Cooperation under alternative punishment institutions: Experimental evidence from commons' dilemma

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Abstract

Although common property right has been observed to outperform state property right in sustaining commons and thereby generating efficiency gain, observations in the field reveal a great deal of variation in resource outcomes. In this paper, using a common pool resource (CPR) framed field experiment, we examine whether cooperation in resource appropriation varies with alternative enforcement institutions. Our treatments included open access regime as a baseline treatment, external/third party enforcement institutions (collective punishment and individual random fine punishment) and peer/diffused punishment mechanisms of the forest commons management. We found that, compared to baseline treatment, all the treatments considered sustained cooperation (reduce resource extraction level), but peer punishment instrument appears to be the strongest deterrent of free-riding behaviour. Among externally imposed enforcement institution, collective punishment performed better than individual random fine treatment. Overall, the analysis shows that peer punishment mechanism (endogenous institution) proves to be effective instrument to correct coordination problems of commons management than external enforcement alternatives. However, there is evidence that the efficacy of the former depends on the cost of enforcement. In terms of policy choice, our results corroborate the significance of devolving authorities to enforce commons management rules to locals than state enforcement in decentralized management of these resources.

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Introduction

As a response to accelerated natural resource degradation, largely spurred by market failure, demographic pressure and institutional failures, recent decades have seen widespread devolution of management of these resources to local community, albeit under various structures of common property right regimes, in developing countries (Sikor, 2005, Larsson and Ribot, 2004, White and Martin, 2002 and Agrawal and Ostrom, 2001). Observation in the field though, shows a great deal of variation in the quality of common property resources management outcomes suggesting that initial design and assignment of property alone doesn't solve resource degradation problems. Both empirical and theoretical literature attributes this realization to pervasiveness of free-riding behaviour in commons dilemma (Ostrom, 1998: 200). The questions though, remain whether such variation in common management outcomes is explained by variation in enforcement institutions to correct free-riding behaviour in common's dilemma. Many researchers argue that enforcement institutions (Ostrom, et.al 1992) and conditional cooperation (Rustagi et.al 2010, Fehr & Fischabacher, 2003) can overcome free-riding problem to a varying degree of success. In field setting observations show that communities engage in supervision and punitive measures to ensure compliance with commons management rules (McCarthy, et.al, 2001; Gibson, et.al, 2004). The enforcement institutions are either externally crafted and enforced viz. monitor and fine (random fining, collective fine) or internally crafted and enforced as informal instruments (peer disapproval, ostracism etc).

One can thus, argue that variation in resources management outcomes may be explained by variation in efficacy of these instruments. In fact, large body of experimental and case study literature have documented efficacy of different enforcements institutions in overcoming non-cooperation in commons' dilemma.

Specifically, framed field experiment evidences have shown both random fine and collective punishment by third party sustain cooperation in commons appropriation (Reichuber et.al, 2009) whereas results from many of public goods lab experiments confirm that peer punishment fosters cooperation in common's dilemma (Ostrom et al., 1992, Fehr & Gächter, 2000, Casari & Luini, 2008). Another array of studies, using public goods lab experiments, have shown that ostracism (threat of expulsion) is the most punitive instrument to deter non-compliance with publics goods provision (Masclet, 2003; and Fehr and Ga¨chter, 2000; Cinyabuguma et.al 2004).

However, much of these evidences emerged from behavioural laboratory experiments with student subjects, which couldn't help to account for context-specific information of relevant structural factors in concrete field settings. Moreover, these studies didn't answer the questions of which of enforcement instrument performs better compared to alternative instruments in fostering compliance with the rules of resources appropriation under a particular field setting. In responding to these empirical uncertainties, the current project is set out to evaluate relative efficacy of alternative enforcement institutions of forest commons management using framed field experiment in rural Ethiopia. Our treatments included open access regime as a baseline treatment, external/third party enforcement institutions (collective punishment and individual random fine punishment) and peer/diffused punishment mechanisms of the forest commons management..

