The Evolution of Cooperation at Saigata Commons: A Game Theoretic Interpretation

Sudeepto Bhattacharya

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SHODH: The Institute for Research and Development
50, Puranik Layout, Bharatnagar
Nagpur, Maharashtra
India
E-Mail: shodh_ngp@sancharnet.in
Website: www.shodh-research.org

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1. Introduction

We present an essay about the community cooperation that has emerged at a CPR at a village comprising a heterogeneous community in Central India.

Being subtractable by consumption and rival in nature, CPRs may perish due to exploitation by appropriators (Ostrom et al., 1994; Baland and Platteau, 1996). The high cost of exclusion coupled with rivalness and subtractibility of CPRs have often tended to render the resources vulnerable to degradation and extinction, thus calling for a management scheme to be implemented for resource conservation. The four regimes of (i) open access; (ii) public property; (iii) private property and (iv) common property are fundamental categories in CPR management. (Bhattacharya and Hussain, 2003).

CPRs have been shown to play crucial role in village economy, performing certain vital functions such as that of subsistence, productive, social security, equity, employment generation, resource and habitat conservation and ecological sustainability (Baland and Platteau, 1996; Bahttacharya and Hussain, 2003). These functional features make the CPRs an important contributor to the consumption basket of the rural populace.

In the present essay we focus on Local Commons, commons for which the resource community comprises the villagers of Saigata village of Brahmapuri Taluka in the Chandrapur district of eastern Maharashtra State.

This essay does not analyze or investigate upon the possible reasons functional in promoting and the emergence of cooperation among individual members of the resource community of the CPR, but merely interprets the existing scenario of such a cooperation in the language of game theory.

The second section identifies the forest at Saigata as a CPR and briefs on its emergence as a CPR. In section 3, we verify the validity of the design principles in the CPR in focus, and in the fourth section we specify the research problem and the method adopted basically for data collection. Section 5 discusses the emergence of cooperation among the individual members of the resource community of the above CPR, with the essay concluding in section 6.

2. Characterization of the forest at Saigata as a CPR.

The following features characterize Common Pool Resources (CPR)

(i) A user group, referred to as the resource community, jointly using the resources;

(ii) Rivalness — consumption by one member of the community reduces the share of the resources available to the others;

(iii) Costly excludability - due to high cost of exclusion, it is difficult to control use of the resources by any individual member;

(iv) May or may not have formal or informal property rights attached.

In Saigata, the forest resource was open access from the mid 50's till the mid 70's, and thus was free good or non - property, freely available to all users. This situation brought about an absence of attenuation, consequently leading to over- consumption of the forest resource thereby reducing it from thick canopy forest to a degraded land. Since mid 70's however, a new and essentially ecological awareness coupled with cognition about the immediate

future occurred among the villagers, particularly catalyzed by a small group of about 21 resource users belonging to the ***Krishak Charcha Mandal*** of the village initiating such a thought process (for details refer to Ghate 2004). This initiative soon saw concerted efforts being undertaken by the resource community to halt any further degradation of the common, simultaneously setting the process of transforming the forest from open access to common property regime. The scenario also led to the emergence of an informal institution called ***Van Sanrakshan Samiti,*** meaning Forest Protection Committee (FPC) in 1979 with its general body, the ***gramsabha,*** comprising the adults of each family of the village as members, governing the forest use for the appropriators through defining and evolving rules and sanctions, characterized by their adaptivness and dynamism. Each household of the community shares the responsibility of vigilance and monitoring anthropogenic activities in the forest and keeping regular watch round the season, not only from within, but also from outside of the village. These activities were labeled ***shramdan*** or voluntary labour, and incidentally did have around 25% free riders. Salaried guards from amongst the villagers were appointed in around early 80's, with the salary generated through an equitable annual contribution from the resource community. Since 1993 the FPC has two guards in employment, with their salary maintained through equal annual monitory contribution from the villagers

