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ORIGINAL PAPER

Forest protection in Central India: do differences in monitoring by state and local institutions result in diverse social and ecological impacts?

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Abstract Protection of forests and wildlife outside protected areas (PAs) is necessary for the conservation of wildlife. Extension of conservation efforts outside the existing PA may result in restrictions on local forest resource use. Such situations arise due to differences in understanding of forest as a resource for communities and as a conservation space for endangered species. A clearer focus is needed on the functionality and socio-ecological outcomes of different forest management institutions to address such issues. We conducted a study in a forest landscape connecting Pench and Tadoba-Andhari Tiger Reserves (TRs) in Central India. The two main forest management institutions were the Forest Department (FD) and local communities managing forest resources. We conducted vegetation surveys and focus group discussions in 15 villages selected based on presence or absence of active protection and monitoring of forest resources by either FD or local people. We found that forests with monitoring had significantly higher tree density and vegetation species richness compared to forests without monitoring. Tree density was observed to be higher in sites monitored by villagers rather than those monitored by FD. Self-regulation and resource sharing in locally monitored forests were more acceptable to local communities. In forests monitored by the FD, local communities indicated a feeling of alienation from

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the forest that weakened their motivation to protect the forest and wildlife. Recognition of local community rights is essential to achieve conservation goals and reduce social conflicts outside PAs, requiring collaboration between state and local institutions.

Keywords Forest institutions · People participation · Forest Department · Bureaucracy · Biodiversity

Introduction

Protected areas (PAs) have been the cornerstone of Indian and global conservation efforts. There are over 209,000 marine and terrestrial PAs worldwide in 2014 that cover more than 30 million km^2 (United Nations list of Protected Areas 2014). In India there are 733 PAs by 2016 that cover 4.89% of the country's land area (ENVIS Centre on Wildlife and Protected Areas 2016). However, effectiveness of conservation and protection by the state Forest Department (FD) varies considerably across these PAs. Furthermore, these PAs have become increasingly isolated as pressure on forests have shifted towards the portion of forests falling outside these PAs (DeFries et al. 2010; Ravindranath et al. 2012). Studies have shown that these forest patches are under great threat and getting degraded due to various reasons such as monoculture tree plantations (teak, eucalyptus), and plantations of coffee and tea, extraction of biomass by local communities, encroachment for agriculture land, demand for timber, among other reasons (Heltberg et al. 2000; Lugo 1997). This impacts the ecological processes such as connectivity among wildlife populations and dispersal that are important for long term species survival and persistence (DeFries et al. 2005; Karanth and DeFries 2010). Since effective implementation of any PA program involves high economic as well as social costs, connectivity across vast landscapes cannot be provided solely by expansion of the PA network; the forest outside the PAs are as important as the PAs themselves (Agrawal and Ostrom 2001; Nagendra et al. 2008).

In India, forests are legally under the FD (Guha 1983) that functions in a hierarchical and top-down manner typical of most bureaucratic agencies of the state (Fleischman 2015; Guha and Gadgil 1989). The department is divided into the following divisions in decreasing order of hierarchy: circle, division, range, round, and beat. Historically, the British introduced scientific management of forests through a centralized approach to forest management and development. The forest management strategies were markedly biased towards commercial and industrial exploitation (Guha 1983). After adoption of the PA model, in post-colonial era, the FD's mandate became protection of the forests. However, outside the PAs the department performs a range of revenue generating functions such as plantation, revenue from timber and non-timber production; and also monitors forest patches (Fleischman 2015). In recent years, the functionality of the FD is always justified for enhancing ecological security and biodiversity conservation (Fleischman 2014). However, Fleischman (2014) has argued that there are several reasons and motivation behind the FD functionality at the local scale such as rent seeking, discursive power, and institutionalized incentives. There are two main functions of the FD: one being beat or coupe cutting (cutting trees in selected beat) and the other of promoting plantation, usually of eucalyptus and teak, which generate revenue for the FD. Many afforestation programs such as the CAMPA (Compensatory Afforestation Fund Management and Planning Authority) were based on this process. Promoting monoculture through plantation results in problems such as biodiversity loss, adverse impacts on soil (Bonell et al. 2010) and

hydrological processes (Krishnaswamy et al. 2012). Thus, ecological services are not enhanced by adopting monoculture plantation as other studies have also suggested (Afreen et al. 2011; Chaturvedi et al. 2011; Das 2010).

Another complexity behind managing forests situated outside PAs in India is the high population density and livestock density living in close proximity to forests with a high dependency on biomass for livelihood. When compared to other countries, a large part of India's population live in and around the forest (DeFries et al. 2010). Historically and traditionally local communities were dependent on forests for livelihood and cultural services. Such dependence promoted practices for monitoring and managing forests. Studies on common pool resources (Agrawal and Ostrom 2001; Nagendra et al. 2008) show how participation by local people through informal institutions can effectively manage common pool resources (Agrawal and Ostrom 2001; Ostrom 2000). Such studies argue that common pool resources could be efficiently managed by local communities through practices such as rights of making rules, ownership over resource and equitable sharing of benefits (Cox et al. 2010). This is often seen coherent with the larger objective of conserving biodiversity (Ghate et al. 2013a). However, such narratives to achieve conservation goals are disconnected with motivation of the local people behind the common resource management. In return for managing and monitoring the forest, local communities seek benefits, such as rights over resource, transparent and equitable sharing of the forest resource, and rights to form and change rules, that are often denied as the decision making power lies with the FD (Cox et al. 2010). Therefore, on many occasions local communities and the FD find themselves in conflict with each other because, of differences in understanding of ownership over resources (Sarin et al. 2003) and lack of adequate dialogue (Castro and Nielsen 2001).

