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Factors Affecting Collective Action for Forest Fire Management: A Comparative Study of Community Forest User Groups in Central Siwalik, Nepal

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Abstract The attributes of social ecological systems affect the management of commons. Strengthening and enhancing social capital and the enforcement of rules and sanctions aid in the collective action of communities in forest fire management. Using a set of variables drawn from previous studies on the management of commons, we conducted a study across 20 community forest user groups in Central Siwalik, Nepal, by dividing the groups into two categories based on the type and level of their forest fire management response. Our study shows that the collective action in forest fire management is consistent with the collective actions in other community development activities. However, the effectiveness of collective action is primarily dependent on the complex interaction of various variables. We found that strong social capital, strong enforcement of rules and sanctions, and users' participation in crafting the rules were the major variables that strengthen collective action in forest fire management. Conversely, users' dependency on a daily wage and a lack of transparency were the variables that weaken collective action. In fire-prone forests such as the Siwalik, our results indicate that strengthening social capital and forming and enforcing forest fire management rules are important variables that encourage people to engage in collective action in fire management.

Keywords Collective action · Forest fire management · Community forest · Community forest user group

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Introduction

The study of collective actions in management of the commons has made significant progress over the last 5 decades. Previous studies have reported that collective management of the commons has led to productive outcomes (Pretty 2003) and successful self-organization (Ostrom 1990, 1999; Pagdee et al. 2006). Because collective management actions have garnered attention worldwide, it is critical to understand the underlying mechanism behind the success of collective management actions. Scholars have focused tremendously on forests, which have reached the second highest consideration in studies of common pool resources (CPR) after fisheries. This has led to the identification and assessment of different approaches to forest management (Laerhoven and Ostrom 2007). Pagdee et al. (2006) reported that participatory forest management is a viable approach for protecting and managing forests.

Community forest (CF) management, a participatory forest management regime in which formally registered user groups from a community in the vicinity of forests are allowed access, use and management rights, is known for its ability to integrate professional skill and local knowledge. The overwhelming participation of users in CF has indicated forest users are both willing and capable of managing forests in their vicinity if given the opportunity (Ojha et al. 2009). Though there are reports on the lack of effectiveness of community forestry on social inclusion and conservation of biodiversity (Gautam et al. 2004; Shrestha et al. 2010), CF management has had tremendous success in forest sustainability (Pagdee et al. 2006; Shyamsundar and Ghate 2011) and individual effort on forest management (Ostrom and Nagendra 2006). Additionally, it has been commonly understood that CF is an essential because it supplies primary forest products (Gautam 2004) and ecosystem services (Dahal and Chapagain 2008).

In Nepal, there are 14,572 formally registered Community Forest User Groups (CFUGs), which include more than 1.6 million households and manage more than 1.2 million ha of forest (34.92 % of the total potential area of CF) by following their Forest Management Operational Plan (FMOP) (GoN 2010). The operational plan is prepared by users and approved by the District Forest Office (DFO), a representative government at the district level. Despite some limitations, CF management in the country is considered to be the most successful approach to forest management (Nagendra et al. 2005; Dahal and Chapagain 2008; Ojha et al. 2009). However, an increase in forest fires, species range shift, wildlife damage to humans and property, and changes in land use practice may reduce the effectiveness of community forest management.

Fire has traditionally been thought to recycle nutrients and promote natural regeneration (IUCN and WWF 2000); however, uncontrolled fires can be detrimental to forest growth and production, resulting in substantial damage to human lives and property. Starting from mid-March to the end of May, fires of different intensities burn the *Shorea robusta*-dominated forest of Siwalik up to three times every year (IFFN 2006a). The shedding of large amounts of leaves in a short 1-month period in a dry and hot season creates favorable conditions for fires to burn frequently in the forest. However, the burning of surfaces for a short period of time, with a thin layer of shallow leaf litters as fuel, does not cause significant damage. Changing climatic conditions have caused forest fires to occur more frequently, resulting in an increased risk to people's lives and property (ITTO 2009). Fire damages approximately 7 % of the 5.83 million ha forest area of the country annually (DFRS 1999; ITTO 2009). Because tropical regions are considered to be the major timber-producing region in Nepal, increased fire frequency (IFFN 2006a) poses a threat to the economy and people's livelihoods. Although *Shorea robusta* forest is relatively tolerant to forest fire and fire opens up germination beds for seeds with viability of $<$2 weeks (Orwa et al. 2009), locals consider uncontrolled fire to be destructive to the forest because it decreases the timber quality of *Shorea* and burns other associated species (IFFN, 2002).

Fire is generally considered a natural occurrence; lightning is cited as the primary source of forest fires globally. However, human activities have been reported to be the primary cause of fire in the tropical region of Nepal (IFFN 2006b). Increased human pressure and fragmented forests favor the occurrence of deliberate and accidental fire from herders and trespassers. By protecting CF from illegal cutting and grazing, the users are also controlling fire (Shrestha et al. 2010), which has resulted in a reduction of damages (IFFN 2006a). Fire is typically managed in CF through controlled burning and by mobilizing users to construct fire lines to exclude and suppress the fire (IFFN 2006b). All of these activities require the active and timely participation of users in a coordinated manner. The outcome of fire management cannot be determined immediately after the fire management efforts, which means that users do not have to face the amount of fire damage in their forest directly. This dilemma is likely to instigate the temptation of free riding by users, which could lead to a collective action problem (Oliver 1993) in FFM. The participation of users in FFM is overwhelming in many CFUGs (IFFN 2006a), whereas others seriously lag behind (FAO 2009).

From the large number of studies in the literature investigating the management of forests and other commons, a list of facilitating conditions for enduring self-organization has been developed. As forest-managing communities differ in their forest management outcomes depending upon the setting (Ostrom and Nagendra 2006), the focus has shifted toward the conditions that reinforce the outcomes of the collective action (Laerhoven and Ostrom 2007). The sharing of attributes with many other resources makes the governance and management of forest resources in a sustainable, efficient and equitable fashion difficult. The difficulty of excluding possible beneficiaries from using primary forest products and ecosystem services reduces the likelihood of users contributing to a forest's long-term sustainability (Ostrom 1999).

Researchers (Wade 1987; Ostrom 1990; Baland and Platteau 1996) have reported numerous favorable conditions for the management of commons, which can be summarized under three domains: resource system characteristics, group characteristics and the relationship between resource system characteristics and group characteristics (Agrawal 2002). The small size of resource systems and user groups, a well-defined boundary, shared norms, past successful experience, pertinent leadership, group members' interdependence, heterogeneity of endowments, homogeneity of identity and interest fall under the first two domains. Similarly, the overlap of resources and residential location and salience of resources fall under the last domain. In addition, Pretty (2003) showed that social capital, which can be defined according to the World Bank (2011) as institutions, relationships and norms that shape the quality and quantity of a society's social interactions, is an important factor in determining the success of collective action because of its strong influence on transaction cost and cooperation and connectedness of networks and groups.

In a meta-study on 59 case studies from around the world, Pagdee et al. (2006) identified 43 variables, ranging from internal attributes to resources and external factors, that have the potential to contribute to the success of CF management. Concurring with Ostrom (1990, 1999, 2000) and Baland and Platteau (1996) in most aspects of CPR management, the study found tenure security, clear ownership, congruence between socioeconomic and biophysical boundaries, monitoring, effective enforcement of rules and regulations, sanctioning, strong leadership, expectation of more benefits than costs incurred, common interest of users and local authority to be important for the success of managing CF.