These operational rules not only have effected conservation of the forest biodiversity at Saigata, but have also been instrumental in improving the overall forest quality as well as evolving a community based forest management system. The community treated different patches of the forest bearing various traditional names as the management zones. Each management zone has its harvest cycle of forest product earmarked, and would thus remain closed for harvest during a fixed period of time each year to allow natural regeneration. Sanctions were levied on each management zone on the type of product that could be harvested from it. Local ecological knowledge was on display in regenerating certain floral species in the forest (Ghate et al. 2001)

In 1993, the resource community formally constituted the Forest Protection Committee with a representation of two adult members from each household of the village in its ***gramsabha,*** under the Joint Forest Management (JFM) programme mooted by the Forest Department, Maharashtra State. However, despite joining JFM, for all practical purposes the resource community ay Saigata continues to implement its earlier evolved institutional instruments and structures. The FPC members have initiated, cooperated on and regulated various forestry and forest management activities to enhance the quality of the forest, as also to augment the ecological services obtained from the forest to the community. The rules enforced are adaptive in nature and are framed as well as modified through democratic participatory process of the members.

Occasional rule breakings and other kinds of defections including withholding help in the participatory process for biodiversity conservation do happen at Saigata. Rule breakings show a seasonal variation with escalation during the summer months of April to June. Defectors usually are apprehended and are punished with the punishment varying in degree proportional to the offence, and virtually never are the punishment too costly for the punisher, the FPC'.

With the enhancement in the health of the forest and increasing of canopy cover and foliage, wildlife, particularly the ungulates started visiting the forest gradually. During the late eighties onward respondents report the sightings of chital (spotted deer ***axis axis),*** neelgai (largest of the Indian antelopes, ***Boselaphus trogocamelous)***, hare (***Lqpus nigricollis),*** wild boar ***(Sus scrofa)*** and birds of various species at a significant frequency. The early nineties saw the arrival of the wolf ***(Cams lupus)*** and the leopard ***(panthera pardus).*** In 2002, the villagers sighted the tiger (***panthera tigris tigris)*** in their forest for the first time.

The basic factor for this conservation and management success of the Saigata community is its decision to adhere to the adaptively evolved rules of the FPC, without the presence of either a central authority or an outside agent to enforce the rules.

The present essay gives a game theoretic interpretation of the emergence of cooperation among the resource users towards a community action to conserve the forest and associated biodiversity at Saigata.

3. Design Principles for the CPR at Saigata.

The analysis of successful community management of CPRs focus on four sets of attributes, describing typical CPRs (Ostrom et al, 1994; Bhattacharya and Hussain, 2004). The attributes comprise

(i) Physical characteristics of the CPR and the technology used to appropriate resources;

(ii) Tools for decision making that govern relationship among the members of the resource community;

(iii) Patterns of interaction among the decision makers upon choice of strategy for the game;

(iv) Outcomes of such interactions.

In spite of the fact that the operational rules may vary across various successful CPR management institutions, a set of necessary and sufficient conditions, called design principles, remain common to all the CPR regimes to be successful Since Saigata forest management is an example of such a success, we document the validity of the design principles operational at Saigata and list these below in summary (Ostrom et al, 1994; Baland and Platteau, 1996, Bhattacharya and Hussain, 2003).

(i) Presence of boundary: The area under the jurisdiction of the FPC has been demarcated and defined through governmental agency.

(ii) Congruence between rules and local conditions: The general operational rules for the FPC are broadly defined by the Forest Department. These rules however, are responsive to local situation and are adaptive in character.

(iii) Collective choice arrangements: Local variations in the above set rules through a need based choice is allowed for.

(iv) Monitoring: The members of the ***gramsabha*** undertake voluntary monitoring on a regular basis, in addition to the pair of salaried guards appointed for the purpose of vigilance.

(v) Graduated sanctions: FPC punishes offenders and defectors according to the severity of offence. Punishment ranges from warnings, to public humiliation and fines, as decided by the ***gramsabha.*** Filing of legal complaints is rarely resorted to.