Before promoting or rejecting either form of management, it is important to understand its ecological as well as social consequences. We study effects of such disparate management approaches on vegetation in the central Indian dry forests, using a range of institutional settings present in the area. Here the forests are managed by (a) strong participation of the local people, (b) joint management by people and FD, and (c) FD only, without any participation from local community. These institutions mainly help in monitoring the forest patch, which in turn help in maintaining forest density and diversity effectively (Fleischman 2009). Therefore, to achieve regional and landscape level conservation goals, such as maintenance of forest corridors outside PAs, one needs to understand the social and ecological impact of local institutions. In this study we address the following questions:

(1) Is there any difference in the vegetation (tree species richness, abundance and biomass) across the institutional settings?
(2) How do the local forest institutions function on ground in terms of rulemaking, monitoring and regulation?
(3) What are the perceptions and motives of different actors, namely, the local community and FD behind forest management? And how do the two interact with each other?

Methods

Study area

This study focuses on the landscape connecting two Tiger Reserves (TRs) covering five districts in Eastern Maharashtra, collectively known as 'Vidarbha' (Fig. 1). The region has

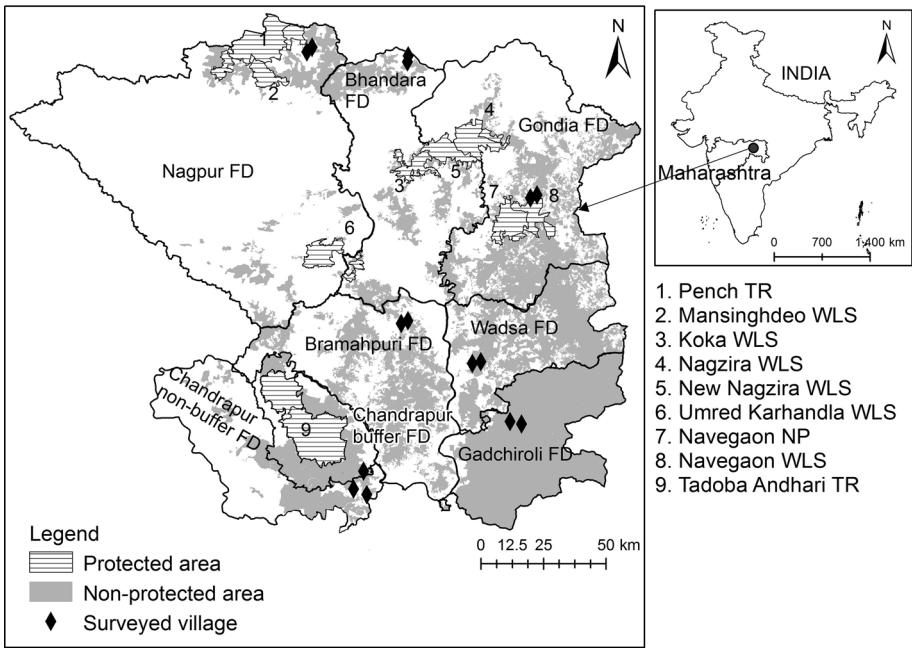

Fig. 1 Distribution of PAs in the study area, and the location of 15 surveyed villages

rich dry tropical forest cover. Our study covered eight forest divisions, with approximately 11,000 km^2 area under forest cover. Out of which, only 1350 km^2 is part of the PA network (Agarwal et al. 2016a). The vast expanse of forest outside the PA also has direct relevance to formal conservation goals as these may serve as potential corridors for wildlife (Ghate et al. 2013b; Joshi et al. 2013). The same forests also provide subsistence and economic benefits to a large population of tribal as well as nontribal communities that live near the forests.

In several such villages, the communities have devised rules and regulations for harvesting, managing and protecting the resource on which they depend (Ghate and Nagendra 2005). At the same time, the State scheme of Joint Forest Management (JFM), focusing on regulating extraction and promoting plantation in forests outside the PA, has been implemented since 1990s. Whether local and state institutions conflict or complement each other will depend on the nature and type of interaction of the two types of institutions. This can ultimately affect rates of extraction from the forest resource and the conservation outcomes. In this study, we adopted methods to understand local people's outlook towards the forest resource and nature of the institutions. We evaluated the ecological effectiveness of the institutions through ecological assessments of forest condition.

Field method

We gathered information on the JFM projects as well as the villages where local informal institutions were present, from FD officials, local non-governmental organizations (NGOs) and other key informants. The villages identified were under eight forest divisions that include Nagpur, Bhandara, Gondia, Brahmapuri, Wadsa, Gadchiroli, Chandrapur buffer

and Chandrapur non-buffer forest divisions. Using this information and adopting a purposive sampling approach, we identified two villages in each forest division, one with a local informal or formal institution and another without. The two villages within each forest division were comparable in terms of population, distance to forest, proximity to market and town, and other facilities.

