The Emergence of Collective Forest Management Regimes; When do open-access resources become managed commons?

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Abstract

In this study cross-national panel data, gathered at the community level in 13 different countries, was used to analyze change in forest conditions. The first question this paper seeks to answer refers to the relation between intensification of forest use and forest degradation. The main findings relate to the apparent ability of forest users to prevent their resource from degrading in spite of an increase in combined harvesting due to population pressure and market integration. Once established that intensified forest use does not necessarily lead to over-exploitation, the second question this paper addresses refers to what it is that forest communities do to successfully keep (or get) their resource in good shape. The findings confirm that institutions for collective action make a significant difference. Improving forests are characterized by forest users who have significantly more *de facto* harvesting rules in place. Furthermore, forest users in forests that are "getting better" engage significantly more often in monitoring, maintenance and improvement activities. These findings invite to a third question: When are communities more likely to indeed craft the institutions of collective action that will either keep or get them away from the tragedy of the commons? The results point towards the importance of allowing forest communities to make their own rules.

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1 Introduction

According to the Food and Agricultural Organization (FAO), during the last decade of the 20th century the world lost 9.4 million hectares of forests[2]. Although much of the dynamics related to de- and reforestation can be argued to be determined by conscious choices regarding land use, many forests deteriorate even though the resources they provide are appreciated by all collective users. These are the kinds of forests this study focuses on.

If forests are valued by all (or most) of its users, why do they degrade? Or maybe equally important, why don't they? I will examine these questions by comparing sets of forests that can be argued to be in danger of disappearing, and another set of forests that seem to do all right. I hope to determine some of the variables that explain the differences between the two comparison groups.

Why do forest user groups not try to prevent their resource from disappearing when they all esteem the goods and services provided by it? Or maybe equally important, when will groups of forest users invest time, energy and resources in keeping their resource fit? These questions will be addressed by comparing two sets of forest user groups, one consisting of groups engaging in the collective management of forests, and the other one consisting of groups who have not managed to organize to prevent a "tragedy of the commons." Again, I will attempt to single out variables that plausibly explain the differences between both groups.

[2] The United Nations Food and Agricultural Organization – Forest Resource Assessment 2000 http://www.fao.org/forestry/foris/webview/forestry2/index.jsp?siteId=101&sitetreeId=1191&langId=1&geoId=0

2 Theoretical Framework

Hardin's quintessential article on the tragedy of the commons (1968) has kept the debate on environmental issues focused on the topic of over-exploitation for over 35 years now. Hardin drafts a scenario of communities facing a social dilemma according to which the benefits resulting from infraction surpass the benefits following from rule obedience. The gains resulting from logging that extra tree are exclusively for the poacher. The costs, consisting of a decrease in overall forest productivity, are divided among all resource users. As a consequence, Hardin argues, local resource users are not likely to devise a sustainable management regime. Hardin's article proved appealing to many non-economists and has led to several generations of public policies geared at either privatization of forest ownership (Demsetz 1967; Posner 1977; Simmons et al. 1996; all quoted in Ostrom 1999) or centrally imposed regimes of natural resource management (Ophuls 1973; quoted in Ostrom 1999).

Several scholars have shown however, that the use of a common pool resource is not the one-shot or finitely repeated Prisoner's Dilemma game that Hardin assumed it to be. Numerous empirical studies have developed a body of convincing evidence that forest communities are able to (self) organize and work their way out of "the trap" pictured by Hardin (See for example Ostrom 1990; Bromley et al. 1992; Baland and Platteau 1996; Gibson et al. 2002). In this paper I examine the process of forest communities collectively acting themselves out of or away from the tragedy of the commons.

The first step in the unwrapping of the "mystery" of forest communities managing to get out off Hardin's trap involves the understanding of what happens when over-exploitation is on the verge of becoming a crucial issue. What is the most likely scenario when forest use intensifies, for example due to population growth or change in harvesting behavior. Boserup (1964) explains the characteristics of agriculture in any specific area and time by looking at the land - labor ratio. She argues that the more densely populated an area, the more intensive cultivation becomes. According to Boserup, intensification brings about innovation of tools and techniques. Furthermore, the pressure on resources due to increased populations leads to investments in land improvement. Importantly, Boserup argues that intensification also shapes institutions. When cultivation cycles become shorter and the quality of land begins to matter, property rights have to be created. Is something similar likely to occur in the context of forest use? Or on the contrary, does increased stress automatically lead to an irreversible decline in the health of a forest resource?

The second step in solving the puzzle of successful and long-lasting common pool resource management regimes involves the understanding of what it is exactly that communities do to successfully keep (or get) their resource in shape. Some communities have proven to be able to do so even when intensified resource use risked adding up to levels of over-exploitation. If all property rights are undisputed and fully enforced, changes in land use are mostly the result of conscious and rational decisions. Forests however, often have management regimes where property rights are dispersed among many and refer to many goods and services. McKean (Gibson et al, 2000) proposes to look at common property regimes as a way of privatizing the rights to goods, without dividing the goods into pieces. Under a common property regime the flow of harvestable products from an interactive resource system is parcelled and privatized. However, the stock as whole stays undivided. Under a common property rights regime individually owned rights to "flow" are based on shared rights to "stock." Often, rights to flow and rights to stock are ambiguous, dubious, contested or not fully enforced. When institutions regarding the *rights to flow* are not in place, individuals do not see their harvesting behavior determined by a clear set of rules that refers to what can be extracted, when, where, how and in what quantities. When institutions regarding the *rights to stock* are not in place, individuals are unlikely to invest in the overall condition of the forest, for example by means of participating in monitoring activities, or by actively contributing to the maintenance or improvement of the entire resource. In the absence of a *de facto* accepted and respected property rights regime that refers to the harvestable products as well as to the entire production system, deforestation may occur in spite of overall appreciation for the resource.