(vi) Conflict resolution mechanism: The ***gramsabha*** meets at regular interval to provide platform to resolve conflicts.

(vii) Recognition of rights to organize: The FPC, formed under the JFM by the Forest Department is recognized as the legitimate organization of the resource community.

(viii) Nested enterprises: The operational arena of the FPC comprises the government officials from the Forest Department and legal components.

4. Research problem and method.

The research problem is:

How did cooperation to conserve biodiversity at Saigata get a foothold and evolve in an overwhelmingly large population of non-cooperators, without a central authority?

Method:

Collection of data has been done through a number of interviews conducted at randomly chosen time intervals, with the community members. A wide use of literature has then been made to provide a game theoretic interpretation of the scenario.

5. Evolution of cooperation.

In the context of conservation of biodiversity at Saigata, cooperation will mean providing help in the collective action through participation in the effort to conserve, while defection will mean either withholding help or causing infraction by choice of action.

The issue is that while individuals can benefit from mutual cooperation, each one of them can also do even better by exploiting the cooperative efforts of the others. This core problem on emergence of cooperation amongst egoists in absence of any central authority has been deliberated upon by several researchers in a variety of contextual settings (Axelrod, 1980a; 1980b; 1981; 1997; and Hamilton, 1981; and Dion, 1988; Dawkins, 1976; Hamilton, 1964; 1967; Hardin 1968; Hardin, 1971;Hinckley, 1972; Nigel, 1971; Jervis, 1978;Luce and Raiffa, 1957; Lumsden, 1973; Maynard Smith, 1974; 1978; and Price, 1973;Rapoport, I960; Schubik, 1970; Taylor, 1977; Trivers, 1971). Our work in interpreting the genesis and nature of cooperation in this paper closely follows in the trend of the above-cited seminal and fundamental results.

Game theory in general and the choice scenario of the Prisoner's Dilemma game in

inherent in situations when n number of individuals interact in a public goods collective action. These games will substantiate the basis of our interpretation of the Saigata scenario in the present paper. For the sake of being rudimentary, we have remained confined to the assumption of pair wise interactions among the individual members of the resource community, and thus have focused only on the two — player version of the above games while interpreting the real - life situation.[2]

Each of the two individual members of the resource community interacting in a Prisoner's Dilemma game has two distinct options for strategy choice - either to cooperate or to defect. The payoff matrix with sample utility points attached to the payoffs for the game is shown in Figure 1 (Axelrod, 1997).

Player 2

Player 1

R=3, R=3	S=0, T=5
T=5, S=0	P=1,P=1

Figure 1

The two constraints defining the Prisoner's Dilemma game are:

(i) $T > R > P > S$;

(ii) $R > (S + T)/2$.

As is evident from the matrix, irrespective of the strategy opted by the other player, the self - maximizing choice of defection yields a higher payoff than cooperation.

The 2 - player version of the game may not capture all the characteristics (other than the most essential ones) of most of the interactions among the members of the resource community, which gives rise to collective action situation with provision of public goods at stake, like the present situation. In such a situation, an individual's choice behaviour will typically depend on the rest of the group's

If the 1st player cooperates, then there is a choice for the 2" player to either cooperate and gain R points of utility (the reward for mutual cooperation), or to defect and to gain T points of utility (the temptation to defect). Constraint (i) implies a player fetches higher points by defecting if the other player cooperates. If, however, the 1st player defects, then there is a choice between cooperation, yielding S points of utility (sucker's payoff), or defection, yielding P points (punishment for mutual defection). Since constraint (i) implies P >S, it pays to defect if the other player defects. Therefore it pays to defect always irrespective of the choice of strategy of the other player. However, through mutual defection, both the individuals obtain P rather than R points of utility, which they both could have obtained had they cooperated. Hence, individual rationality leads to a sub- optimal outcome for both the individuals, and hence the dilemma. Constraint (ii) implies that being exploited is not as good an outcome as mutual cooperation.