Our contribution to literature is three-fold; first, we compare the relative efficacy of each of the treatment alluded to instead of evaluating them separately, second, we compare external (third party) enforcement institutions with diffuse (peer punishment) sanctioning institutions using aa framed field experiment as opposed to laboratory experiment common in extant

literature. Moreover, we provide external validity of results from related studies of public goods lab-experiments.

We found that, compared to the baseline treatment, all of our treatments sustain cooperation (reduce resource extraction level), but peer punishment instrument appears to be the strongest deterrent of free-riding behaviour. Among externally imposed enforcement institution, collective punishment performed better than individual random fine treatment. Overall, the analysis shows that peer punishment mechanism (endogenous institution) proves to be an effective instrument to correct coordination problems of commons management compared to external enforcement alternatives. However, there is evidence that the efficacy of the former depends on the cost of enforcement. In terms of policy choice, our results corroborate the significance of devolving authorities to enforce commons management rules to locals than state enforcement in decentralized management of these resources.

Background

Until recently, most of Ethiopian natural forest had been managed under government -controlled forest conservation initiatives, an approach which took stronger momentum since mid-1970s (Kubsa et.al 2003). The initiatives resulted in establishment of different types of protected areas such as state-owned Forest Priority Areas (FPAs), National Parks, Game Reserves, Sanctuaries and Controlled Hunting Areas. By definition, all FPAs are state-owned, settlement inside the FPA is prohibited and only the government may harvest the forest products. However, deforestation and environmental degradation, which rapidly continued apace, forced the forest administration to seek for alternative policy instrument instead of the government controlled forest conservation approach (Tesfaye et.al 2010, Kubsa, et.al 2003).

Participatory Forestry Management (PFM) system has recently been adopted to safeguard forests while respecting traditional users and including them in the management process. In effect, it granted local people, typically those living inside or adjacent to forest, use right to use and manage their forests as common property resources.[1] Adaba-Dodola PFM, in south eastern Ethiopia under the name WAJIBA, which is acronym for Forest Dwellers' Association in local language, is one of the six pilot projects. It was established through bilateral government's support of German Society for Technical Cooperation (GTZ) in 2000 and currently covers about 16526ha of natural forest. Membership of the program and block boundary was made on the basis of the settlement pattern. The maximum size of the WAJIB group per forest block was limited to 30 households (Tesfaye 2010, Kubsa et.al 2003). Priority in the selection of members is based on the length of residence in the forest. The duration of residence is not necessarily based on the establishment of the respective households, but also considers the settlement of their ancestors. For this reason, a newly established household that descends from a family that has lived in the forest block for a long time can be given priority over an older household whose ancestors are recent settlers. This rule was assumed to be in line with the traditional way of laying claims on rights to land.

Moreover, the PFM forests are subdivided into forest blocks. Each block is managed by organized user group of not more than 30 members per 360has of forests, which was based on the calculation of a carrying capacity of 12 ha per homestead (Uncovsky, S. 1998). The maximum number of 30 members has proved to be the most appropriate in terms of manageability and positive impact with respect to forest conservation as compared to total

[1] It is to be noted that participatory forest management (PFM) is used as an umbrella term to refer to the various systems that have been developed in different countries including community forest management, collaborative forest management, and joint forest management (Anders, 2000).

village community that always comprises more than 30 homesteads (Kubsa et.al, 2003, Tesfaye, et.al 2010). This arrangement required that total wood consumption/harvest of each group is expected not to exceed the annual increment of 1 m3/ha/year. Each WAJIB group has the privilege of deciding on what and how much to use from the forest so long as it respects this limit and other requirements of forest utilizations. In effect, operational rules of forest utilization are formulated by the WAJIB members and elaborated for each forest block/group. The operational rules pertaining to forest use include; (i) using only dead wood for fuelwood, (ii) only branches of trees are removed for fence construction, (iii) limited number of mature trees are harvested by members after obtaining permission from the WAJIB assembly and selection of harvestable tree by ad-hoc committee (iv) closing pasture lands temporarily to grow grass (v) browsing animals are not allowed to regeneration areas in the forest, (vi) number of animals and period of grazing in the pasture land is predetermined, (vii) expansion of farm plots and compound fences is strictly prohibited. Forest user groups are primarily responsible for enforcement of these rules in their forest blocks and the village administration's role, for the most part, is resolving disputes between forest user groups and non-PFM groups. Within each block, group members are required to patrol the forest daily on rotating basis across members to monitor non-compliance. Upon detection of non-compliance, each group imposes sanctions on the offender through its executive/management committee. The sanction naturally spans reprimands, monetary fines and expelling from PFM membership depending on the degree of offense (Kubsa et.al, 2003). This is what we construe as peer-punishment in this study.