Studies on collective actions in the community forests of Nepal have reported that a formal mode of organization, general assembly decision making and membership of 80–100 households can improve the participation of forest users (Joshi et al. 1997). Similarly, regular and local monitoring (Nagendra 2007), sanctioning of rules and a higher level of local enforcement can aid in forest growth and management (Gibson et al. 2005; Chhatre and Agrawal 2008). In addition, improved socioeconomic conditions of forest users contribute to greater user participation (Agrawal and Gupta 2005), whereas the genuine engagement of users in deciding and following rules and monitoring others (Ostrom and Nagendra 2006) and stronger social capital reduce transaction costs (Adhikari and Lovett 2006). Transferring bureaucratic power to local people (Ojha 2008) and democratic decentralization can improve forest governance, long-term sustainability and the effectiveness of local institutions (Nagendra et al. 2005).

As suggested by Agrawal (2002, 2003), only a few variables are significant when a study of single resource types under a management regime in a physiographic region is carried out, but few potential variables from the pool of variables identified in previous studies for the management of commons have been assessed. We conducted a study comparing the attributes of users, attributes of forests and their interaction among users to identify the conditions that are conducive to collective actions for FFM in CFUGs. The study examined whether the variables highlighted in previous studies are equally influential for FFM in CF.

Materials and Methods

Study Site

The Siwalik region of the Makwanpur and Chitwan districts in the Central Development Region of Nepal was chosen for the study. The criteria for selecting the districts were (1) dominance of forest as land cover type, (2) a relatively long history of community forestry in the area and (3) high susceptibility to forest fire (IFFN 2006b; DFO/Makwanpur 2011; DFO/Chitwan 2011). The area selected for the study is located between 27°21′ and 27°46′N latitude and 83°55′ and 84°35′E longitude; it has a tropical climate. The forest, which is primarily composed of mixed *Shorea robusta*, is the dominant land cover in the area (56.7 % in Makwanpur and 62.92 % in Chitwan) (DDC/Chitwan 2005; DDC/Makwanpur 2010). Most of the accessible forest area, except the area in Chitwan National Park and its buffer zone, has been handed over to the local people as CFs. The study area has a mixed settlement type, where the majority of people are from the hilly regions of the country and inhabited the area after the 1950s (Gurung 2001). People in the area have heterogeneous socioeconomic conditions. Except for a small area in the town and district headquarters, the major occupation of local people is farming (DDC/Chitwan 2005; DDC/Makwanpur 2010). The forest is the major source of inputs, such as leaf litter, agricultural implements, fodder and timber, required for farming.

The study was conducted by regrouping CFUGs into two groups, namely the active and passive groups, based on the degree of collective action demonstrated by the CFUGs in managing fire in their CFs. The criteria for selecting CFUGs were (1) CFUGs with maximum user participation in the FFM, (2) CFUGs that show intolerance to fire in their CF through plans and programs and (3) CFUGs that contact stakeholders, primarily the DFO and Federation of Community Forest User Groups of Nepal (FECOFUN), to coordinate and support FFM. Governmental organizations, e.g., the DFO, and nongovernmental organizations, e.g., the FECOFUN, which have been working closely with CFUGs in forest management, helped select the ten strongest and ten weakest CFUGs that met the above criteria; the strongest CFUGs were grouped in the active group and the weakest in the passive group for the case study, as suggested by Agrawal (2001). In particular, this study focused on capturing the overall spatial and socioeconomic variability within the area. Table 1 presents a basic description of the investigated CFUGs, and Fig. 1 shows their spatial location and distribution pattern in the area. The ex-post accuracy of classification was measured against the criteria during data collection from the CFs and was found acceptable (Fig. 2). Data on user participation and the extent of damage were calculated as an average over 2 and 5 years, respectively, from their records, whereas other data were collected from either stakeholders or their FMOP. The group of CFUGs differed significantly in both the level and type of effort for FFM and the outcome indicated by the percentage of area burned every year.

Table 1 Basic description of studied CFUGs

Active group				Passive group			
Name of CFUG	Registration year (district)	Area of CF (ha)	Number of HHs	Name of CFUG	Registration year (district)	Area of CF (ha)	Number of HHs
JyamireKalika	1993 (Mak)	410	477	Thakaldada	1996 (Mak)	99.47	130
Chanauta	1998 (Mak)	316.92	229	Ektare	1994 (Mak)	58.8	170
NeureniChisapani	1990 (Mak)	71.13	248	KalikaChandika	1998 (Mak)	896.75	212
Dangdunge	1995 (Mak)	196.4	400	Panchakanya	1995 (Mak)	516.61	211
Ashok	1993 (Mak)	137.5	193	Namobuddha	2000 (Mak)	115	170
Mahankal	1997 (Mak)	155	71	Ratmate	1997 (Mak)	457.28	312
Sundar	1995 (Mak)	109	206	Satanchuli	1999 (Chi)	198.1	560
Parebashwori	1996 (Chi)	1311.9	601	Jaldevi	2001 (Chi)	189.87	982
Shivapuri	1995 (Chi)	127	261	Rambel	2001 (Chi)	197	1306
PashupatiKailashpuri	1996 (Chi)	127	226	ParipakhaHardadada	2001 (Mak)	163.88	222

Mak Makwanpur district, *Chi* Chitwan district, *HHs* households

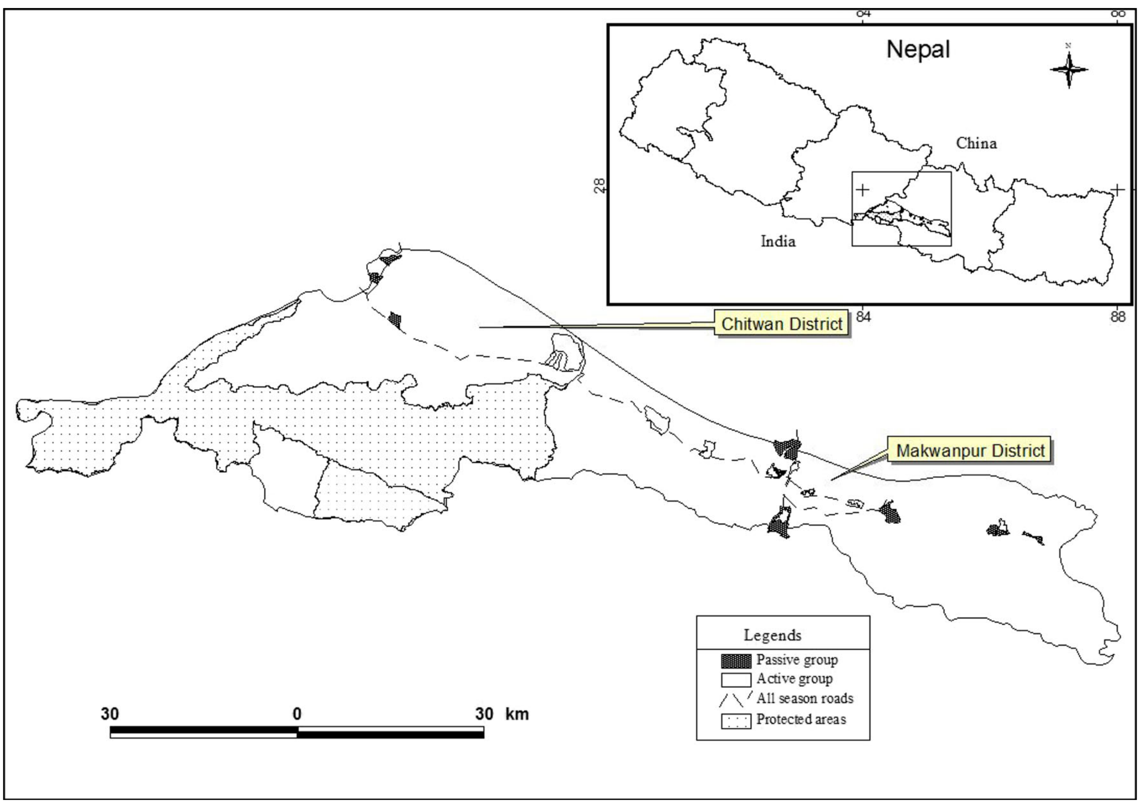


Fig. 1 Location map of the study area

Data Collection and Analysis

Data from all of the selected CFUGs were collected from October 2011 to February 2012. The basic demographic information of the users was collected from CFUG constitutions, FMOPs and users' CFUG records. Other data were collected employing the following methods:

Socioeconomic Data

The data on users' ethnic, occupational and wealth status were taken from the FMOP and CFUGs' constitutions. The users were categorized into three classes of ethnic groups: (1) Bramhin/Chettri (socially advantaged group), (2) Janajati (socially disadvantaged group) and (3) Dalits

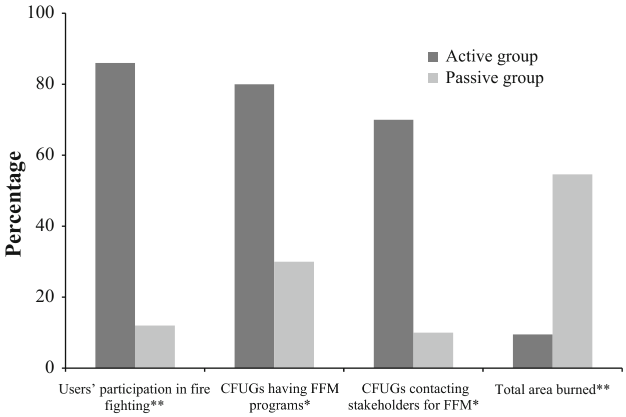


Fig. 2 Ex-post accuracy of selected CFUGs according to the selection criteria. * and ** denote significant differences at 95 and 99 % confidence levels, respectively, according to Fisher's exact test

(socially discriminated group). Similarly, the users were categorized into three wellbeing classes—(1) well off, (2) medium and (3) poor—based on their possession of livelihood assets, as recommended by the Community Forestry Guideline (2001) of the Government of Nepal. The users were grouped according to the wellbeing classes based on food sufficiency, land holding size, and regularity and amount of income; poor users were below the national poverty level, and those in the other two categories crossed the threshold of the national poverty level.

Biophysical Data

The data of growing stock in community forests and the current condition of the forest were taken from their 5-year FMOP, in which the aboveground growing stock was measured in nested plots of 25×20 m^2, 10×10 m^2, 5×2 m^2 and 1×1 m^2 for trees,[1] poles,[2] saplings[3] and seedlings,[4] respectively, employing stratified random sampling with a sampling intensity of 0.5 % and analysis to obtain the growing stock per hectare, as directed by Revised Guideline for Community Forest Resource Inventory (2004) of the Government of Nepal. Data on the past condition of the forest, experience of forest product scarcity and ease of access were collected by interacting with elder users who had been settled at the area longer than the others. FMOP also supplied data on the demand for basic forest products. To analyze the dependency of users on CF for ecosystem services, data on the current sources of drinking and irrigating water, the availability of alternatives and the importance of soil conservation from CF were collected by visiting the area and interacting with users. The length of the roads between CFs and both the district headquarters and the nearest forest office was measured based on a map and using a GPS receiver in the field to compare the CF locations. Participatory mapping of the area was performed to study user settlement patterns.

Organizational Functioning

The minutes of the CFUG Executive Committee (EC) meetings and general assembly furnished information on the actual selection procedures of leaders, the regularity of forest management activities for the last 2 years, number of users present in the meetings, agenda and decisions of the meetings, forest product distribution patterns, and the method and amount of CFUG income and expenditure. The EC members were queried to assess the extent of their fulfillment of responsibility and exercise of power to understand the division of power and responsibility among leaders. Data on the informal rules, implementation statuses of different types of rules and status of conflict, basis of leadership selection, coordination and networking with stakeholders, rule formation method, communication and mobilization of human resources in FFM and other forest management activities, information on fire regimes within the CF for the last 5-year period and other information were collected through group discussions with EC members and various interest groups in the CFUGs. The status of participation, conflict and cooperation of community members and unity shown by users in community development programs served as indicators of the social capital of the community. The user attendance log for development activities and interactions with development workers who were active in the area supplied information on this aspect.

Data Analysis

The variables considered in the study were qualitatively and quantitatively compared between CFUGs of the active and passive groups to understand the type and level of their influence on response of user groups in FFM. Ethnic and wealth heterogeneity was quantified using the ethnolinguistic fractionalization index suggested by Taylor and Hudson (1972). The index, which ranges between 0 and 1, has a positive correlation with heterogeneity. The Mann-Whitney test, suggested by Mundry and Fischer (1998) for its robustness with a small sample size, was applied to test the significance of the difference observed in the attributes of forests and users and the functioning of CFUGs, where quantification of the information was possible. The median

[1] Woody plants having breast height diameters ≥30 cm.

[2] Woody plants having breast height diameters between 10 and 30 cm.

[3] Woody plants having height >1 m but breast height diameters <10 cm.

[4] Woody plants with heights between 30 cm and 1 m.

value was used because of the small sample size and resulting nonparametric nature. Similarly, for other variables whose quantification was difficult, each CFUG was categorized into classes that differed in strength, as depicted by their performance. The number of CFUGs in each category was counted, and Fisher's exact test was used to test the significance of the categorized data. The Freeman-Halton extension was used to obtain a 2 × 3 contingency table. The data are presented in tables, bar diagrams and boxplots, where * and ** are used to indicate whether the variable is significantly different between the active and passive groups in FFM. The box plots represent quartiles (Q), and the whisker lengths represent one half of the difference between the first and third quartiles.

Results

Forest Resource System and Units

The area of the studied CFs ranged from 58.8 to 1,311.9 ha, where the medians of the total area and area per household were larger in the passive group than in the active group; however, the difference was not significant (Table 2).

The current levels of aboveground growing stock do not show a significant difference between the groups. Although the density of growing stock was found to be higher in CFs of the active group, this difference was not significant (Table 2). The density of plants by number did not differ significantly for seedlings and trees. In contrast, the density of saplings and poles was found to be significantly higher in CFs of the active group. Some of the CFUGs have constructed a fire line to ease fire control and movement within the forest. The length of the fire line that also served as a forest trail in CFs in the active group was significantly higher than that observed in the passive group (Table 2).

The condition of the forest in the past before the community took control of conservation was not significantly different among the groups (Fig. 3). The number of forests from the active and passive groups that fall under severely degraded, degraded or intact forest categories was not significantly different. Currently, all of the forests of both active and passive groups fall under the good or fair categories of forest conditions, as dictated by the amount of aboveground growing stock, as suggested by the revised Guideline for Community Forest Resource Inventory (2004) of Government of Nepal. CFUGs were found to manage land and construct office buildings for the daily activities and storing properties of CFUGs. Some CFUGs engaged in the construction of other community infrastructures such as roads and school buildings. CFUGs in the active group were engaged in the construction of community infrastructures and rural electrification at a significantly higher level than were passive CFUGs (Fig. 3).

Users and Governance System

Households were the unit of membership for all of the CFUGs and served as the basis of membership and cost and benefit distribution within CFUGs. The number of households in a CFUG ranged from 71 to 1,306, without remarkable variation in the average family size. The number of users' households and populations were not significantly different between the CFUGs in the active and passive groups (Table 3).