The third step involved in increasing the understanding of what makes a common property management regime successful relates to the circumstances that facilitate the emergence of the institutions described above. When are communities more likely to indeed craft the institutions of collective action that will either keep or get them away from the tragedy of the commons? Ostrom (1999) argues that certain *attributes of the resource* and certain *attributes of the users* are crucial in determining whether or not an effective collective forest management regime will germinate, develop and mature. Olson (1965) also addressed the conditions under which groups according to him would be able to solve their collective action problems. From him I also borrow some independent variables to explain variation in levels of collective forest management. I examine the influence of *group size* on the ability to overcome collective action problems. I will also look at *heterogeneity* as a factor possibly complicating the emergence of institutions for collective action. Finally, I assess whether the existence of a *leader* that is willing to invest in forest management, in spite of the danger of other community members free riding on his/her efforts, will enhance the chance of the development of effective institutions for collective action.

3 Data

In 1993 the International Forestry Resources and Institutions (IFRI) research program was created as a global, interdisciplinary research network at the Workshop in Political Theory and Policy Analysis at Indiana University. Ever since, IFRI has been working to gather systematic data on local forest governance systems around the world. IFRI, by means of a set of carefully designed standard research protocols focuses on empirical analysis of the human-ecological interface. The IFRI database integrates biophysical with social data about factors that affect forest ecosystem dynamics in 13 countries in Africa, Asia, Latin America, and North America.

a. Forest Conditions

It is not clear how healthy forest conditions can be meaningfully distinguished from degraded forest conditions in a comparative exercise that includes a selection of forest sites scattered around the globe. First, when comparing forests in different ecological zones, the use of absolute values referring to proxy measures such as tree and vegetation density, species diversity or groundcover is not feasible. A second problem, is the uncertainty regarding the extent to which any chosen proxy indicator is linearly correlated with that dependent variable. It can plausibly be argued that the relation between "vegetation density" and "forest quality" is in fact curvilinear. Third, defining "forest quality" depends on purpose and perspective. Species diversity may be valued differently, depending on the main use of the resource. Recognizing these difficulties, I opt to construct an *index of change in forest conditions*. The cumulative effect of results related to four different measures, each one of them to a certain extent related to change in forest conditions, may strongly point into a particular direction.

b. *The Direction of Causal Flows and Simultaneous Causation*

An analysis that attempts to explain forest conditions by looking at a series of explanatory variables is typically complicated by uncertainty about the direction of the causal flow and by the fact that various processes may take place simultaneously. For example, population pressure may be the cause of a forest being in poor condition. But at the same time a forest in good condition may attract more people that want to take advantage of the riches a healthy forest has to offer. Also, a healthy forest is probably both the *result of* and the *incentive for* collective action and effective forest management. The effect of endogeneity on the test results can be bypassed by assessing the correlation between a set of explanatory variables and *change* in forest conditions.

c. *Selection Bias*

Determining whether it can be claimed that any observed variations in the dependent variable is *caused* by a certain explanatory variable is particular difficult in cases, such as this one, where it proves practically impossible to compare treatment groups with control groups that are both randomly assigned. Non-random assignment leads to samples with unequal characteristics. Variation on important characteristics between treatment and comparison groups may very well (partially) account for differences in outcomes. Therefore, it becomes more difficult to single out the net impact of the independent variables than it would have been if the data gathering process had

had the characteristics of a *true experiment*. (Grossman and Tierney 1993; Lalonde and Maynart 1987). When designed properly, experiments that do not rely on random assignment of comparison groups ("*quasi experiments*") are argued to be potentially useful (Heckman and Smith 1995; Dennis 1990; Dunford 1990). I will use matched constructed comparison groups as a manner to more or less get around the selection-bias issue. Rather than running regressions, I will simply present correlations between sets of variables (Gibson et al, 2002).

d. Missing Cases

It has been argued that the loss of information due to missing cases will lead to imprecise regression results (Gibson et al 2003; Little and Rubin 1987). The gaps in my data urge me to choose between either eliminating all incomplete observations or imputing all missing values. The imputation of missing values would lead to a larger number of observations, which in turn would diminish the standard error of the correlation results. But, it would also increase the measurement error. This feature would lead to a biased coefficient that lies closer to zero. A Kolmogorov-Smirnov test reveals that the missing values are indeed equally distributed over the possible scores on the index of change in forest conditions. Therefore, I opted for the elimination of cases with missing data.

4 Methodology

a. The Statistical Tests

First, for both research questions two sets of comparison groups are generated that significantly vary on either one of the two dependent variables (forest condition and level of collective action). The bulk of the analyses will rely on descriptions of the sets of comparison groups. The mean values of a series of explanatory variables will be compared between both groups. By means of a t-test it will be established whether these means differ significantly.