In addition to operational rules outlined above, WAJIB is also bound to external rules, which governs its relation with regional/provincial government. In effect, WAJIBs are required to enters into contract, namely a Forest Block Allocation Contract (FBAC), with the government,

the latter represented by district Forest Service (FS). According to the FBAC, the rights of the WAJIB include settlement in the forest block and utilization of forest products for both home consumption and sale. The duties of WAJIB include restricting settlements to the carrying capacity of the forest block, maintaining initial tree cover, paying forest rent and regulating access. The annual forest rent is about USD1 per ha and is only payable for the area not covered by forest in order to encourage the WAJIB to increase the forest cover. The respective village administration retains 40% of the rent in order to support the non-WAJIB community members, which can be considered as benefit-sharing mechanism between the government and the community members living adjacent to the FPA.

Moreover, FBAC stipulate that the forest administration also has the rights of access to visit the forest blocks at any time, and to call and attend WAJIB members' meetings. The duties of the forest administration include providing technical and organizational assistance, conducting annual tree cover assessment and settlement census, defending the interests of WAJIB against others and providing assistance in cases of litigation.

The FBAC also stipulate that Forest Service and village administration can monitor (patrol the forest) every six months and impose sanctions in case of failure on the side of the WAJIB to comply with the agreement. The sanctions are imposed on a particular WJAIB group as a whole, in case of significant reduction of tree cover, non-payment of rent, the presence of excess settlement and admitting non-WAJIB members. This is what we construe as collective punishment/fine in this study.

Design of framed field experiments

We conducted a common pool resources framed field experiment in selected villages of Dodola district, Bale region of southern Ethiopia, where common property management of forestry programs are implemented. We framed the experiment with harvesting of forest products; harvestable tree crop (timber tree) for sale under common property management regime. The framing mimics the actual practices of WAJIB's arrangement, allowing the subject to be familiar with the context.

The experiment is based on the interaction (game theoretic) decision problem of $N = 5$ identical individuals, who use common property forest resource while facing social dilemma (cooperation versus defection) under varying enforcement institutions to overcome these dilemmas. We followed within subject experimental design as was in related studies; Velez et.al (2009), Vollan (2008), Ostrom et al. (1994), Falk et al. (2002) and Casari and Plott (2003). In using the forest each individual is faced with concave payoff function given by equation (1) below;

$$\pi_i = e_i + px_i - c(x_i + x_{-i}) - d(x_i + x_{-i}) \quad (1)$$

Where e_i is endowment, x_i is quantity of logs individual i harests, p is a unit price of log, x_{-i} is quantity of log harvested by remaining members of the group. The last two terms in(1), which are respectively externality of increased harvest effort to other users and externality of reduced off-site services of forest stock, reduced water cleaning, increased flood etc. are what constitute sources of social-dilemma in this experiment

The experiment was run with randomly selected 200 farmers, which was split into 40 groups (5 farmers each) of joint forest users. As alluded to above, e experiment involved the following

treatments ; open access as baseline treatment, supervise and fine, collective punishment both by third party and two peer punishment treatments(one without cost and the other with cost).