All of the socioeconomic attributes of CFUGs considered in the study [literacy rate; ethnicity and wealth heterogeneity using the ethnolinguistic fractionalization index suggested by Taylor and Hudson (1972)] were not significantly different between the active and passive groups (Table 3). Therefore, a greater literacy rate and

Table 2 Area and productivity of CFs

Attributes	Sub-attributes	Active group			Passive group			*P* value (Mann-Whitney test)
		Median	Max	Min	Median	Max	Min	
Size of resource	Area of CF (ha)	146.3	1,311.9	71.13	193.4	896.8	58.8	0.678
	Area of forest per household (ha)	0.635	2.18	0.29	0.710	4.23	0.15	0.850
Productivity of resource	Seedlings (number/ha)	8,305	21,797	3,250	8,442	25,465	2,504	1.000
	Saplings (number/ha)	1,811.5	2,694	1,108	1,115.5	3,439	380	0.017*
	Poles (number/ha)	431	758	97	229	397	68	0.028*
	Trees (number/ha)	76	108	36	50.5	127	23	0.151
	Aboveground growing stock (m^3/ha)	187.2	387.9	127.90	130.3	427.68	65.1	0.473
Human constructed facilities	Length of fireline cum forest trail	2.0	18	0	0	1.5	0	0.026*

Max maximum value; *Min* minimum value

*and ** denote significant differences at the 95 and 99 % confidence levels, respectively

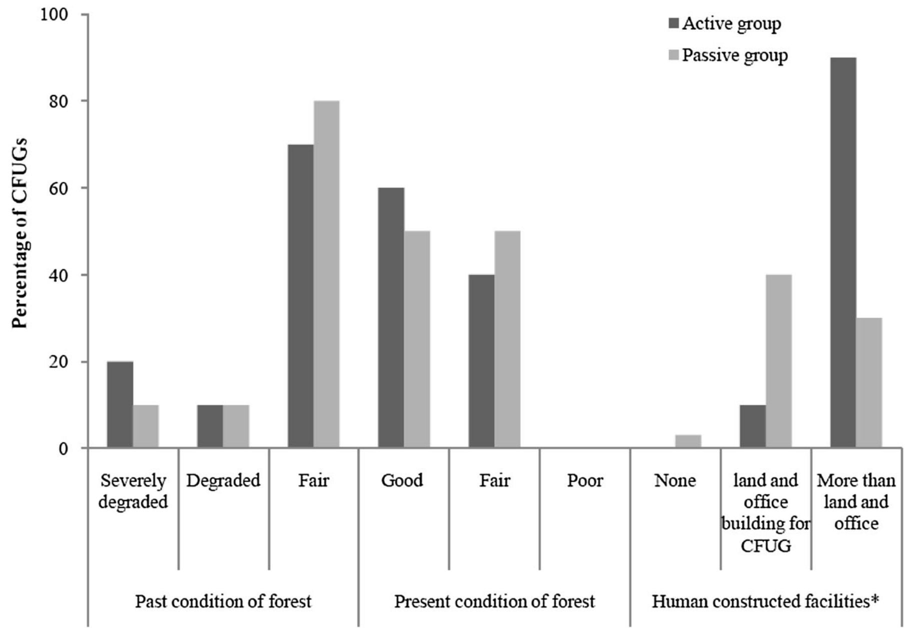


Fig. 3 Present and past conditions of forest and human constructed facilities by CFUGs. *Asterisk* denotes significant difference at 95 % confidence level in Fisher's exact test

Table 3 Socio-economic profile of user groups

Attributes	Sub-attributes	Active group			Passive group			*P* value (Mann-Whitney test)
		Median	Max	Min	Median	Max	Min	
Group size	Users' population	1,487.5	3,736	489	1,380.5	6,529	850	0.671
	Number of users' HHs	238.5	601	71	217.0	1,306	130	0.910
Socio-economic attributes	Literate users (%)	83	94.00	70.00	85	90.00	50.00	0.934
	Index of ethnic heterogeneity	0.36	0.57	0.22	0.44	0.52	0.08	0.597
	Index of wealth heterogeneity	0.54	0.66	0.31	0.62	0.66	0.27	0.131
	Unskilled daily wage earner (%)	4	17	1	11.5	47	3	0.037*
Location of the community	Distance of community from district headquarter (km)	21.0	44	2	7.5	48	1	0.472
	Distance of CF from nearest forest office (km)	8.5	26	1	4.5	29	2	0.568

HHs households, *Max* maximum value, *Min* minimum value

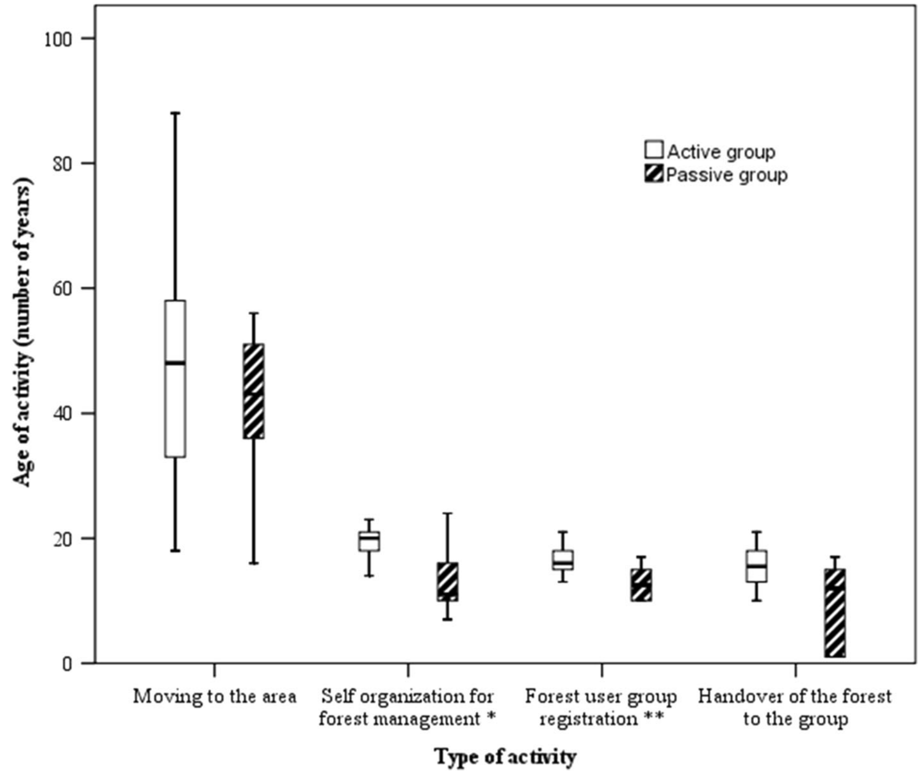
* and ** denote significant differences at 95 and 99 % confidence levels, respectively

heterogeneity in the community do not contribute significantly toward promoting collective action for FFM. However, users' dependency on a daily wage from unskilled labor, which often requires working outside their place of residence for long periods of time, was found to be detrimental to participation in collective action for FFM. The distance between CFUGs and both the district headquarters and nearest forest office and proximity to markets and the forest office showed a negative association with the level of collective action for FFM in CFUGs (Table 3). However, the difference in distance to those centers from CFUGs was not significant.

As presented in Fig. 4, the collective action for FFM was found to be independent of the age of the users' settlement. However, the length of time during which users are engaged in forest conservation and management has a positive association with the FFM response of CFUGs. The difference between the age of community self-organization for forest conservation and CFUG registration was significantly higher for CFUGs in the active group than in the passive group; however, the difference in the age of CF handover and number of FMOPs completed was not significant. In addition, the extent of fulfilling the forest product demand was not significantly different between the groups (Fig. 5).