In the cases where an ordinal value is analyzed, I will use the Kolmogorov-Smirnov test to compare the distributions over a range of categorical values. The Kolmogorov-Smirnov test is usually used to determine whether a sample comes from a population with a specific distribution. The test relies on the fact that the value of the sample cumulative density function is asymptotically normally distributed. Given the hypothesized continuous distribution function F without jumps, this test compares F to the empirical distribution function, F', of the samples. The Kolmogorov-Smirnov test-statistic D is the largest absolute deviation between F(x) and F'(x) over the range of the random variable. In this paper the test will be used to determine whether 2 comparison groups are the same or not.

b. The Comparison Groups

Hayes (forthcoming) uses comparison groups to analyze the impact of park management on forest conditions. The study discussed in this paper leans importantly on the technique proposed by her. In the data set, forests were ranked according to a series of measures related to forest conditions. A set of four measures particularly captures dynamics in forest conditions. A categorical 3 point scale was used, according to which the scores are distributed around an average. The parameters assessed separately include change in tree density, change in bush and shrubs density, change in ground cover, and change in area under forest cover. Based on interviews with (representatives of) all forest users, all four of these variables were coded to have stayed the same (0), increased (2), or decreased (-2) during the five years prior to the survey. The index of change in forest conditions constructed for this study equals the sum of all scores on these indicators. In order to construct the comparison groups those forests scoring zero on the measures (that is, those forests that on average did not change during the five years prior to the inventory) were eliminated. This allowed me to examine what distinguishes forests that are getting better from forests that are getting worse.

Regarding the second dependent variable in this study an overall index of engagement in collective common pool resource management was created. For each forest user group it was recorded whether they participated in any form of monitoring (1) or not (0); whether they had any effective harvesting restriction rules in place (1) or not (0); and whether they effectuated any resource maintenance or improvement activity (1) or not (0). The respective scores on the three indicators were added together. For the creation of two comparison groups based on this index, those groups with minimum scores (zero and one) were separated from those groups with maximum scores (two and three).

5 Forests under Pressure

The probability that the delicate line between harvesting activities and a resource's carrying capacity snaps, so one could reason, is much higher when that resource is under pressure. I will look into this hypothesis by contrasting comparison groups in terms of population pressure, levels of extractive use and market integration.

a. Number of users per hectare

Is a forest that is used by more people more likely to score low scores on measures for forest-conditions? In order to calculate how intensively the forests in the samples are used, the numbers of members of all user groups that are reported to somehow use the forest were added together. The total number of forest users was then divided by the forest size in hectares.[3]

In order to test whether the mean of the number of users per hectare between the two comparison-groups differ significantly, a two-sample t-test assuming unequal variances between groups was performed. According to the null-hypothesis, there is no difference between the mean number of users per hectare in the improving comparison group and the mean number of users per hectare in the declining comparison group. The alternative hypothesis states that the mean number of users per hectare in the ameliorating forests is larger than the mean number of users per hectare in the comparison group of forests that are growing worse.

Table 1: T-test: Average number of users per hectare[4]

Forests with improving conditions	forest with declining conditions	T-test statistics (unequal variance)	P-value
25.012 (n=52)	10.366 (n=75)	-2.7797	0.9966*

* The reverse alternative hypothesis, namely that the mean user-density in forests whose conditions are ameliorating is bigger than the mean user density in degrading forests, has a p-value of 0.0034

The index argued here to capture change in forest conditions during the five years prior to the survey, reports a significant difference in the average per hectare usage between the comparison groups. But contrary to the alternative hypothesis, forests that are getting better have to deal on average with a significant higher population pressure[5].

[3] I recognize that the comparison here performed is affected by the fact that the forests included probably differ in terms of carrying capacity. A certain level of usage that would exceed the pace of resource regeneration in one forest, may cause no problem whatsoever in another. Future research would have to take this fact into account.

[4] The values representing the number of users per hectare are not appropriately distributed for a hypothesis test. A square-root transformation of the number of users per hectare leads to the distribution that lies closest to the t-distribution.

[5] Note that there is a time lag between the variables compared here. The data set only reveals the number of forest users at the time the survey was conducted. It does not inform us how population may have developed during the five years the forest is reported to have changed.

b. Levels of extractive forest use

Is a forest with higher levels of extraction less likely to avoid degradation? Extractive use, rather than for example use for recreation, soil and water conservation or nature appreciation, could be argued to affect the fragile balance between resource use and regeneration more significantly. It could be expected furthermore that the harvesting of wood products has a significantly higher impact on forest conditions than for example the harvesting of mushrooms and grasses. Does wood extraction constitute a form of pressure most forest systems are unable to deal with? In order to test whether the quality parameters of the forests in my sample are indeed negatively affected by high levels of extractive use, I created a measure that consists of the count of the number of tree-derived products[6] from a forest[7].

First, I will examine the difference in the mean number of tree-derived products extracted from the forests that are assigned to each one of the comparison groups. A two-sample t-test assuming unequal variance will allow me to establish whether the mean number of tree-derived products between the two comparison-groups differ significantly. According to the null hypothesis, no difference exists between the mean number of wood products harvested in the improving comparison group and the mean number of wood products harvested from the deteriorating comparison group. The alternative hypothesis states that the mean number of tree-derived products harvested in the comparison groups that is getting better is greater than the mean number of tree-derived products extracted from the forests that are declining.

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[6] In order to generate the variable used in this section all those products that were referred to as *timber, construction wood, poles, pinewood, trees, tree parts, wood, firewood, fuel wood and charcoal* were counted.

[7] Note that this indicator is not based on the quantity of each product that is harvested.