Data on vegetation

We identified forest patches from which the villages were extracting resources. In each of these forest patches, we established 30 random circular plots of 10 m radius. At each plot we recorded species identity, Girth at Breast Height (GBH), and height of all individuals greater than 10 cm GBH. Within each 10 m plot, we established two nested concentric plots of 3 and 1 m radius. In the 3 m plots we recorded GBH and height of all trees, shrubs, and climbers with GBH less than 10 cm and height greater than or equal to 1 m. In the 1 m plots we recorded all trees, shrubs, climbers and herbs with height less than 1 m. Later, diameter at breast height (DBH) was calculated using GBH. Out of 16 selected villages, vegetation data was collected for 15 villages. This was because in one buffer zone forest division, viz. Chandrapur, there were no villages with local forest institutions (refer Agarwal et al. 2016b, for more details on vegetation sampling).

Our study is a space for time substitution as ideally one should track both categories of forests through time. However we have chosen the two types of forests in close proximity to ensure similarity in initial conditions and other biogeophysical factors.

Data on institutions

At each village, we conducted semi-structured focused group discussions each lasting about 3–5 h at public meeting places. People representing different groups, typically a mix of elderly men, and young to middle aged men were present. We also tried to ensure that we captured the views of women via separate interactions. We gathered additional information through open ended questions from key informers and forest officials in each division. We asked questions with the objective of gaining insights about the three main components that were considered for understanding the institution namely, constitution, functionality, and motivation. The questions included how the forest committee was constituted, who took initiative to constitute the committee, and how members were elected. In order to understand the functionality, we asked questions related to rules and norms, who made these rules, whether the rules were based on the consideration of equity or not. We also asked questions relating to imposition of fines. Apart from this, we asked questions such as why members of the committee were interested in the management and what motivated them to constitute the committee.

The effectiveness of the local or state institutions will depend on ability to monitor and moderate, resource use from the forest. Therefore, we particularly focused on monitoring practices by the different institutions. Our hypothesis was these would have most direct impact on vegetation. We borrow definition of monitoring from Ghate and Nagendra (2005) that defines monitoring as the process of restricting outsiders from the use of forest resource along with mechanisms to ensure rule compliance and dealing with infraction.

Table 1 Description of the variables used as fixed effect

Levels	Variables for fixed effect	Description
Forest	Area of forest patch	Area of forest patch from digitized polygon of each village
	Surrounding village population	Total population from 2011 census data of villages within 1 km buffer around each surveyed village
	Adjoining forest area	Area of forest in 2 km buffer around each nearest village, as people from each village could travel a minimum distance of 2 km
Plot	Slope	Calculated using ASTER DEM data of 30 m resolution
	Distance to village	Distance from each plot to the respective village
	Distance to non-forest edge	Distance from each plot to non-forest edge such as road, agricultural field, water body
Village	Population	From 2011 census data
	Increase in population	Difference in population from 1991 to 2011 using census data
	Distance to market	Distance from each village to nearest market

Analytical methods

Analysis of vegetation data: We used Generalized Linear Mixed Models (GLMM) (Bates et al. 2012) to compare observed tree species richness and tree abundance between categories of institutions identified using interview data. Vegetation biomass was not considered for the regression since it did not vary across monitoring categories. We used the institution type along with other landscape variables as fixed effects and village code as random effect of intercept (Table 1). The landscape variables were divided into three levels viz., plot, forest patch and village. We compared two generalized linear mixed models, one with only institutions categories, and the other with institutions categories and one variable from each of the landscape level, which was highly correlated with tree abundance and species richness. The villages selected were only a small subset of all the possible villages that can have similar institutions. Therefore, we included village identifier as random effect. Regression for species richness had poisson error structure while for abundance and biomass we used negative-binomial distributions (He and Gaston 2000; Smith and van Belle 1984; Ver Hoef and Boveng 2007). We used the lme4 package (Bates et al. 2012) in R 3.2.2 (R Core Team, Vienna, Austria) software to perform the GLMM.

We checked for spatial autocorrelation using 'Moran's I'. We also compared strength of spatial autocorrelation in observed values of species richness and abundance with residuals of regression with institutional categories, which was our main variable of interest. The autocorrelation in regression residuals was not significant. Therefore we use non-spatial regression models for the rest of the analysis. We used the package spdep version 0.6-6 (Bivand et al. 2013) in R 3.2.2 (R Core Team, Vienna, Austria) software to estimate spatial autocorrelation.

Results

Based on the focused group discussion, we found that monitoring is an integral component of the local forest institutions. Effectiveness of these institutions was based on effective monitoring. With the help of monitoring and forest management, one community restricts

Table 2 Information on local institutions and monitoring status

Village code	Local institutions	Year of JFMC formation	Monitoring
V1	JFM	2006	FD
V2	–	NA	FD
V3	Community managed and JFM	1994	People
V4	–	NA	None
V5	Community managed and JFM	1998	People
V6	–	NA	None
V7	JFM	2000	None
V8	–	NA	None
V9	Community managed and JFM	1998	People
V10	–	NA	None
V11	JFM	2000	People
V12	–	NA	FD
V13	JFM	2003	FD
V14	–	NA	FD
V15	JFM	2002	People
V16	–	NA	FD

the use or overuse of the forest resource by other villages, and also controls the use within the community. Most forest patches are under Reserve Forest (RF) category, hence the forest patches are also monitored by forest guards. We found that our sampled villages broadly fall under three different categories of monitoring (Table 2).

(1) Monitoring by forest guards (FD).
(2) Local people participation in monitoring (People).
(3) No involvement of FD and local community in monitoring (None).