If the two individuals playing the above game never meet again, i.e. if they play single - shot Prisoner's Dilemma game, then the only strategy that is the solution for the game is to defect, thus becoming the Nash equilibrium. The strategy to defect, in this context, also becomes a collectively stable as well as an evolutionarily stable strategy (Baland and Platteau, 1996).

However, in the domain of normal and regular village level interactions, two individuals have a finitely high probability to met more than once, and in general the number of such interactions that the two may undergo is not fixed in advance. (If there exists a fixed, pre - decided number of interactions between the two, then again by theory of backward induction it can be proved that to defect always would be the only Nash equilibrium and collectively stable strategy).

Some probability, w, can then be associated with the interactions as an indicator of the fact that after the current interaction, the same pair of individuals will meet again. This probability we [0,1] is the discount parameter, representing the degree

to which the payoff of each move is discounted relative to the previous move. The smaller its value, the less important the future becomes relative to the present.

Collected field data shows that poverty has not made the discount rate high for the villagers of Saigata, and their time preference is biased towards future consumption. Their mode of an almost total dependence on the forest for livelihood has gradually shown a shift towards reduced dependence, with the populace finding out exit options from the acute poverty trap. The villagers have found occupations in the fields, forestry work and in the nearby towns. It would therefore be logical to assume a reasonably high value for w in our discussion.

In Saigata, the general concern about biodiversity of the village being lost found its manifestation through the members of the ***Krishak Charcha Mandal,*** with all its 21 members resolving to initiate a collective action to conserve as also rejuvenate the biodiversity of the village forest.

These 21 individuals were the initial cooperators, who would always reciprocate cooperation. Their iterated pair wise interactions would then result into each individual's receiving a utility of R points per move as indicated in Fig. 1.

As shown above, to defect always using the strategy ALL D is collectively stable (Axelrod, 1997). Therefore the 21 cooperating individuals had to invest a high effort to reach out the issue of the necessity of conservation of the CPR and thus enhance the forest biodiversity to the other resource community members.

In their effort through routine and regular village level interactions, the cooperators could realize that a conversion of the villagers from defectors to cooperators, i.e., invading the defectors (cooperators obtaining a higher average score when playing an ALL D, than that obtained by ALL D playing other ALL Ders) would require not individual but concerted, joint effort to be invested. This was basically so because whenever a cooperator would arrive in an environment which was

overwhelmingly dominated by the always defecting ALL D players, the lone newcomer would not have any other player who would reciprocate cooperation for it to secure a foothold at least.

The cooperators found that instead of individual efforts, if the effort to invade would be made as a cluster by all or a few of them, they would stand a much better probability of succeeding to invade the ALL D population, thereby fetching cooperation a foothold. This fact could be understood using a numerical illustration discussed below.

Since the value of w is high for the resource community, we set w = .9. Let V (A | B) be the expected payoff (in terms of utility) an A - strategist gets while playing a B - strategist. Consider the following interactions, where we use the payoff values from the payoff matrix in Fig. 1.

$$\begin{aligned} V(\text{ALL D} \mid \text{ALL D}) &= P + wP + w^2P + \ldots \\ &= P/(1-w) \\ &= 1/.1 \\ &= 10. \qquad (1) \end{aligned}$$

$$\begin{aligned} V(\text{ALL C} \mid \text{ALL D}) &= S + wP + w^2P + \ldots \\ &= S + wP/(1-w) \\ &= 0 + .9/.1 \\ &= 9 \qquad (2) \end{aligned}$$

$$\begin{aligned} V(\text{ALL C} \mid \text{ALL C}) &= R + wR + w^2R + \ldots \\ &= R/(1-w) \\ &= 3/.1 \\ &= 30 \qquad (3). \end{aligned}$$

The above shows that if the ALL C's are a negligible proportion of the entire population, the ALL D ers will almost always interact with each other and will score 10 points each, as implied by equation (1). Lone ALL C ers cannot get cooperation a foothold, as their score of 9, given by equation (2) is even below that of the average scores of ALL D ers. However, equation (3) implies if the ALL C ers have a sufficient proportion of their interactions with themselves through reciprocating cooperation, each of them then will get enough opportunity to score 30 points.