Table 2: T-test: Average number of wood products extracted

Forests with improving conditions	Forest with Declining conditions	T-test statistics (unequal variance)	P-value
0.958 (n=71)	1.222 (n=81)	2.0325	0.0220

Higher levels of extraction are associated with forest degradation. Where more wood products are extracted, forests are significantly less healthy than five years prior to the inventory.[8]

c. Levels of Market Integration

The "market" is a third and last form of pressure discussed in this paper that can be argued to complicate any attempt of forest users to keep their combined harvesting activities within the limits of a forest's carrying capacity. Commercial rather than consumptive use of forest resources can be argued to rapidly increase the quantity of products harvested. Does market integration spur over-exploitation? Or on the contrary, does market integration lead to forest communities taking better care of their resource?

In order to address these questions two measures were created thought to reflect different aspects of exposure to the market and levels of commercialization of forest use. First, all sets of comparison groups are evaluated according to the frequency at which the forests communities visited markets.[9] Secondly, a count of the number of products that are harvested from each forest for commercial purposes was made.

[8] Outliers do not have a disproportional influence on the average number of wood products harvested form the forests in the samples.

[9] Distance to the market was considered a less suitable measure for "exposure to commercial exploitation". 20 Kilometers in the US mean something different than that same distance in the hills of Nepal.

All forest user groups were asked how often they frequented a market[10]. I expect that higher levels of market integration would lead to a higher probability of resource over-exploitation. Therefore the t-test hypotheses are set as follows:

H_0: $\mu_{\text{declining forests}} = \mu_{\text{improving forests}}$ H_A: $\mu_{\text{declining forests}} > \mu_{\text{improving forests}}$

Table 3: T-test: Average market frequency

Improving Forest Conditions	Declining Forest Conditions	T-test statistics (unequal variance)	P-value
186 days (n=54)	148 days (n=77)	-1.6925	0.9533*

* The reversed alternative hypothesis (the average number of days markets are frequented is higher in the comparison groups of forests whose index of change in forest conditions scores high) has a p-value of 0.0467

The users of those forests that are getting healthier consistently report that on average they frequent markets more often. The observed difference is statistically significant.

For each forest I calculated how many products that were harvested were sold on a market[11]. I expect that higher numbers of products harvested for commercial purposes are correlated with higher levels of resource degradation. Therefore the t-test hypotheses are set as follows:

H_0: $\mu_{\text{declining forests}} = \mu_{\text{improving forests}}$ H_A: $\mu_{\text{declining forests}} > \mu_{\text{improving forests}}$

Table 4: T-test: Average number of products marketed

Forest in good conditions	Forest in poor conditions	T-test statistics (unequal variance)	P-value
0.214 products (n=70)	0.608 products (n=79)	2.3457	0.0104

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[10] The ordinal ranking ranged from (1) almost every day, (2) two to four times a week, (3) every week, (4) every two weeks, (5) once a month, and (6) once a season. In order to create a continuous scale the respective categories were converted to number of days per year a market was visited by forest user groups. When more than one group was reported to use a forest the group that frequented markets the most was taken into account.

[11] Regarding each one of the products reported to be harvested from a particular forest, one of the questions asked in the IFRI survey is "*How is this product used by individuals in this group?*" The variable "Number of forest products marketed" displayed in this paper was calculated by adding the answer-categories "*primarily used to produce other products for sale*", "*primarily sold in a local or nearby market in the settlement area*", and *"primarily sold in an external market"*.

The null hypothesis is rejected in this case. A higher number of forest products harvested for commercial purposes is significantly associated with declining forest conditions. When commercial forest use is disregarded market integration seems to be associated with increasing scores on indicators for change in forest health. However, when the levels of extractive activities for the purpose of marketing are examined the balance between use and regeneration is more easily jeopardized.

6 Institutions of Collective Action

I have shown that change in forest conditions cannot always be straightforwardly explained by simply looking at variables of pressure on forest resources. Some forest communities have proven to be able to handle the pressure and apparently came up with ways of keeping their harvesting behavior in line with the resource carrying capacity. In other communities the crises caused by these pressures apparently did not provoke the emergence of sound management practices to overcome the problem. In this section I will examine what it is that forest users do to successfully convert an open-access resource that is vulnerable to the tragedy of the commons into a common-pool resource where communities act collectively to keep their forest in good shape and prevent it from disappearing.

I will address three forms of action that I think are crucial to common pool resource management. First, an effective way of keeping individual forest extraction down must be found. Second, an effective way of controlling whether others won't violate these harvesting restriction rules must be in place. And third, forest users must actively engage in maintaining or improving their resource.

a. Harvest Restrictions

In an attempt to match the combined quantity of forest products harvested with the reproductive capacity of a resource, users can either try to adjust harvesting behavior or enhance forest resource production.

For all forest products extracted from a forest data are available regarding whether a rule setting a maximum harvestable quantity applies to that product. Apart from reporting whether or not such a restriction rule applies, additional information is available in the IFRI data set regarding the extent to which that rule is actually obeyed[12]. It can be plausibly argued that especially restricting the harvesting of *wood products* will have a significant impact on the conditions of a forest. Earlier, I calculated how many tree derived products are extracted from each one of the forest in the sample. Here I will analyze both of my comparison groups in terms of the number of those wood products harvested to which *no restriction rule* applies.