The users of CFUGs in the active group had faced more acute scarcity because of unchecked harvesting and greater difficulty in accessing the forest because of strict

Fig. 4 Age of various CFUG-related activities



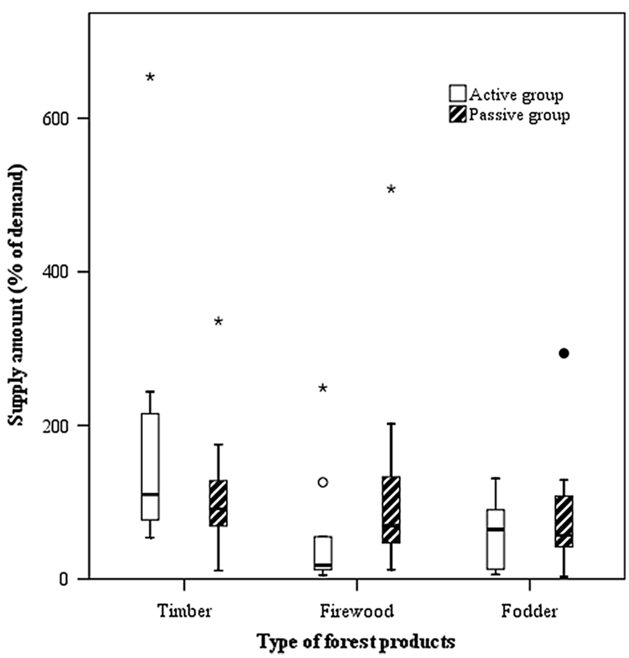


Fig. 5 Status of forest product supplies within CFUGs

monitoring by government forest staff compared with those in the passive group (Fig. 6). Similarly, CF was the primary source of ecosystem services, such as soil conservation and drinking and irrigation water. However, there was not sufficient data or evidence to reject the null hypothesis stating that the supply of ecosystem services encourages forest users to engage in collective action in FFM.

The social capital depicted huge differences between the communities differing in their FFM collective actions. All of the considered components of social capital, i.e., participation (Wollebaek and Selle 2003), solidarity, cooperation and cohesion (Dudwick et al. 2006), were found to be superior in communities that belonged to CFUGs in the active group compared with those in the passive group (Fig. 7). The communities that had problems with participation, disagreements, and a lack of trust and cooperation in other developmental activities were found to possess CFUGs that were weaker in their collective FFM action. This finding indicates there is a strong and positive association between collective action for FFM and other collective actions within the community.

CFUGs in the active and passive groups did not differ in the method of selection of EC, a committee that provides leadership to the CFUG (Fig. 8). However, more CFUGs in the active group had a regular tenure of leadership, i.e., EC, and a fair sharing of power and responsibilities among the leaders. Many such ECs in the passive group were dissolved because of the hostility of different factions within the group and corruption charges. Leadership with balanced power and responsibilities (as indicated by all EC members performing the duties given to them by the CFUG

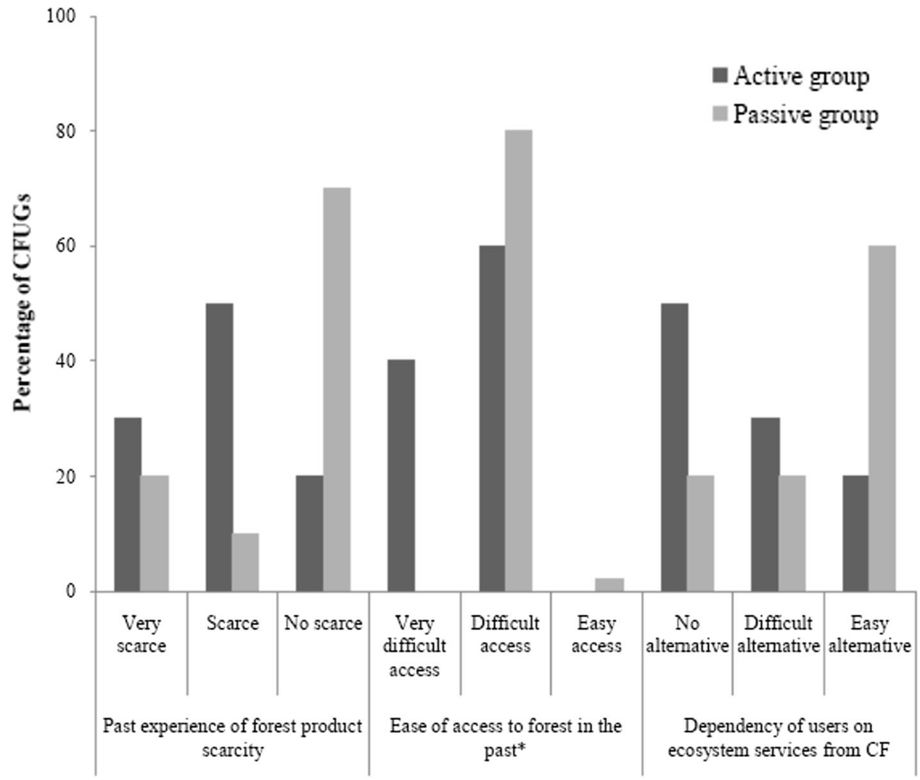


Fig. 6 Past experience of forest product scarcity and salience of forest for ecosystem services. * and ** denote significant differences at 95 and 99 % confidence levels, respectively, using Fisher's exact test

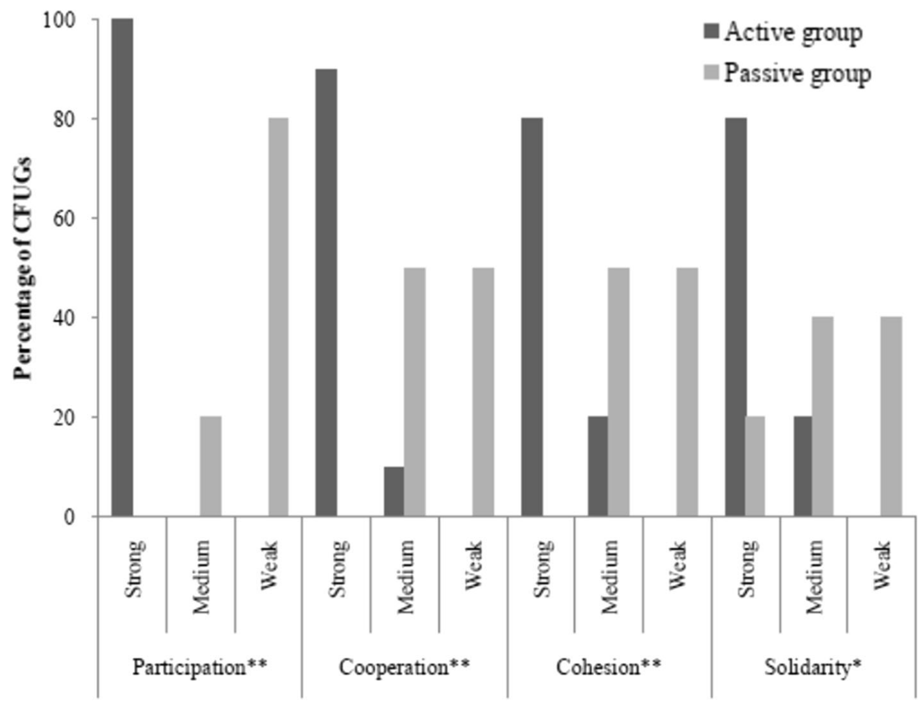


Fig. 7 Status of components of social capital in CFUGs. * and ** denote significant differences at 95 and 99 % confidence levels, respectively, using Fisher's exact test

constitution) coordinated with the DFO and security forces to obtain support in fire-fighting when the fire exceeded their controlling capacity.