Effect on vegetation in different monitoring categories

Estimating spatial auto-correlation

Observed species richness and abundance are spatially autocorelated. However, the magnitude of spatial auto-correlation in residuals of generalised linear mixed model for abundance and species richness with institutional categories, is much weaker and not significant (Table 3).

Table 3 Spatial auto-correlation

Variable	Moran I statistic	Variance	Standard deviation	P value
Tree abundance	0.3009	0.00013	25.97	<2.2e−16
Residual of GLMM model for abundance	0.00319	0.000136	0.464	0.321
Species richness	0.2860	0.00013	24.65	<2.2e−16
Residual of GLMM model for species richness	−0.0109	0.000136	−0.745	0.7719

Effect of institutions on vegetation using generalized linear mixed model

There was variation in the abundance and species richness across villages. To account for these differences we used GLMM with random intercepts term for village. Forest patches that were not monitored had consistently lower abundance and species richness than forests that were monitored by either people or FD (Fig. 2a, b). However, which institution was carrying out monitoring was of little importance. The magnitude of difference between monitoring by people and FD was always much less than that between monitored and unmonitored forest patches (Fig. 2a, b). The relative ranking of the three categories was consistent even after including other potential predictor variables. When comparing abundance of stems with different DBH, abundances of small stems were most different between forest patches with and without monitoring (Fig. 2c, d). On the contrary, tree biomass of the forest plots was not different across the three categories (Fig. 2c, d).

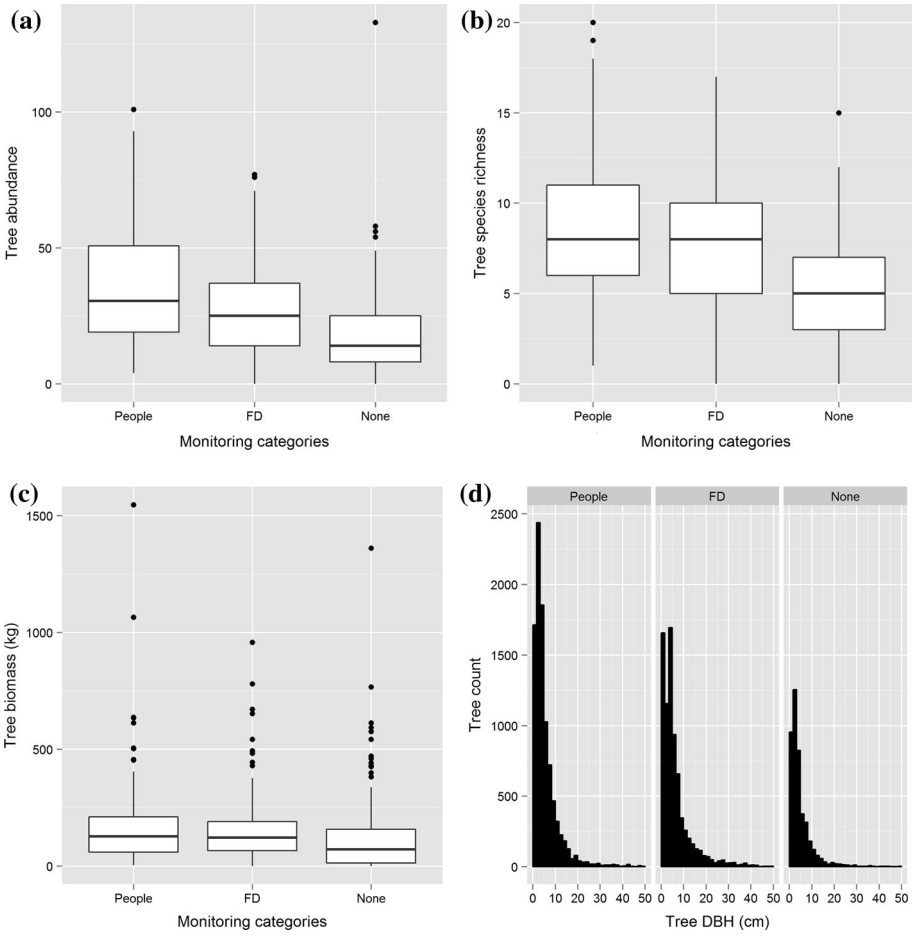

Fig. 2 **a** Tree abundance; **b** tree species richness; **c** tree biomass and; **d** frequency of tree DBH in the forest patch of villages in different monitoring categories

Table 4 GLMM for tree abundance

GLMM for tree abundance (family: negative binomial)	Variables for fixed effect	Estimates of fixed effects	Estimates of village random effect	AIC	Log likelihood	Pseudo R^2
Null	1	4.86 (±0.17)[c]	0.4248	5334.8	−2664.4	
Monitoring	People	3.50 (±0.14)[c]	0.091	3714.9	−1852.4	0.30
	FD	−0.27 (±0.20)				
	None	−0.66 (±0.22)[b]				
Monitoring, area of forest patch, population increase, distance to village	People	3.47 (±0.14)[c]	0.091	3715.6	−1849.8	0.30
	FD	−0.28 (±0.21)				
	None	−0.54 (±0.24)[a]				
	Distance to village	0.10 (±0.05)[a]				
	Increase in population	0.09 (±0.10)				
	Area of forest patch	0.006 (±0.11)				

a < 0.05, b < 0.01, c < 0.001

Null model was performed in order to compare with different other models. The AIC value of null model was highest as compared to other models implying that adding covariates would be useful to understand the relation with tree abundance and species richness. In all the models, variance explained by the random effect term was very small. Therefore, most of the unexplained variance was either random or due to unmeasured process.

