2 + 2\alpha(a-y)(a-\alpha x) - 4\alpha(a-y)(a-x) >$

$\alpha^2(a-y)^2 + (a-\alpha x)^2 - 2\alpha(a-y)(a-\alpha x) =$

$[\alpha(a-y) - (a-\alpha x)]^2 \geq 0.$

The strict inequality holds because, $(a-\alpha x) > (a-x)$, since $\alpha < 1$.

Hence, the discriminant is strictly positive. Q.E.D.

Step 2: I will show that the root with the plus-sign is bigger than one.

Let us denote the coefficients of p(δ) as follows:

$$a = \alpha(a-y);$$

$$b = -[\alpha(a-y) + (a-\alpha x)];$$

$$c = (a-x).$$

We have to prove that the following inequality holds:

$$\begin{aligned} \frac{-b + \sqrt{b^2 - 4ac}}{2a} > 1 &\Leftrightarrow \\ \sqrt{b^2 - 4ac} > 2a + b &\Leftrightarrow \\ b^2 - 4ac > 4a^2 + b^2 + 4ab &\Leftrightarrow \\ a + b + c < 0 &\Leftrightarrow \\ (a-x) + \alpha(a-y) - \alpha(a-y) - (a-\alpha x) < 0 &\Leftrightarrow \\ (a-x) < (a-\alpha x) & \end{aligned}$$

This is true, since $\alpha < 1$. Q.E.D.

Step 3: It will be shown that the root with the minus-sign is smaller than one.

For this proof we have to make use of the same notation as in step 2:

$$\begin{aligned} \frac{-b - \sqrt{b^2 - 4ac}}{2a} < 1 &\Leftrightarrow \\ -\sqrt{b^2 - 4ac} < 2a + b &\Leftrightarrow \\ \sqrt{b^2 - 4ac} > -2a - b &\Leftrightarrow \\ b^2 - 4ac > 4a^2 + b^2 + 4ab & \end{aligned}$$

This is the same inequality as in step 2 and the same reasoning applies here. Hence, the proposed inequality holds. Q.E.D.

On basis of these three steps and the fact that p(δ) is a dale parabola, which should be smaller than zero, it can be concluded that the root of step 3 is the sought for critical discount factor. Q.E.D.

The proof of theorem 2 can be found directly:

Here we have to proof that ϕ < (a-x)/(a-y). For that the notation of step 2 of the last proof will be used again.

$$
\begin{aligned}
\frac{-b-\sqrt{b^2-4ac}}{2\alpha(a-y)} &< \frac{a-x}{a-y} \Leftrightarrow \\
-\sqrt{b^2-4ac} &< 2\alpha c + b \Leftrightarrow \\
\sqrt{b^2-4ac} &> -2\alpha c - b \Leftrightarrow \\
b^2 - 4\alpha(a-y)c &> 4\alpha^2c^2 + b^2 + 4\alpha c[\alpha(a-y)+(a-\alpha x) \Leftrightarrow \\
-(a-y) &> \alpha(a-x) - \alpha(a-y) - (a-\alpha x) \Leftrightarrow \\
y &> \alpha y] \Leftrightarrow \\
1 &> \alpha
\end{aligned}
$$

This was already assumed and the inequality holds Q.E.D.

6. References

1. K. Chopra, G. K. Kadekodi, and M. N. Murty, 1990, Participatory development, people and common property resources, Sage publications, New Delhi, pp. 163.

2. G. K. Kadekodi and Wietze Lise, 1995, Investment in ecology by peoples' participation, **Asian Pacific Journal of Energy**.

3. M. C. W. Janssen, J. Gorter and S. van de Meerendonk, 1993, Cooperation in finitely repeated prisoners' dilemma, Tinbergen Institute, Erasmus University Rotterdam, discussion paper, TI 93-205.

4. W. Lise, 1995a, Participatory development, a path to ecological preservation, an approach with case studies and modelling, **International Journal of Environment and Pollution 5**, 243-259.

5. W. Lise, 1995b, Preservation of the commons by pooling resources, modelled as a repeated game, Centre for Development Economics, Delhi School of Economics, Working paper series, No: 27.

6. S. Sinha, 1995, The Chakriya Vikas Pranali, Economic Development Associates, Final report, 1.