For FFM activities, free-riding attempts were less costly in CFUGs in the passive group, whereas they were very costly in CFUGs in the active group. In addition to social cost, the defectors were fined more, charged a higher price for forest products than other users and denied forest products for certain terms in extreme cases. CFUG sanctions were established for users who were absent from fire management activities, particularly fire-fighting, which is a significant part of collective action for FFM (Fig. 8). In

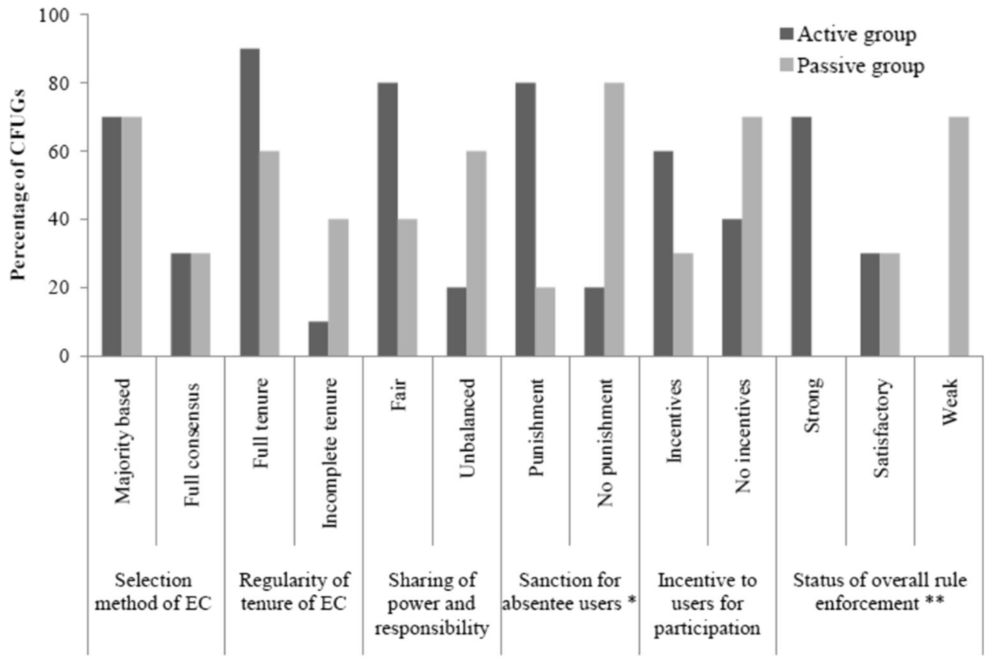


Fig. 8 Status of leadership and sanctions and incentive to promote participation in FFM activities in CFUGs. * and ** denote significant differences at the 95 and 99 % confidence levels, respectively, in Fisher's exact test

both groups of CFUGs, there are provisions to users such as monetary payment, prizes and snacks as incentives for their presence during fire management programs to encourage users to undertake such collective action. The greatest difference was observed in rule enforcement. CFUGs in the active group had a stronger adherence to government rules, the CFUG constitution and FMOP and punished the defectors more severely compared with the passive group.

Most of the CFUGs in the active group followed collective monitoring by forming appropriate rules to avert free-riding, mobilizing the existing community organizations or forming subgroups at each hamlet in large CFUGs and strictly implementing the rules; all of the CFUGs in the passive group were found to be weak in this aspect. For example, the fine for absenteeism was commensurate to a daily wage for general labor, equivalent to 2.5 USD in CFUGs in the active group, whereas it was much less, equivalent to 0.6 USD, in the passive group, which resulted in the presence of 86 and 12 % of the users in the active and passive groups, respectively, for fire-fighting. Similarly, due to differences in the level of rule enforcement, a significantly lower percentage of users of CFUGs in the passive group paid the necessary fees compared with those in the active group (Fig. 9).

The constitutional rules across the CFUGs in both groups were not substantially different in the rules themselves or in the rule formation processes. Because of the compulsion imposed for users to be present to obtain membership, the percentage of users attending a general assembly called to discuss the CFUG constitution was not significantly different between the groups: 72.5 and 70 % of users in CFUGs belonging to the active and passive groups, respectively, attended the general assembly to endorse the constitution drafted by the active 17 and 7.5 % of users. The percentage of users involved in drafting the constitution was significantly different between the groups (Fig. 9). The CFUGs in the active and passive groups

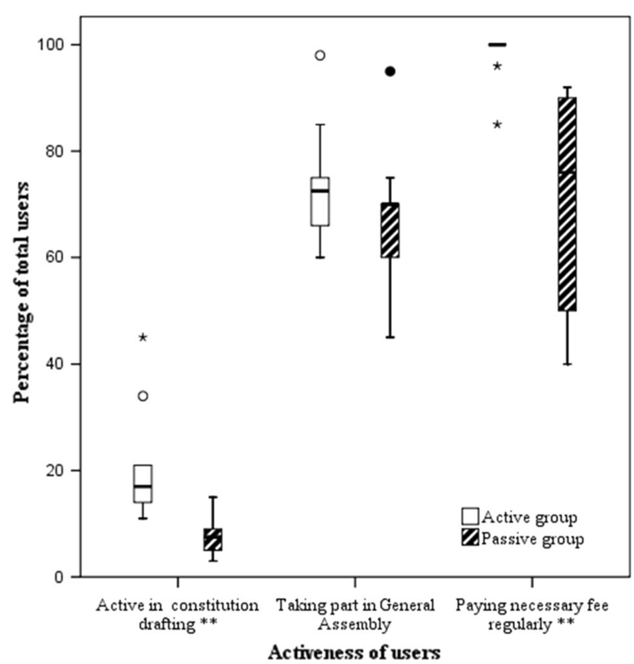


Fig. 9 Status of user participation in the formation of rules and compliance with rules. * and ** denote significant differences at 95 and 99 % confidence levels, respectively, in the Mann-Whitney test

differed to some extent in their collective choice and operational level rules in both the rule-making process and the types of rules made. The collective choice rules in all of the CFUGs in the active group were made by the general assembly, whereas the rules in most of the CFUGs in the passive group were developed in EC meetings.

Interaction Among Users and with Resources

Users in the CFUGs interacted differently, particularly in distributing benefits, sharing information, managing conflicts and investing in the CFUG fund. When harvesting was monitored by users and the DFO, all of the CFUGs adhered to their approved FMOP for the amount of forest product harvested from their CF. Except for the less transparent system in most of the CFUGs in the passive group, the forest product distribution systems within the CFUGs did not diverge perceptibly. The product prices were determined based on the purchasing capacity of average users, the capacity of the forest to meet demand and the market price of the product; a large price difference was not found between the groups, as indicated by the price of *Shorea robusta* timber. A remarkable difference between the groups was observed in the price of timber to outsiders from the CFUGs having an excess of production compared with demand. Although all of the CFUGs followed the same formal procedures, the average sale price of timber showed significant differences. For instance, in CFUGs in the active group, *Shorea robusta* timber of the same quality was sold at more than double the rate of the passive group: the price of a cubic foot of timber in CFUGs in the passive group was between 5 and 10 USD, whereas it was between 10 and 20 USD in CFUGs in the active group.

CFUGs did not differ in the rules of economic transactions or in the number of the transactions (Fig. 10). The amount of total annual income, total expenditure, and expenditure in forest development and FFM was not significantly different between the active and passive groups. In spite of the government rule that CFUGs should invest at least 25 % of their total income in forest development, most of the CFUGs failed to comply. Instead, five CFUGs from the active group and two from the passive group had payments for forest watchers, which fell under administrative costs as an investment in forest development. Reconciling this difference resulted in only four CFUGs from the active group and one from the passive group complying with this rule. Similarly, an interesting pattern in the expenditure of FFM was observed: the FFM expense of CFUGs in the passive group, which had funds for FFM, went toward fire watchers and some special groups, whereas those in the active group focused on raising awareness, increasing the building capacity of users and improving the mechanism for mobilizing users during a fire-fighting operation.