In case of abundance, landscape variables had very little effect on the model. The pseudo-R^2 as well as AIC values of models with only institutional categories and more complex model with landscape variables were almost identical (Table 4). While in case of species richness, the explanatory power of any model was very poor, therefore it is difficult to draw inference on relative importance of variables (Table 5).

The two models, other than null model, show that tree abundance in unmonitored forest patches was significantly lower as compared to monitored forest patches. The tree abundance in forest patches with FD monitoring was lower as compared to forest patches with people's participation in monitoring by −0.2 (Table 4).

Similarly in the case of species richness, both the models show that species richness in unmonitored forest patches was significantly lower as compared to monitored forest patches. The species richness in forest patches with FD monitoring was lower as compared to forest patches where there was people's participation in monitoring (Table 5).

Focus group discussion in different monitoring categories

Constitution

All the selected villages with participation by local communities had JFM committees, which were almost 15 years old (Table 6). These villages had a longer history of informal management of the forest since the 1980s, and the formal JFM committees were constituted later, after the introduction of the JFM programme in this region. The JFM committee

Table 5 GLMM for tree species richness

GLMM for tree species richness (family: poisson)	Variables for fixed effect	Estimates of fixed effects	Estimates of village random effect	AIC	Log likelihood	Pseudo R^2
Null	1	1.93 (±0.08)[b]	0.095	2313.2	−1154.6	
Monitoring	People	2.13 (±0.09)[b]	0.039	2305.3	−1148.6	0.005
	FD	−0.13 (±0.13)				
	None	−0.58 (±0.14)[b]				
Monitoring, area of forest patch, population increase, distance to village	People	2.10 (±0.08)[b]	0.033	2297.9	−1142.0	0.01
	FD	−0.12 (±0.12)				
	None	−0.47 (±0.14)[a]				
	Distance to village	0.07 (±0.02)[a]				
	Increase in population	0.02 (±0.06)				
	Area of forest patch	0.05 (±0.06)				

a < 0.01, b < 0.001

was constituted by the community and the members selected by the villagers in the village assembly (*gram sabha*). All the households had one or two members from the committee. In the past 15 years, the committee were re-elected at least twice and recently, the composition of female members had also increased.

In contrast, only two villages had JFM committees in the villages where the forest was monitored by the FD. These committees had been functioning for the last 10 years (Table 6). The JFM committees were initiated by the FD and members were elected by the forest officials. The selected members were also found to be members of the village committee (*gram panchayat*). In the past 10 years, the original JFM executive committee members had not changed. Only the number of executive members had increased due to recent changes in the rules of the JFM committee.

Functionality

In the villages where the local community participated in forest management and monitoring, the people had a good understanding of their forest boundary, rules and norms, and were also involved in rule making through village meetings or JFM committee meetings (Table 7). In most of the villages, local people were directly involved in monitoring the forest, in groups that were formed by involving each household on a rotational basis. Village V3 appointed two guards from the village for monitoring the forest, who were paid collectively by the villagers. Harvest of fuelwood, timber and other non-timber forest products (NTFPs) was regulated by the committee with complete restriction on any resource use by outsiders. Fines were imposed by the committee if anyone violated the rules. These villages have a good relationship with FD, were beneficiaries of plantation projects, and had a share in timber proceeds and received a yearly JFM prize from the state government.

In contrast, in the villages where the forest patch was monitored by FD officials, the forest guard and other department staff had a clear idea about the forest boundary but

villagers were less sure about theirs (Table 7). Even though villagers were aware of the forest boundary, they did not strictly adhere to these limits and used to extend collection of forest resource in a 2–3 km radius around the village based on their convenience and restrictions on collection. Everyone in the village knew the rules of RF, such as the ban on carrying an axe into the forest and prohibition on taking a bullock cart and bicycle inside the forest for any collection. They were allowed to collect fuel-wood and NTFPs from the forest, but cutting live trees as taking logs was completely prohibited. The violators were fined by the forest guard based on the number and size of the logs illegally extracted.

Motivation

From group discussions and informal interactions, in the villages, where people were participating in forest monitoring, the feeling of belonging towards their forest was found to be strong. The villagers were also influenced by the local leaders and NGOs. From the interview data we found that in these villages the motivation was resource based as these villages are highly dependent on forest resource for their livelihood (Table 8). The ownership over the forest patch led to decreased struggle over resources and more equitable and fair sharing of the resources. Self-governance nature of the resource use had enabled them to restrict outsiders and maintain the patch in such a way that the resource would be available in the long term. Villagers had the right to make rules and modify them with consensus if needed. In many instances, local rules and norms of forest management pre-dated the formation of JFM committees. These existing formal or informal committees were renamed as JFM committees and showcased as JFM success stories. Villagers felt that the presence of the FD was helpful in regard to reducing the incidence of violent interactions with outsider villages. They also took pride in stating that the forest density had increased over time.