Does the average number of tree-derived products that are not subject to any rule restricting the harvestable quantity differ significantly between the sets of comparison-groups? A t-test was performed to answer this question. Since I expect that forest degradation will be associated with a larger number of wood products extracted to which no restriction rules apply, the hypotheses were set as follows:

[12] For each forest product harvested a question was asked regarding whether or not restrictions on harvesting the product in question in regard to quantity existed. Another question referred to the level of obedience regarding forest product harvesting rules. For this part of the analysis all products were counted to which no restriction rule applied, plus all products to which rules did apply but where it was reported that these rules were not generally followed by the individuals from the user groups (answer categories: "*rarely or never", "sometimes", and "about half of the time*").

$H_0: \mu_{\text{declining forests}} = \mu_{\text{improving forests}}$ $H_A: \mu_{\text{declining forests}} > \mu_{\text{improving forests}}$

Table 5: T-test: Average number of products without restriction rules

Forests with Improving conditions	Forest with Declining conditions	T-test statistics (unequal variance)	P-value
0.339 products (n=59)	0.806 products (n=67)	3.0763	0.0013

The null hypothesis is rejected. Forests with conditions that have been increasing during the previous five years harvest significantly fewer wood products that are not subject to some sort of rule restricting the harvestable quantity that is generally respected and obeyed.

b. Monitoring

Effectively setting restrictions on the quantities of harvestable produce that any individual can extract from the forest is a first step to have communities respecting the carrying capacity of their resource. The engagement of all members of a forest users group in monitoring activities will decrease the possibility of any restriction rules being broken. The reassurance that rules are obeyed will strengthen the monitor's own commitment to those same rules (Gibson et al. 2003).

All forests were coded according to their level of monitoring activities[13]. In order to test whether the mean level of monitoring varies significantly among the two sample groups representing opposing trends in forest conditions, again a two-sample t-test was performed. Since I expect forest conditions to be positively correlated with the reported levels of monitoring, these are the hypotheses to be tested:

[13] Groups that reported year round monitoring in the forest(s) they used received three points. Groups that reported seasonal monitoring were assigned two points. Those groups that monitored on an occasional basis were given one point. Finally, zero points were allocated to those group reported not to engage in monitoring at all. In order to establish monitoring levels per forest the average monitoring level of all forest user groups intervening in that forest was calculated. The scores from all forest user groups were added and divided by the number of groups using a particular forest. The score of a forest on this monitor index can thus range from zero to three.

$H_0: \mu_{\text{declining forests}} = \mu_{\text{improving forests}}$ $H_A: \mu_{\text{declining forests}} < \mu_{\text{improving forests}}$

Table 6: T-test: Average monitoring level

Forests with improving conditions	Forest with declining conditions	T-test statistics (unequal variance)	P-values
1.94 monitoring level (n=74)	1.33 monitoring level (n=78)	3.2539	0.0007

The significance of the correlation between increasing forest conditions and the level of monitoring is convincingly strong (significant at the 0.0001 level).[14]

c. Resource Maintenance and Improvement

The former two sections focused on activities meant to bring the combined quantity of forest products harvested down. In an attempt to synchronize levels of forest use and a resource's regenerative capacity, one could also choose to consolidate or enhance forest production.

I coded forests according to the level of engagement of the forest users in resource maintenance and improvement activities[15]. I expect change in forest conditions to be positively correlated with the reported levels of maintenance and resource improvement activities. Therefore the hypotheses for the two-sample t-test are set up as follows:

$H_0: \mu_{\text{declining forests}} = \mu_{\text{improving forests}}$ $H_A: \mu_{\text{declining forests}} < \mu_{\text{improving forests}}$

Table 7: T-test: Average number of maintenance activities

Forests with improving conditions	Forest with declining conditions	T-test statistics (unequal variance)	P-values
4.066 activities (n=76)	2.500 activities (n=82)	4.2017	0.0000

The t-test statistics regarding the evaluation of the difference in mean levels of maintenance and improvement activities between comparison groups based on forest change are among the most outspoken so far. User groups that invest in resource

[14] No influential outliers were found.
[15] Forest user groups were asked whether or not they did or did not engage in ten specific maintenance activities. The scores on all ten activities listed above were added together.

maintenance and improvement activities do seem to succeed in either keeping their resource in good health or getting it back on the track of recovery.

7 Incentives for Collective Action

Earlier, I have argued that although some forms of *pressure on forest resources* are difficult to deal with, forest communities do seem to be capable of keeping their combined harvesting behavior in tune with the forest's productive capacity. I have tried to provide empirical support for the argument that the crafting of *institutions for collective action* may be an effective way to avoid over-exploitation. In this section I empirically assess a series of variables that explain when communities are most likely to indeed craft such institutions, and when not.

As in the previous sections I composed two comparison groups, one arguably engaged in collective forest management and the other not. The same variables used as independent variables in the previous section were used to separate the comparison groups from each other. Groups were coded according to whether they did (1) or did not (0) have harvesting restriction rules; whether they engaged in monitoring activities (1) or not (0), and whether they participated in resource maintenance and improvement activities (1) or not (0). The scores on the index for collective management range from 0 to 3. Groups scoring either 0 or 1 were separated from groups scoring 2 or 3.

a. Forest Size

Ostrom (1999) argues that *spatial extent* is an important attribute of the resource that enhances the chance of self-organization. A resource is to be sufficiently small so that users can develop accurate knowledge about external boundaries and internal microenvironments. T-test results reveal that forests in the IFRI data base that are improving are smaller than those forests that are not. Due to outlying observations the reported forest sizes do not respect a t-distribution. After a log transformation they do however. A two-sample t-test performed on the logged values reveals that the differences in average forest sizes are significant at the 0.0001 level (two tailed t-test statistic = 5.1657).