Experimental protocol

In implementing the experiment, each of the 40 groups played a baseline treatment as typical common-pool resource game for 4 rounds on the basis of model presented above with a unique Nash equilibrium at $x_i = 9 \forall\ i$ a social optimal use level at $x_i = 2$. By baseline treatment, we mean a situation where no rule exists to govern how much one would take from the forest (an open access regime scenario). Prior to the implementation of the experiment, subjects were provided with verbal and written information concerning the payoff structure and were asked questions to make sure everybody understood the experiment. In addition, subjects played 4 rounds of the game for each treatment as a pilot to ensure a clear understanding of the game (experimental task) prior to actual sessions of actual experiment. We have checked consistency of the decisions of each subject with experimental instruction via observing the decision and why he/she took that decision. For most part, subjects understood the task from 2^{nd} through 3^{rd} rounds of practices. We moved onto actual implementation of the experiment after making sure that each subject has understood the task. We started with baseline treatment and allowed them to play it for 4 rounds. After 4^{th} round of baseline treatment sessions, new treatment with the rule, which requires that each individual would harvest only a socially optimal level of 2 logs was introduced. In this treatment, an individual subject can either defect or comply with the rule of harvesting 2 logs a month as a socially optimal appropriation. Defection is supervised and, when detected, it entails fine for every unit of deviation from optimal quantity of harvesting the resources. Subjects face an exogenously given probability of detection of 50%.. Here again

subjects played the game for 4 rounds after which new treatment of collective punishment was introduced.

In collective treatment, it is assumed that monitoring the harvest decision of each farmer is prohibitively costly, whereas aggregate harvest decision, can easily be observed (the regulator may patrol the forest and observe the total cut down of forest trees, but cannot verify who didn't comply with the rule). The regulator thus, ensures compliance by imposing fine on the group of forest users if aggregate harvest exceeds the socially optimal level of 10 logs (2logs *5), such that for each subject, the fine bill is proportional to the deviation of total harvest from socially optimal level in total. This is akin to Segerson (1988) collective tax mechanism for non-point pollution problems. After 4^{th} session of playing this task, subjects moved onto playing the game under peer punishment treatments. In these treatments subjects are given the opportunity to simultaneously disapprove the non-compliance behaviour of each other after they are informed about the harvest level of the other group members. Each subject disapproves non-compliance behaviour after they are informed about the harvest level of the other non-complying group members; assign 0 - 10 points (from lowest to the highest disapproval level) at the end of every experimental session, which was played for 4 rounds. We followed the protocol of Hayo and Vollan (2012), Masclet (2003), Fehr and Gatcher (2000). In one of peer-punishment, subjects assign the disapproval points while in other subject faced a punishment cost in assigning disapproval points. The punishment cost ranged from the lowest point 0, which a subject loses when he punishes no point to the highest 30 point, which he loses if he assigns the disapproval point of 10.

After each session for each game, subject was provided with private information on his/her payoff. Moreover, after each of sessions, subjects were asked privately how much they expected

the majority of his group has harvested in and the number of people who defected in each sessions of all treatments. We then, also randomly selected 50% of the subjects and re provided them with information on average and total group harvest after learning their expectations on these quantities. In all the games, subjects were not allowed to communicate to each other and that was strictly monitored. Along with the experiment, we also interviewed the subjects and conducted group discussion to generate data on variables related to the resource extraction behaviour of peasant households.

Overall, the experiment allowed us to generate data on joint forest using household's resources extraction behaviour (forest extraction in the form of logging) while facing social dilemma (cooperation versus defection) under varying enforcement institutions to overcome these dilemmas. Such data cannot be generated through survey methods as collective rule enforcement mechanism (fining, collective tax and ostracism) don't vary from program to program in field setting unless one conduct randomized control trial (RCT) experiment.

Result and discussion

In what follows, we present preliminary results of our analysis. Staring of with descriptive analysis of household characteristics, presented in Table1, we see that the age of our subjects averaged 43.5 years (middle age group) of which 90% are male. Average education level among the subjects was grade 5, which make it possible that the subjects can understand written information of experimental tasks. In terms of wealth, average subject holds 1.710ha of land and 1.748 horses. Most subjects live within distance of 90 minutes walks from markets (towns). Our measure of religiousness, described as whether a subject is part of mosque leadership committee, indicate that only a slight fraction of 14% of our subjects are religious.