In contrast, in the villages where the forest patch was monitored, there was a lack of motivation towards forest management among villagers. Four out of six villagers had responded that they would like to manage the forest patch without any intervention from the department (Table 8). The FD focused on managing forest patches via plantation projects. They selected villages for creation of JFM committees based on the availability of areas for plantation. Forest officials mentioned that they had been given targets from higher authorities to create JFM committees in each range, which was the reason to form JFM committee. They were tasked with demonstrating a high success rate of plantation, and preferred planting teak because this species grows in this region relatively easily as compared to mixed species plantation.

In all the villages, we found strong cultural dependencies on the forest, with traditions of worship of *Madhuca longifolia* and *Ficus* trees. Although there were no sacred patches conserved, villagers refrained from cutting sacred trees. They believed that the forest was important for maintaining the biodiversity, soil, air and rain, and wanted to protect forests even though they faced problems such as crop depredation by wild animals.

Unmonitored forest patch

In unmonitored forest patches there was no defined boundary for forest resource use (Table 9). The forest patch of the village had degraded over time. The people of this village had recently encroached upon forest land for agricultural purposes. In two locations, the villagers were aware of the forest boundary and also interested in the protection of the forest. However, there was high pressure from outside villages. The population of

the two villages was low, while the villages outside had a higher population (Table 9). Villagers did try to prevent forest use by outsiders, and this had resulted in a few incidences of violence. But the violators had political support, and the villagers progressively lost interest in protecting the forest.

We found that the local people were distrustful of forest policies. There was a lack of interest in protecting the forest patch both among villagers and forest officials. Various reasons were stated in different locations such as local political support, the influence of local militancy and violence, degraded condition of forest, and absence of plantation projects.

Discussion

The study found that monitored forests were performing better when compared to unmonitored forest in terms of both tree abundance as well as species richness. Previous research has shown that monitoring of common pool resources and sanctioning of violators had a positive relationship with effective community based natural resource management (Ghate et al. 2013b; Ghate and Nagendra 2005). Similarly in this study as well, monitoring has emerged as an important component that is associated with reduced degradation. Even though the difference in abundance and species richness was not very high in people-monitored verses FD-monitored forest patches, there was positive social implication in the villages with active participation in forest management. It was found that participation from local people is important, especially from the point of view of rule-making and equitable management of resource use. Research has demonstrated that local participation in forest management has led to better forest management (Cox et al. 2010; Ghate et al. 2013a) as this provides rights to make and modify rules for the use of common pool resources.

In this study we found that the villages that had local participation of people in forest management had a clearer understanding of forest boundaries—a finding supported by previous research on community management of resources (Cox et al. 2010). Studies have demonstrated the importance of vertical and horizontal interplay between community and state institutions (Berkes 2007; Brondizio et al. 2009). Thus, we suggest the FD should provide increased support to community based institutions for better functionality.

Many studies have found that the bureaucratic and hierarchical nature of the FD was a major reason for the failure of JFM programs (Fleischman 2014; Nayak and Berkes 2008; Sarin et al. 2003). Previous research has suggested that the FD seeks monetary benefits through plantation and JFM projects. They seek power and control over the forest resources including timber and NTFPs to restrict the local communities. They also do not want to delegate the power of making rules and control over resources to the local community (Fleischman 2015). Our research corroborates this. We find that traditional 'Nistar Rights' under which the villagers are permitted to use the forest resources for their subsistence without any restriction, were no longer available to the villagers. Instead, fines were imposed, villagers were forced to surrender their axe, bullock cart or bicycle to the FD. Such instances had led to distrust and conflict between villagers and FD, alienating the villagers from the forest, and reducing their sense of belonging.

The status of the forest patches under FD is known to be dynamic as the functioning of the institutions depend on the quality, competence and attitude of the forest staff. The FD staff keep changing every 2–3 years (Fleischman 2015). During interviews, people said

that the changes in guards led to changes in implementation. Forest guards, who are in the lower rank of the FD, usually communicate with the villagers regarding policies. Responses of the local people and outlook towards the forest and the FD depend a great deal on the interaction between forest guards and other officials (Vasan 2002). However, the status of the FD officials was very dynamic and vary based on their individual backgrounds and training imparted before they join the department. In contrast, the forest patches under the management of local communities was found to be more resilient to these crucial micro-level changes, as the functionality was dependent on the local people, and their interest and motivation was long-term and less dynamic (Ghate et al. 2013b). For instance in village V9, people mentioned that they had some differences with the range officer in the past, because of which the process of monitoring was affected, but later due to good leadership of committee members from the village, people started monitoring the forest patch again (Table 7). Hence the forest patch is more resilient to such external changes.

The mosaic of PAs linked to forests outside PAs is needed to achieve larger conservation goals, as this provides better connectivity across PAs for wildlife movement and supports livelihoods of the local community (Nagendra et al. 2008). There is a need to find a balance between conservation goals, socio-ecological stability, and sustainable use of forest resource. The literature on common pool resources broadly discusses the role of local people, and rules and norms in managing the resources (Agrawal and Ostrom 2001; Ghate et al. 2013a; Ghate and Nagendra 2005; Hayes and Ostrom 2005). The state policies also play a major role in facilitating support to the local community (Berkes 2007). However, these polices neglect the motivation of the local community behind participation in forest management. Studies show that local people need rights over resource management, instead of externally enforced rules (Torri 2011; Vollan 2008). In many cases JFM committees are not successful because of the hierarchical nature of the committee (Fleischman 2014). The villages where we found active participation of the local people in management are heterogeneous (Poteete and Ostrom 2004). The core reasons behind better functionality may differ from case to case but by and large they had equitable sharing of resources, the rights to formulate the rules, and support from the FD (Cox et al. 2010). Whereas, where top down approach is practiced by the department and rules were externally enforced on the community, people seem to be alienated from the forest and lacked interest in monitoring and managing the forest (Gautam et al. 2004; Sarin et al. 2003). This further makes the forest corridor more fragile and in danger of degradation, rendering forests less sustainable for both people and wildlife.