With regard to the correlation between *forest size* and *levels of collective forest management,* I anticipate levels of collective action to be negatively correlated with the size of the forest. A two-sample t-test assuming unequal variances was performed on the logged values for *forest size.* Congruent with Ostrom's argument of *spatial extent* I expect that the bigger the forest, the lower the score on the indicators of collective action will be. Therefore the hypotheses for the two-sample t-test are set up as follows:

$$H_0: \mu_{\text{low collective action}} = \mu_{\text{high collective action}} \quad H_A: \mu_{\text{low collective action}} > \mu_{\text{high collective action}}$$

Table 8: T-test: Average forest size[16]

High Levels of CPR Management	Low Levels of CPR Management	T-test statistics (unequal variance)	P-value
1979.86 ha (n=118)	1026.46 ha (n=62)	5.7128	0.0000

Forest size emerges as a convincing variable for the explanation of the variation in the scores on my index of collective forest management. Smaller forests are more likely to be improving. Communities using smaller forests are more likely to develop institutions for collective forest management.

b. Importance of the Forest

It was reported in the IFRI survey how many individuals in the user group depended significantly on the forest for their own subsistence. This information allowed me to calculate the proportion of all forest user group members that depend on the

[16] The values for forest size, ranging from one hectare to nearly 50,000 hectares, do not follow the t-distribution. A log-transformation proves helpful.

resource in question. Ostrom (1999) mentions “salience” as one of the attributes of the user group that could be thought of as explaining variation in self-organization.

I anticipate levels of collective action to be positively correlated with the proportion of the forest users groups that depend on the forest for their livelihood. I expect that the more people in the group depend on the forest, the higher the score on the indicators of collective action will be. Therefore the hypotheses for the two-sample t-test are set up as follows:

$$H_0: \mu_{\text{low collective action}} = \mu_{\text{high collective action}} \quad H_A: \mu_{\text{low collective action}} < \mu_{\text{high collective action}}$$

Table 9: T-test: Average proportion of group members depending on forests

High Levels CPR Management	Low Levels CPR Management	T-test statistics (unequal variance)	P-values
56%	78%	-3.5476	0.9997

Strangely enough, the higher the average proportion of group members that depend on the forest for their subsistence, the lower the index for collective forest management. The independent variable may need to be improved in order to be useful in the kind of comparison here proposed. Case studies may be more appropriate to look into the relation between *salience* en the emergence of institutions for collective action.

c. Group History

According to the concept of social capital (Putnam, 1993; Woolcock, 1998; Fox, 1989; Gibson, year) groups in time develop trust, mechanisms of reciprocity, and shared experiences in the collective solution of societal problems. This is argued to enhance the chance that they will have fewer problems solving collective action problems. Ostrom (1999) also names a group’s prior organizational experience and the level of trust as attributes that are likely to increase the chance of self-organization. I anticipate levels of collective action to be positively correlated with the age of the forest user group. I expect that the older the group, the higher the score on the indicators of collective action will be. Therefore the hypotheses for the two-sample t-test are set up as follows:

$$H_0: \mu_{\text{low collective action}} = \mu_{\text{high collective action}} \quad H_A: \mu_{\text{low collective action}} < \mu_{\text{high collective action}}$$

Table 10: T-test: Average group history[17]

High Levels of CPR Management	Low Levels of CPR Management	T-test statistics (unequal variance)	P-values
55 years (n=109)	70 years (n=58)	-2.1158	0.9819

Again, the numbers do not support the alternative hypothesis. I do not find evidence that the time a group has been in existence is a significant variable explaining variation in the score on the index of collective forest management. On the contrary, groups that are more involved in collective forest management are significantly younger. Evidently more factors than age alone go into the estimation of any group's levels of trust, reciprocity and prior experience in collective problem solving. Does the measure used here maybe pick up the fact that younger groups are still more dynamic? Are older groups maybe more likely to have shifted from forestry to other economic activities such as agriculture? Case studies seem an appropriate method to look into this question in more detail.

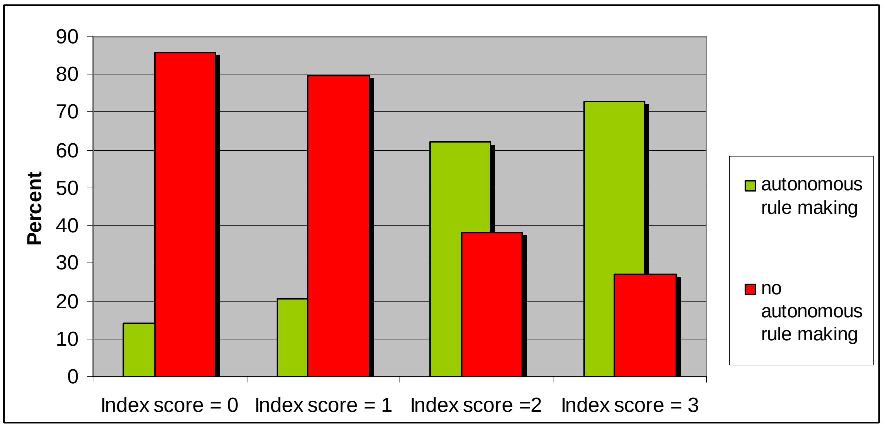
d. Autonomy

Ostrom (1999) mentions autonomy as one of the attributes of the user group that will enhance the likelihood of a group's involvement in collective forest management. I anticipate levels of collective action to be positively correlated with the level of autonomy that forest users groups have regarding the management of their resources. I

[17] The t-test is performed on the square-rooted values, since that particular transformation resulted in a normal distribution.

expect that the higher the level of autonomy, the higher the score on the indicators of collective action will be.