More CFUGs in the active group were ahead in keeping users informed about fire danger, inculcating users with FFM techniques and teaching them to be alert for forest fires. Additionally, CFUGs differed in the actions taken

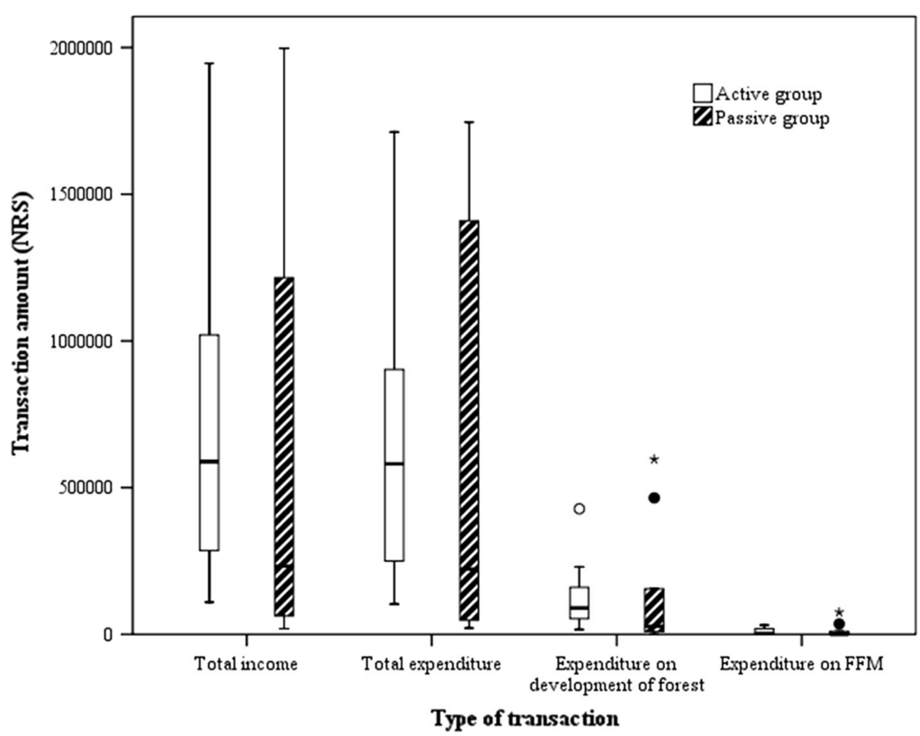


Fig. 10 Income and expenditure of CFUGs

immediately after detecting a fire. In passive CFUGs, the person who detected the fire reported to EC members or CFUG offices, whereas in most of the CFUGs in the active group, the person directly informed nearby village leaders to quickly mobilize users. Due to this practice, even in the case of emergencies, information about a forest fire incident in CFUGs in the passive group followed a long channel before it reached users, which resulted in a spread of fire that was beyond their capacity to control with the available skill and resources.

Although some variables, including the age of self-organization, social capital and enforcement of rules, showed a remarkable difference between the groups, no single variable was found to be entirely responsible for instilling differences in the collective action of all CFUGs in FFM. The study found that the performance of CFUGs in FFM is not absolute but depends on the composition and interaction in the Social Ecological System (SES).

Discussion

This research showed that the social ecological attributes of CFUG affect the collective action of communities for FFM in Nepal. However, research has indicated that all of the facilitating conditions for managing other commons are not equally important in the collective action in FFM in CFs of Nepal. Although the size and location of resources and the size of the managing community play a pivotal role in determining the success of self-organization in managing canal irrigation and pasture land (Wade 1987), their role is insignificant in FFM in the CFUGs of Nepal. In contrast, socioeconomic attributes, experience with forest product scarcity, the dependency of users on the forest and leadership functioning agreed with previous studies, but the effects were not significant. However, consistent with the existing literature on the management of commons (Baland and Platteau 1996; Ostrom 2000; Varughese and Ostrom 2001; Agrawal 2003; Pretty 2003; Agrawal and Gupta 2005; Pagdee et al. 2006), the current stocking of saplings, physical assets developed by CFUGs, status of access to the forest in the past, age of self-organization and CFUG, social capital, degree of participation of users in crafting constitutional rules, provision of sanctions and enforcement of rules were found to have significant influences on the CFUGs' collective action for FFM.

The relatively uniform distribution of forest area per household to total area of CFUG partly explains the difference in the findings from earlier studies regarding the size of the forest resources (Wade 1987; Baland and Platteau 1996) on collective action for FFM in the Siwalik region of Nepal. The general pattern of CF handover shows that larger forests were handed over to larger user groups. This finding indicated that most CFs have the required level of monitoring and investment for forest conservation and management, irrespective of their spatial extent. Although the high participation of users in greening denuded hills (Gautam 2004)already proved that the resource condition is less important to users in initiating conservation and development, none of the forests in the Siwalik reached the state of exhaustion; thus, the effect of resource exhaustion noted by Ostrom (2000) and Pagdee et al. (2006) could not be confirmed. The slightly greater density of growing stock and young plants that have passed their sensitive stage of growth in the forests of active CFUGs could be attributed to the high level of protection efforts, including the control of forest fires (Chhatre and Agrawal 2008). The higher density of saplings and poles and the lower density of larger plants in CFs of the passive group indicate weak protection efforts among CFs in the passive group.

The negative association between the distance of CFUGs to both market and forest offices and collective action for CFUG in FFM indicates the possibility that CFUGs are constrained by market pressure (Pretty 2003) and the domination of techno-bureaucratic doxa described by Ojha (2008). The uniformity of most rules but difference in their implementation implies that the fettered role of users in rule formation and proximity of government offices increase the pressure to implement rules that are not crucial for solving pressing problems. The location of the CFUGs did not agree with the proposition that proximity to markets lessens the dependency of users on forest (Agrawal et al. 2006; Ghate et al. 2009), which in turn has a negative effect on collective action (Ostrom 1999). The collective action for FFM is less dependent on the supply of ecosystem services and the most basic forest products. This supports Bawa et al. (2004), who claimed that ecosystem services from tropical forests are crucial for users but not sufficiently crucial to instigate collective action.

Large CFUGs that are active in FFM devised a way to overcome the problem of high transaction costs for communication. The practice of having a large user group is not necessarily a problem for FFM in Siwalik, as claimed by Olson (1965), Wade (1987) and Baland and Platteau (1996). Similarly, Joshi et al. (1997) suggested that a large user group, i.e., 80–100 members, which 95 % of the CFUGs exceed, is neither necessary nor easy for execution because of procedural difficulties. Due to the embedded nature of SESs, any attempt to divide the forest and decrease its size may incite environmental damage (Pretty 2003). The large size of user groups is not always a limitation; successful CFUGs have benefitted from abundant human resources that can be used for intensive monitoring and greater investments in forest and fire management. The larger CFUGs in the active group have somewhat refuted the proposition of Pretty (2003) and instead agreed with Varughese and Ostrom (2001) and Poteete and Ostrom (2004), who found that forming subgroups and mobilizing users in those subgroups effectively reduced the transaction costs and increased the noticeability of the users (Wade 1987).

This research disagreed with the findings of Baland and Platteau (1996) concerning ethnic, wealth and occupational heterogeneity. The reason that ethnic heterogeneity was not significantly different could be due to a diluted culture in a conglomerated settlement that has a socioeconomically diverse population of different ethnic origins (Gurung 2001). The weak effect of supply in relation to the demand for basic forest products could be the reason that wealth heterogeneity was not significantly different. A significantly different proportion of users surviving on a daily wage from unskilled labor agreed with the findings of Adhikari and Lovett (2006) regarding the economic condition and occupation of users. Users' abilities to contribute to collective action are more influential than ethnic, wealth and occupational heterogeneity. Moreover, the high rate of poverty (Agrawal 2003) in CFUGs is detrimental to voluntary collective actions (Adhikari and Lovett 2006). Consistent with Ostrom (2009), the length of users' experience in forest resource management positively correlated with the CFUGs' FFM performance. This finding implies that time is also an important factor for institutional functioning where difficult access to the forest in the past has incited users toward resource conservation.