Conclusion

In order to achieve conservation goals, protection of forests outside PAs is important to ensure forest connectivity across larger landscapes at the regional scale. We found that forest patches that are monitored have improved vegetation quality (tree density and species richness) when compared to unmonitored forests. In the monitored forests, those with active monitoring by local people performed better as compared to FD managed forests, in terms of forest management institutions. Analysis of the interviews point out that when forests were managed entirely by the FD, lack of access to the forest led to mistrust, alienated local communities from the forest and weakened their motivation to protect and nurture the forest. Hence, to achieve conservation goals, the state should facilitate more

local participation in forest management policies by providing community rights for decentralized forest governance. The findings of such region-specific experiments would better help design collaborative conservation planning between the FD and local communities. This will also help provide effective mechanisms for protection of biodiversity outside PAs with the participation of incentivized and empowered local communities.

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Compliance with ethical standards

Conflict of interest The authors declare no conflict of interest.

Appendix

Table 6 Comparison of responses to questions relating to constitution of forest management committee between villages monitored by people and FD

Theme	Monitored by people's participation	Monitored by forest officials
JFM or any other institution involved in forest management	All the selected villages had JFM committees. In one village the JFM committee recently in 2010 changed to eco-development committee	Only two out of six villages had JFM committees
Timeframe of the committee set up	The committees were set up during 1998–2000	The committees were set up in 2003 and 2006
Presence of formal or informal forest management committee in the past	Three out of five villages had an informal arrangement to protect the forest	None of the villages had the informal arrangement to protect the forest
Committee initiated by	Committees were mostly initiated by villagers and also had FD and NGO support	Committees were mostly initiated by FD
Executive committee member	The numbers varied from 8 to 15. Women were also part of the committee	The numbers varied from 11 to 13
General body member	One or two members from each household	One member from each household
Member selection	Members were nominated by villagers and then unanimously selected through village meetings	Members were selected by FD

Table 6 continued

Theme	Monitored by people's participation	Monitored by forest officials
Presence of village committee member in JFM executive committee	All the villages had members other than from village committees	Members from the village committee were present in the executive committee such as the village president
Changes in structure after the committee was formed	Around 2–4 committee members were re-elected and 50% of the committee members were represented by women	Number of members increased, however no change in the president and executive committee members

Table 7 Comparison of the responses to questions relating to functionality of forest management committees between villages monitored by people and FD

Theme	Monitored by people's participation	Monitored by forest officials
Rules	Local residents could collect fuelwood and NTFPs. The villagers had to take permission from the committee if they needed logs from the forest. Villagers were allowed to cut the branches of the trees. Villagers should take forest resource only as per their need. There were restrictions on people not belonging to the village from using the forest resource	There were restrictions on logging and hunting. Local residents could collect fuelwood only through head loads. There were allowed to collect the NTFPs after FD permission. Taking bullock cart, bicycle and axe for wood collection was prohibited
Who made the rules	Villagers made the rules in V3, V9 and V15 villages. In the remaining two villages V5 and V11, villagers with the influence of the FD made the rules	In all the villages' FD made the rules
Committee meeting	In villages V3, V5, V9 and V15 meetings were held at least once a month and V11 held meetings based on issues	Committee meetings were never conducted
Good understanding of rules	Villagers had good understanding of rules made by the villagers as well as of the common RF rules	Villagers had good understanding of the rules made by FD as well as of other norms. However, they did not follow the rules
Rules differ from FD's rules	Yes	No
Clearer forest boundaries	All villages had clearly defined boundaries. In village V11 some part of the forest was transferred to Wildlife Sanctuary (WLS) in 2012	In all villages, the FD assigned one or more compartments to each of the villages. However, villagers used the forest 2–3 km around their village according to their convenience

Table 7 continued

Theme	Monitored by people's participation	Monitored by forest officials
Activities in past 10 years	All the villages carried out plantation more than once that mainly included bamboo, mixed species and teak. They also made fire and drainage lines, and forest ponds, and were actively involved in forest monitoring	Villages V1, V13 and V14 had carried out plantation mainly of bamboo and mixed species. Out of which V1 and V13 had successful plantation. V1 village also made bunds in the forest
Monitoring	Villagers were actively involved in monitoring. In village V5, V9, V11 and V15, 2–4 people from each household on rotation basis went for monitoring. And in village V3 all households paid Rs. 200/year for 2 guards to monitor the forest	In all the villages monitoring was done by the FD. Mostly interested in plantation patches. In V13, villagers said that they sometimes helped FD when fires broke out
Flexibility of the rules	If someone in a village needed extra timber or any other resources, they had to inform the JFM committee after which they were allowed to procure them	No
Graduated sanctions or punishment	In all villages except V5, after a few warnings, committee members or the village guard collected a fine depending on the logs and financial condition of the violators. And in V5, the villagers informed forest guards about any issues	In all the villages forest guards collected the fine
Relation with FD	Except in V11 all villages had a positive relationship with the FD. In village V11 the negative relationship was after the transfer of the forest patch into PA. In village V9, committee members were able to resolve the disputes with forest officials through dialogue	There were conflicts between the FD and villagers
Memorandum of understanding (MOU) signed between FD and the committee	Yes	Villagers were not aware of any MOU and said that the committee existed in name only
Benefits received from the FD	All the villages received funds for plantation and forest pond projects. LPG was provided by the FD. Villages V3 and V15 obtained around Rs. 2 lakh as share in timber proceeds. In one village, FD initiated a project to manufacture incense sticks. V3 village also was rewarded Rs. 5 lakh for the best JFM committee. All the villages also received entry point benefits to form JFM committees	Two villages got employment during plantation projects. However, funds were handled by the FD. In one village because of conflict people did not carry out plantation.