Figure 1: Forest user groups compared according to "autonomy"

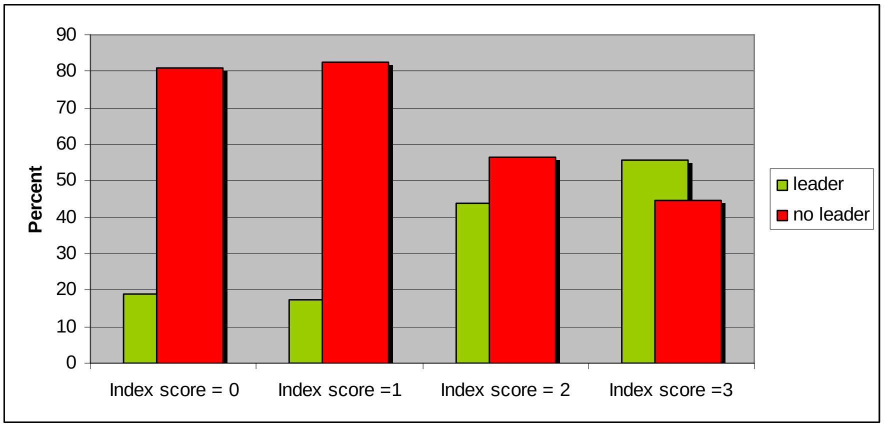


Autonomy is an important variable when looking for an explanation of variation of a group's engagement in collective forest management. The observed difference in the distribution between the comparison groups is significant at the 0.001 level.

e. *Leadership*

Olson (1965) argues that collective action is more likely to occur when certain groups or individuals are willing to bear a disproportional part of the costs involved in the organization, and when they are willing to accept that others will free-ride on their efforts. The IFRI data set reports whether a groups has any individual that acted as a leader, investing time, energy or resources in the management of the forest. When plotted on the index scores it is clearly illustrated that leadership is an important factor.

Figure 2: Forest user groups compared according to "leadership"



A Kolmogorov-Smirnov test furthermore confirms that the observed difference in distribution is significant at the 0.001 level.

f. Group Size

Mancur Olson (1960) argues that smaller groups will have less problems organizing than larger groups (See also Poteete and Ostrom, 2004). In congruence with Olson's argument I anticipate levels of collective action to be negatively correlated with the size of the forest user group. I expect that the bigger the group, the lower the score on the indicators of collective action will be. Therefore the hypotheses for the two-sample t-test are set up as follows:

$$H_0: \mu_{\text{low collective action}} = \mu_{\text{high collective action}}$$
$$H_A: \mu_{\text{low collective action}} > \mu_{\text{high collective action}}$$

Table 11: T-test: Average group size[18]

High Levels of CPR Management	Low Levels of CPR Management	T-test statistics (unequal variance)	P-value
619 members (n=113)	464 members (n=73)	-2.3552	0.9900

My data set does not support the alternative hypothesis. Again, it seems that for a valid analysis the independent variable (group size) has to be fine tuned in order for it to

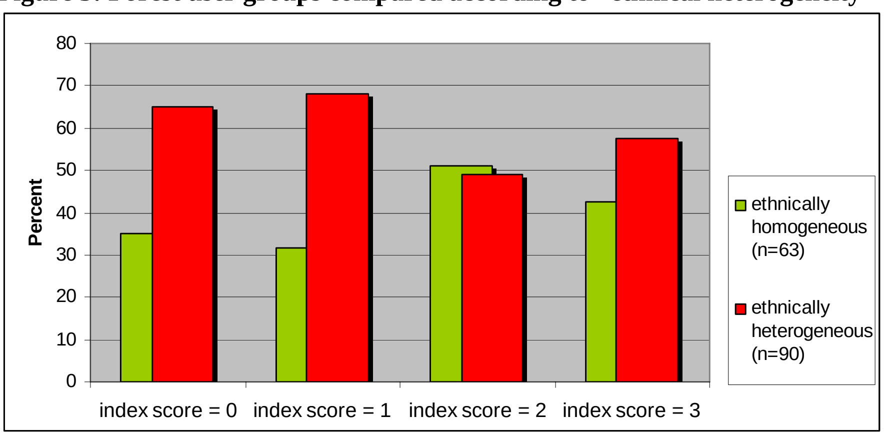
[18] The t-test is performed on the log values for "group size", since that particular transformation resulted in a normal distribution.

be useful in the kind of comparison here proposed. (For a detailed discussion regarding the nuances related to the possible links between "group size" and "collective action" see Poteete and Ostrom 2004)

g. Heterogeneity

Many scholars have looked into the relation between group heterogeneity and levels of collective action (See for example Fearon and Laitin 1996, Baland and Platteau 200, Heckaton 1993, Velved 200, all quoted in Poteete and Ostrom, 2004). Heterogeneity can refer to cultural divisions, economic differences, spatial distribution, political power, etc. Given the data availability in an analysis that encompasses the entire IFRI data base I will assess the impact of heterogeneity defined in terms of ethnicity and religion only. For the analysis those groups consisting of one ethnicity were coded "*homogeneous*". Those groups composed of members belonging to two or more ethnicities were coded "*heterogeneous.*"