In addition, the study concurs with the findings of Adhikari and Lovett (2006), who found that the socioeconomic conditions of the community affect the social capital in the village. Strong social capital, which averts the collective action problem through a strong enforcement of rules, has a strong positive association with activeness in FFM. Unlike the other variables considered, social capital in the community had a uniform effect in collective action for FFM in all CFUGs. On this basis, enforcing rules may be sufficient to achieve the goal recommended by Nagendra (2007), but in the absence of strong social capital, leadership is not sufficient to carry out its strict execution (Pretty 2003). As opined by Pretty (2003), users' trust in other users is critical for user participation in FFM, which explains the importance of social capital for FFM in CF. Moreover, he indicated that the problem with having a lengthy channel of information sharing in CFUGs in the passive group is indirectly associated with weak social capital. Strong social capital coupled with proactive and responsible leadership (Ostrom 1990; Baland and Platteau 1996), collective monitoring (Nagendra 2007) and strong local enforcement (Gibson et al. 2005; Chhatre and Agrawal 2008) was commonly observed across all CFUGs that were active in FFM. Regardless of how the leaders are selected, their acceptance by users, a fair division of power and responsibility, and allowance to work their full tenure enhance the social capital, which results in improved collective action for FFM.

Payments to users for their participation in collective action do not necessarily enhance the participation of users unless such payments are sufficient to change their livelihood (Shyamsundar and Ghate 2011), which also applies to FFM. Instead, expenditures on strengthening the capacity of users have helped promote participation and improve the effectiveness of FFM activities. Similarly, the current study elucidated that a binding rule from the government regarding investment of CFUG income was ineffective. Ironically, the government focused on forming a uniform rule and blueprint plans that condoned the local context, as described by Nagendra (2007), but could not ensure the maintenance of CFUGs records, which serve as the basis for monitoring. Comparing and monitoring CFUGs with different record-keeping systems are difficult, which may lead to erroneous conclusions and inappropriate prescriptions.

Agreeing with findings of previous studies in the management of commons, the current study revealed that rules do not lead to a significant difference in collective action for FFM if monitoring and enforcement are weak (Nagendra 2007; Chhatre and Agrawal 2008). Conforming with Ghate and Nagendra (2005), this study showed that strong adherence to rules and enforcement of sanctions does not weaken social capital; instead, it alters the shortcomings that arise from the collective action problem (Gibson et al. 2005; Chhatre and Agrawal 2008) and ensures success (Gautam and Shivakoti 2005). Unless the users are ready to abide by the rules, any rules that are formed will be ineffective. The readiness of users to adhere to rules is indicated by their level of participation in rule making (Ostrom and Nagendra 2006), as shown by the cases of the CFUGs in the study. As indicated by Adhikari and Lovett (2006) and Agrawal and Gupta (2005), unless special arrangements are made, those who are better off in the community benefit disproportionately from rule making, which undermines participation among the marginalized population. Diversifying rules to improve access from all classes of users and maintaining the transparency of the functions of leaders has positive effects on FFM because it encourages users of all classes to contribute to CF (Adhikari and Lovett 2006).

Figure 11 shows how different factors contribute to user participation in forest fire management in their community forest. Both a positive effect [indicated by a (+) sign] and a negative effect [indicated by a (−) sign] on user participation in collective action are shown, which contribute to forest fire management in a community forest. Some factors directly affect user participation in forest fire

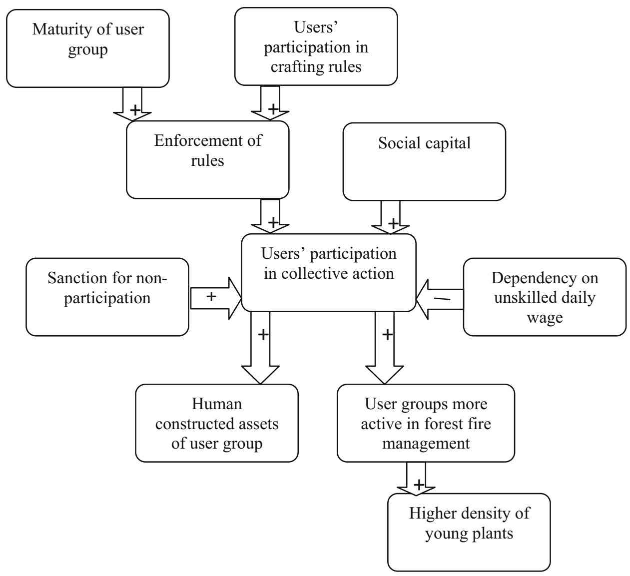


Fig. 11 Pattern of the effect of factors on forest fire management in community forests

management, whereas others are indirect. Similarly, factors such as human-constructed assets of user groups and a higher density of younger plants could serve as indicators of community activeness.

The results represent the CFUG conditions in the Siwalik region based on similarities in their socioeconomic and physiographic conditions (Gurung 2001) and external sociopolitical conditions. However, extrapolating the results to other parts of the country may need to be calibrated because of different socioeconomic conditions. Although the study was conducted using a particular resource type in a small physiographic region within a particular management regime, to a large extent, the results were consistent with other studies on the management of commons.

Conclusions

Our study shows that participation in forest fire management is dependent on the interaction of several variables, including social capital and enforcement of rules and sanctions. Our results further suggest that focusing on any one variable in assessing participation in collective action may be misleading because of the complex interaction of variables that potentially leads to a change in people's attitude toward collective action. Regarding the interdependency of many variables and their effect on functional mechanisms, Pagdee et al. (2006) presented an assessment of specific variables that can provide a pragmatic approach to gaining insight into CFUG activeness in FFM in an SES. Because of a strong relation with other variables, the social capital, types of rule and status of enforcement may provide information on the status of user interaction in CFUG.

Creating an affable environment for users to participate in every activity of CFUGs facilitates the smooth operation of the group, which can also be achieved by transparency in the function of leaders. In this regard, encouraging people to participate in decision making through mass meetings and collective action (Joshi et al. 1997) could be the starting point. Whereas poverty and dependency of users on agriculture farming and other daily work restrict people from participating in collective action, activities that promote and improve the economic condition of users are critical in engaging poor and disadvantaged groups in collective action (Agrawal and Gupta 2005; Adhikari and Lovett 2006; Ostrom and Nagendra 2006). Programs to reinforce social capital (Shyamsundar and Ghate 2011) could be helpful in enhancing user participation, whereas inciting users to form rules and sanctions for fire management, collective monitoring, downwardly accountable leadership and improvement in communication channels could help improve the collective action for FFM. Dividing larger user groups into village clusters to work at the operational level and cooperating with existing local organizations could enhance noticeability, thereby minimizing the likelihood of free riding.

Policy makers should acknowledge the peculiarity of every SES and the multidirectional effect of variables at different scales. Therefore, policy makers should focus on diversifying the rules in CFUGs that would increase participation in forest fire management and other collective actions. In addition, future studies should focus on quantifying the strength of influential variables that would enhance the understanding of how to increase participation in collective actions such as forest fire management. Although our study showed that focusing on one variable to assess the effectiveness of collective action can be misleading, we did not try to quantify the response of each variable to collective action. Therefore, future research should also focus on the quantification of influence and interconnectedness of variables in collective actions.

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