Turning to main results, Table2. presents mean harvest of forest under different treatments. The results show that the highest mean harvest of 6.36 logs has been observed under baseline treatment, which is consistent with priori expectation of behaviour under open access regime, . However, this estimate is lower than expected Nash-equilibrium solution of 9 logs by 2.6 logs. Although the explanation of this deviation is beyond our interest, the result is however, consistent with those from many of public goods lab experiment studies in behavioural economics. Peer punishment without cost yielded the least mean harvest compared to rest of treatments. This is followed by the result obtained from peer-punishment treatment with cost. Among externally imposed enforcement institution, collective punishment yield lower predicted mean of harvest than individual random fine punishment treatment.

In Table2, we present estimates of average treatment on treated (ATT) of each treatments taking harvest outcome of baseline treatment as counterfactual. The results show that different treatments performed differently in fostering cooperation among the subjects. With ATT estimate of -3.909 logs, which is equivalent to reduction of overharvest by 61.45%, peer punishment without cost of punishment proved to be the strongest deterrent of non-complaint behaviour compared to rest of the treatments. This is followed by peer punishment with cost, which yielded an ATT estimate of -3.739 logs or 58% reduction of overharvest. The order of these results supports the hypothesis of down-ward sloping demand curve of punishment (Carpenter, 2007). Within externally enforced institution, collective punishment treatment appears to be stronger yielding an ATT estimate of -3.1755 logs compared to ATT estimate of -3.058 logs obtained under random fine treatment. Moreover, pairwise comparison of results (ATT estimates) follows the same order of performance as above, with peer punishment without cost of punishment performing the best in deterring non-compliance (see Table4).

Overall, we can make the following important observations. First, compared to externally imposed enforcement mechanism, internally devised enforcement appears to be stronger tool of sustaining the commons, but its efficacy depends on the cost of enforcement. Second, our result support the choice of collective punishment instrument in events of adopting externally imposed enforcement mechanisms. Moreover, our findings lend supports to evidence from public goods lab-experiment studies (Masclet, 2003; Fehr and Ga¨chter, 2000; Casari & Luini, 2008).

Conclusion

In this study, through framed field experiment, we evaluated relative efficacy of alternatives common's enforcement institutions including standard monitoring and fining mechanism, collective fine and peer punishment mechanisms. Our analysis showed that, compared to baseline treatment, all treatments considered bolster cooperation (reduce harvest level of forest). However, the efficacy fostering cooperation among commons resource users varied among treatments generally and between internally devised (endogenous) and externally imposed (exogenous) enforcement institutions particularly[2]. Specifically, we found that endogenous institution in the form of peer punishment with no cost of punishment proves stronger tool to fix coordination problems (social-dilemma) of forest commons management. There is also evidence of inverse relationship between peer punishment and cost of punishment implying the importance of enforcement cost to sustain commons when peer punishment mechanism is used. The implication is that transaction cost of commons property regime in the form of enforcement cost is likely to undermine sustainability of commons via weakening locals' enforcement mechanisms. Overall, our results underscore the importance of devolving the authority to enforce

[2] In literature this instruments are referred to as centralized and diffused enforcement institutions respectively.

forest commons management rules to locals than state enforcement in the decentralized management of these resources.

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Table1. Descriptive statistics of socio-economic background

Variable	mean	Standard deviation
age	43.455	13.358
sex	0.9300	0.2551
education	4.876	3.320
land holding	1.710	1.351
horse	1.79	1.748
distance market	90.32	46.402
religion position	0.139	0.347

Table2. Treatment effect of individual enforcement institution

T	ATT	Std. Err	[95% Conf.	Interval]
(2 vs 1)	-3.058511	.2711787	-3.590011	-2.52701
(3 vs 1)	-3.175532	.2634933	-3.691969	-2.659095
(4 vs 1)	-3.909574	.2316105	-4.363523	-3.455626
(5 vs 1)	-3.739362	.2487856	-4.226972	-3.251751