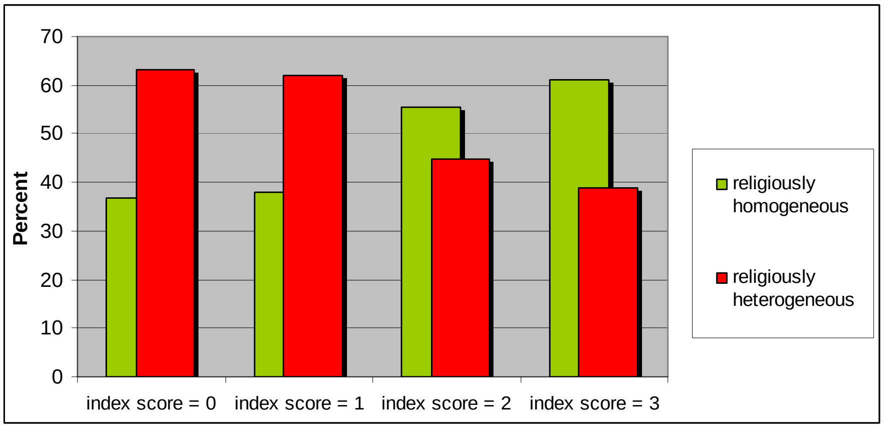
Figure 3: Forest user groups compared according to "ethnical heterogeneity"



Although the trend observed in the graph above is congruent with the expectation that heterogeneous groups will score low on the index of collective forest management, this impression is not statistically significant.

Secondly I assess the variation in levels of collective forest management with regard to different levels of religious heterogeneity. All forest user groups the members of which all adhered to one single religion were coded *"homogeneous"*. Those forest user groups where not all members shared the same religion were coded *"heterogeneous."*

Figure 4: Forest user groups compared according to "religious heterogeneity"



In this case the observed trend proves to be statistically significant. Religious heterogeneity on the other hand does have a statistically significant impact on collective action with regard to forest management

Poteete and Ostrom (2004) look at a series of empirical research based on the IFRI data and show demonstrate that heterogeneity does not always negatively affect some forms of collective action. Case studies may be a more appropriate way to look at the precise relation between different forms of heterogeneity and the occurrence of successful and long-lasting forms of collective forest management.

8 Discussion of the Results

Many empirical analyses using the same or similar data focus on singular countries (See for example Gautam et al. 2004 (Nepal), Ghate 2004 (India), Gibson and LeHouq 2003 (Guatemala), Kajembe et al. 2003 (Tanzania), Becker and Ghimire 2003

(Ecuador), Gombya-Ssembajjwe et al. 2003 (Uganda), Southworth and Tucker 2001 (Honduras), Becker and León 2000 (Bolivia)). Restricting the search for drivers of deforestation to one particular region allows the researchers to take into account climatic, ecological, institutional and historical variables that are particular to any locality

Regardless of country or region specific particularities, this study has tried to identify some more general principles that help to explain why forest conditions may deteriorate or why forest users may organize in order to prevent that. First, I examined how forest conditions are likely to react to stress? It is clear that the relation between "intensified forest use" and "forest degradation" is not always as straightforward as often thought. Surprisingly, improving forest conditions are correlated with *higher* levels of users per hectare. This result may suggest that population pressure could result in an incentive for forest communities to get their act together and collectively work on the improvement of their resource. The finding that the users of improving forests are more integrated into the market than forest users harvesting from declining forests, may be unanticipated also. Does that market integration result in forest communities perceiving their forests as potential income generating resources that are to be taken care of?

Returning to the questions asked at the beginning of this paper, if forests are valued by all (or most) of its users, why do they degrade? Or maybe equally important, why don't they? What do forest users do to deal with stress on forest conditions? Forest users that successfully manage to keep (or get) their resource away from a tragedy of the commons have put in place a particular set of institutional arrangements. Improving forest conditions are correlated with *less* forest products harvested to which no harvesting rules apply, with *higher* levels of engagement in monitoring activities, and with involvement in a *higher* number of resource maintenance and improvement activities.

The second set of questions I asked myself in the introduction was why forest user groups do not try to prevent their resource from disappearing when they all esteem the goods and services provided by it? Or maybe equally important, when will groups of forest users invest time, energy and resources in keeping their resource fit? Under what circumstances is it most likely that institutions for successful and long-lasting forest management will emerge? A common pool resource management regime requires collective action. When will forest users collectively act their way out of the tragedy of the commons? The comparison group that on average scores low on the index for collective forest management shows a significantly *high* proportion of forest user groups that have no leader. Furthermore, this same comparison group shows a significantly *high* proportion of forest user groups does not make (part of) their own rules. Also, forest user groups that are more involved in collective forest management tend to harvest from significantly smaller forests.

Methodologically it has proven difficult to deal with endogeneity. Collective forest management may cause healthy forests. But healthy forests may also cause collective forest management. Fortunately, after ten years, IFRI is at a point where more and more sites are visited and surveyed for a second time. This opens the possibility to construct time-series regression techniques in the very near future that are able to deal with endogeneity and causality problems in the analysis of forest management regimes.

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