If an ALL C player has a proportion p of its interactions with other ALL C ers and a proportion 1-p with ALL D ers, then his average score will be 30p + 9(1-P).

ALL C players in a cluster will do better than the ALL D players if

30p + 9(l-p)>10.
=>21p + 9> 10
=>p>l/21.

.'.even if only 5% of the interactions of the ALL C ers are mutual , the cluster of ALL C players will record a higher average score than the large population of ALL D ers they enter. Also, since the ALL C players do very well when they meet each other, they do not need to meet each other very often at the village level interactions to make their strategy superior to ALL D. Thus, when w is large enough, a cluster of ALL C players can become viable in an environment composed overwhelmingly of ALL D ers.

The 21 individuals could thus convert more individuals to be cooperators at Saigata. Initially, these converts too were landholders, who apparently understood the imperative of conservation and regeneration of the forest because they had a

high stake involved in the process. Being landed, they would require agricultural equipments, most of which are made of wood from big sized trees. In absence of such trees, the cost to invest for procuring the implements would go much higher, with a sizeable reduction in the profit margin. The landless, on the contrary, were better off individually to act rationally by exploiting the forest resource with a concern about the immediate present, since they were at the subsistence level already.

Initial moves as also the later ones by the cooperators had been such that the cooperators would never be the first to defect. Such a strategy has never made the initiator a sucker. Respondents however inform that while playing the other landholders reluctant to cooperate in the cause of conservation of CPR as also the landless, these cooperators would immediately reciprocate defection by punishment. Generally, therefore, the cooperators adopted a Tit For Tat strategy (TFT), which cooperates on the first move and then does whatever the other player did on the previous move. Such a strategy has been categorized as a ***nice*** strategy by Axelrod (Axelrod, 1981) - a strategy that will never be the first to defect, but is provocable and immediately reciprocates any defection unforgiving.

TFT, adopted adaptively initially by the cooperators, spread in the whole population of defectors once a cluster of cooperators invaded them. Such a strategy, given a large enough value of w as it is in Saigata, will remain collectively stable (Axelrod, 1981). Therefore, such a strategy would never be invaded by an ALLD in the current environment, or by a cluster of ALLDers. Hence, cooperation once started, would get established and robust, thus promoting a sustained cooperation between the resource community members to ensure conservation and management of the CPR.

6. Conclusion

The foregoing discussion interprets the community action to cooperate for conservation and management of CPR at Saigata, which they have now come to identify as 'my forest', as a Prisoner's Dilemma game, thereby reflecting individual choices in public goods interactions. It illustrates how cooperation among the members of the resource community can emerge in a population dominated by non — cooperators. Cooperation, however, fails to get a foothold if an individual or a scattered aggregate of cooperators attempts an interaction with the defectors. It can emerge .and become established through interactions between a cluster of cooperating individuals using a nice strategy like the TFT and the unconditional defectors, provided these individuals have approximately 5% of their interactions with each other. Such an interaction results into an invasion of the entire environment by the cooperators, making cooperation to conserve CPR thrive at Saigata.

Nice strategies as TFT can become collectively stable if w is large, which at the present time is so at Saigata. TFT is also robust and can protect itself against any cluster of individuals using any other strategy as well as against a single individual (Axelrod, 1981).

Thus in Saigata forest, mutual cooperation for biodiversity conservation and management of the CPR has emerged in a world dominated by unconditional defectors without a central authority by initiating with a cluster of individuals adopting a nice strategy of reciprocal cooperation.

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