Table 7 continued

Theme	Monitored by people's participation	Monitored by forest officials
Bank account	Yes with signatories' from FD	Villages V1 and V13 had bank account with signatories' from FD
Corruption	In all villages except V11, forest guards were not taking bribes from the violators. Only in V11 did the forest guard occasionally take bribes from violators	In all the villages the forest guard, according to the villagers, used to take a bribe

Table 8 Comparison of the responses to questions relating to the motivation behind forest management committees between villages monitored by people and FD

Theme	Monitored by people's participation	Monitored by forest officials
Drivers and actors behind initiative	In village V3 the protection of the forest was initiated by a village leader. In V9 some villagers were influenced after attending meeting on forest protection. In three other villages (V5, V11 and V15) people were informally protecting the forest and also received support from the FD later through various plantation projects	There were conflicts between villagers and FD. Villagers said they had been maintaining the forest in the past but due to the FD's interference, they were not interested anymore. On the contrary the FD wanted to form the committee owing to plantation projects and also due to pressure from central government policies
Motivation behind the formation of the forest management committee	Overall in all the villages these committees provided the villagers the ownership over the forest patch and decreased their struggle over resources. It gave voice for equitable and fair sharing of the resources and also enabled them to restrict outsiders. Forest officials were motivated to help these villages in order to showcase it as their success stories	Villagers were found demotivated in terms of protecting the forest because of conflict with FD. Forest official were interested in managing the forest because of plantation projects, mainly that of teak, due to its high success rate. Villagers believed that forest officials were interested in earning extra income through bribes
Involvement of villagers in protecting the forest	Yes	No
Traditional norms	Villagers worshipped the *Madhuca longifolia* and *Ficus* trees, and the former was not cut. Wildlife and the forest were also worshipped	Villagers worshipped the *Madhuca longifolia* and *Ficus* trees, and the former was not cut. Wildlife and the forest were also worshipped
Forest help the villagers	Villagers were found to be dependent on the forest for their livelihood and also culturally. They also believed that the forest is important for maintaining the biodiversity, soil, air and rain	Villagers were found to be dependent on the forest for their livelihood and also culturally. They also believed that the forest is important for maintaining the biodiversity, soil, air and rain
Violence	Earlier there were instances of physical violence while protecting the forest from outsiders. The FD helped in minimising the violence by stopping the outsiders from using forest resources	No such event happened in the past

Table 8 continued

Theme	Monitored by people's participation	Monitored by forest officials
Perception regarding the condition of forest	In villages V3, V5, V9 and V15 forest density increased due to active involvement of people in monitoring the forest. In village V11 the forest patch was transferred to WLS, after which in the remaining forest patches, tree density decreased	During the interview people mentioned that in all the villages the tree density had decreased over time. And in villages V1 and V13, people said that the density of trees only increased in plantation plots

Table 9 Response from the villages where people and FD both were not interested

Theme	Not monitored
Rules	There were restrictions on logging and hunting. Local residents could collect fuelwood only through head-loads. Taking bullock cart, bicycle and axe for wood collection was prohibited
Who made the rules	In V4 and V6, villagers said nobody was interested in making rules. In villages V7, V8 and V10, rules were made by FD. However, villagers were not following the rules
Good understanding of rules	General RF rules were known to everyone, however due to lack of proper monitoring nobody followed the rules
Clearer forest boundaries	Villages V4, V6 and V10 had no clear boundary. V7 and V8 villages had clearly defined boundary
Condition of forest	In all the villages, tree density in the forest had decreased over time
Monitoring	No monitoring the forest
Graduated sanctions or punishment	In all villages except V7, no fines were charged. In V7 forest guard occasionally collected a fine
Relation with FD	Villagers were in conflict with the FD
Corruption	In V4, V6 and V10 villages there were no instances of bribing reported. In V7 and V8 villages the forest guard used to take bribe from villagers as well as outsiders
Willingness of the community towards managing the forest without FD's help	All the villages said they were unable to manage the forest without the FD
Dependence of villagers on the forest	Villagers were dependent on the forest both for their livelihood, and culturally. Villagers also believed that the forest is important for maintaining biodiversity, health of soil, air quality and rainfall
Plantation programs	Villages V4 and V7 had plantation projects in 20–25 ha land but were unsuccessful. The remaining V6, V8 and V10 villages did not have any plantation activity
Reason for villagers and FD not showing interest in forest protection	In villages V4 and V6, the FD neglected the forest patches mainly because of the current degraded condition of the forest patch and absence of plantation projects. V10 village was in an area impacted by militant violence, and V7 and V8 villages were facing difficulties because of violators from neighbouring villages, with local political interference

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