Table3. Relative efficacy of alternative enforcement institutions

	T		Contrast	Std. Err	[95% Conf.	Interval]
2	vs	1	-3.058511	.2711787	-3.590011	-2.52701
3	vs	1	-3.175532	.2634933	-3.691969	-2.659095
4	vs	1	-3.909574	.2316105	-4.363523	-3.455626
5	vs	1	-3.739362	.2487856	-4.226972	-3.251751
3	vs	2	-.1170213	.2248058	-.5576325	.3235899
4	vs	2	-.8510638	.1864198	-1.21644	-.4856877
5	vs	2	-.6808511	.2073721	-1.087293	-.2744093
4	vs	3	-.7340426	.175052	-1.077138	-.390947
5	vs	3	-.5638298	.1972157	-.9503654	-.1772942
5	vs	4	.1702128	.1520156	-.1277323	.4681579

Fig1. Mean values of harvest under alternative treatments

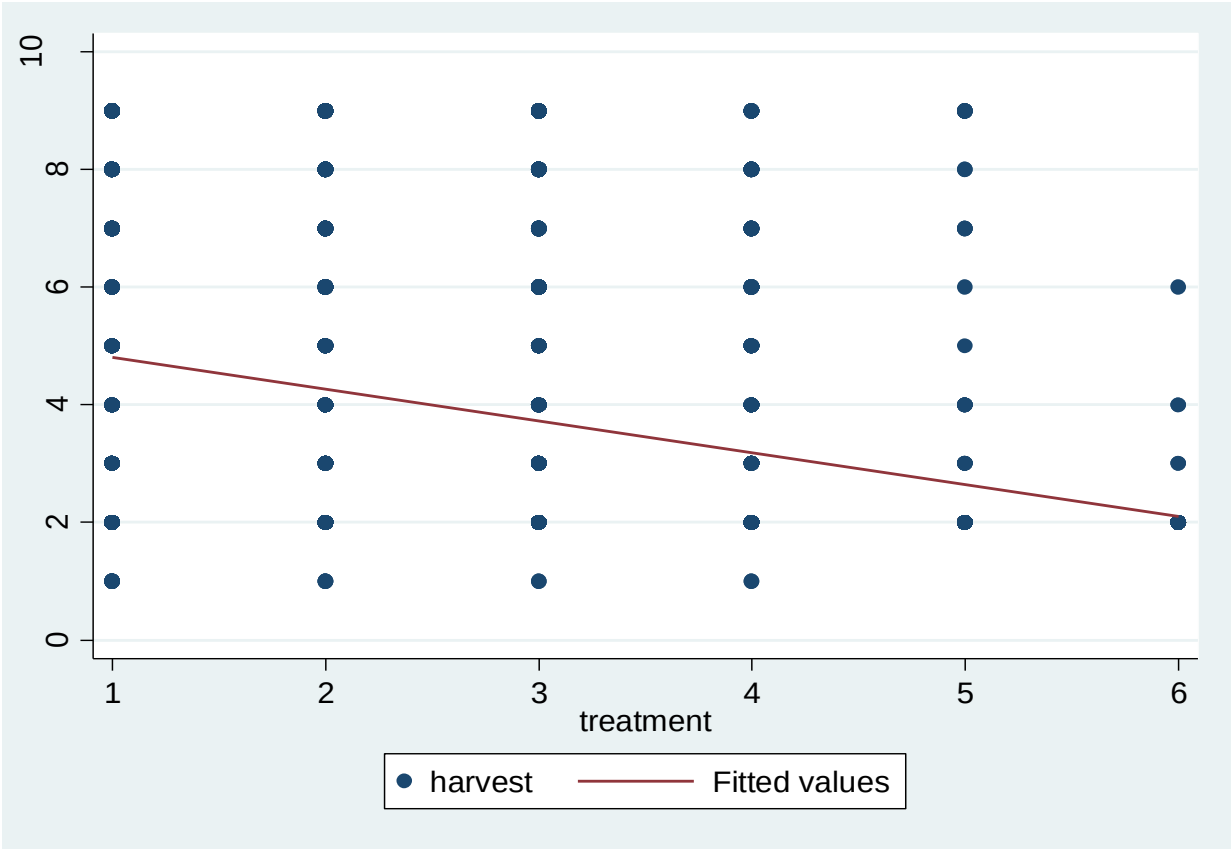

Fig2. 95%CI ATT comparison of multi-valued treatment effect evaluation model