International Master Programme
at the Swedish Biodiversity Centre

Master theses
No. 44
Uppsala 2007
ISSN: 1653-834X

Tree species diversity in existing community based forest management systems in central mid-hills of Nepal

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CBM MASTER THESES SERIES

Swedish Biodiversity Centre
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Abstract

Status and tree species diversity in community forests were studied in mid-hills areas of Nepal. Tree species richness, tree population distribution and number of desired tree species were calculated to evaluate the differences between different forest management systems. A total of 5 community forests, one National Park and one government managed forest were selected and inventoried in the southern aspect between 1 500-2 200 m elevation above sea level. Group discussions with community forest user group members, key informant surveys were done to obtain information regarding existing forestry practices, preferences and their goal for forestry activities. Different diversity measures were calculated to examine the tree diversity and heterogeneity of the forests. The total species richness was highest in Ratmate danda community forests but similar to the National Park. However, it was lower in other community forests, and lowest in the government managed forest. The small sized trees (dbh<10 cm) were almost similar in density in all forests, but middle classed trees (dbh 10-29.9 cm) were higher in numbers in Ratmate danda and Lapsaura danda community forests, similarly as in the National Park. It was lowest in Kumari community forest and government managed forest. The numbers of harvestable trees (dbh> 30 cm) were comparatively higher in three community forests similarly as in the National Park. The desired timber trees are more common in community forests than in the National Park. Community forestry can contribute tree species diversity if people have a broad selection of species preferences. Government managed forest of the hill sides are severely degraded by people and has a very low number of stems and species. The proper management systems either special government programme or community forestry has to be implemented for restocking this forest. Similarly, the extension programmes about forest management and tree species diversity, its importance and process should be incorporated in existing community forestry systems.

Key words: Tree species diversity, Community forestry, Government managed forest, Mid-hills, Nepal.

Contents

Introduction

Background

Forests offer diverse sets of habitats for plants, animals and micro-organisms, holding the vast majority of the world's terrestrial species (CBD 2001). The Asia-pacific countries occupy about 19 percent of the global forest area (FAO 2007). The region has about 25 percent forest cover, but it decreased by 10.5 million ha during the 1990s and the forest degradation continues to be a serious problem (Brown & Durst 2003). The deforestation and degradation support habitat fragmentation and reduce forest diversity. Forest biodiversity is the result of complex historical interactions among physical, biological, and social forces over time and different systems of forest management is enhancing or reducing their diversity (Mc Neely 1994). Since forests have been an essential basis of human prosperity, providing diverse products and services throughout the evolution of mankind, peoples' own knowledge is important in sustainable forest management approaches. The Jakarta declaration of the eighth world forestry congress 1978 emphasized the relationship of forest and rural communities and highlighted the role of forestry in socio-economic development and the need for urgent action to safeguard the world's forest resources (FAO 1978). Similarly, the resource managers around the world are concluding that conservation is more effective when it includes local interests and their participation (Freeman 1997) and community based forestry theories and methodologies have been spread rapidly in the world (Pikun 1998; Bhattarai 1990). Now community based forestry has come into the national agenda in the Asian region and is being practiced in several countries since the last few decades (Gilmour et al. 2004).

Nepal has diverse forest resources with a variable geography, aspects and altitudinal differences (60 m to 8,884m from sea level). Forests are interlinked with Nepalese economy. Gradually the deforestation increased with the political scenarios in 1950 and all forest was nationalized in 1957. The nationalization separated local people from the forest, but at the same time government had limited institutional set up to control and manage the entire forest areas of the country. People started to treat the forest as open access (open for all to use) which increased deforestation (Khanal 2004). Now, Nepal has been practicing different forest resource conservation and management strategies to manage the state owned forest by keeping the land tenure under the government authority. Currently, community forestry, protected areas, leasehold and government managed forestry (GMF) systems are the ongoing strategies.

The concept of protected areas (PA) in Nepal was primarily initiated for the protection of wildlife, especially endangered species (Upreti 1991). Since 1973, Nepal has established an extensive network of protected areas. Now, more than 18 % of the country's total land area is declared as protected areas. Legally, local people have no right to enter and use forest resources from the national and wildlife reserve unless special arrangement have been made by the authority, but there are certain provisions of use in conservation areas and buffer zones. The first protected area of Nepal was established in 1973 and the number expanded to nine National Parks (NPs), three wildlife reserves, three conservation areas and one hunting reserve. The biodiversity is high and very diverse due to large variation in altitude and aspect (Maskey 1996).

However, the distribution of protected areas does not include all physiographic regions of the Nepal, there are only two protected areas, established in mid-hills; one is located in the mid-hills of central development region and another is in the mid western development region of Nepal (DNPWC 2005). Due to the great variety of terrain and the occurrence of subtropical to temperate flora and fauna in this zone, the mid-hills have the greatest ecosystem diversity as well as species diversity in Nepal. Nearly 32% of the forests occur in the mid-hills, and the zone includes 52 out of total 118 different ecosystems of Nepal (Maskey 1996).

Community forestry (CF) has been taken as major program of the forestry sector in Nepal since 1980 (HMG/N 1988). In this system, part of the government managed forests is given to local communities to conserve, develop and sustainable use the forest resources under national and their own local rules ((DoF, 2005). Nepal has been practicing community forestry since 1970's and it has a successful history among all Asian countries. Nepal has already handed over 1.1 million ha of national forest (about 25 percent of the total national forest) to nearly 14,000 community forest user groups (CFUGs). These forest areas are managed by more than 35 percent of the total human population of the country (Nurse & Malla, 2005). Local communities of mid-hills are cohesive communities, and most of them are dependent on the forest for essential products, which are the ideal conditions for community forestry practice (Gilmour & Fisher 1991). Now most of the forests in mid-hills areas managed as CF (DoF, 2005).

Forest diversity and human activities

Unwise human interventions and misuse of the resources are the main threat to the loss of biodiversity. Biodiversity losses due to human activities exist worldwide and in developing countries have been significant and even alarming (Scherr 2003). Silvicultural activities change the tree species composition (Schelhas & Greenberg 1996) and if not carried out with caution, it can

threaten biodiversity (Putz & Blate 2001). Currently, silvicultural activities carried out by CFUGs in Nepal are based on the knowledge and skills of local people rather than scientific justifications (Ojha 2002; Acharya 2003). The current CF practices in the mid hills and its effects on tree species diversity are not addressed in the existing literature.

Problem statement

Mid-hills are richer in biodiversity than other areas in Nepal. The existing protected areas are not sufficient enough to conserve the biodiversity and unique landscapes. There are still several important ecological regions and landscapes that need to be protected for both local and global importance (Maskey 1996). These important forests are under the management of local communities as CF.

Community forestry is a branch of forestry as well as applied social sciences requires the application of knowledge on sociology, political economics, ecology, forest management, modernised theory etc to address the relation between human being and nature (Putz &Blate 2001). The CF-approach emerged at the end of the 1970's, to address widespread forest loss and environmental degradation, which was previously managed by the government. To improve and maintain the productivity of these forests, government has started to hand over the forest to the local communities. There are contradictory statements regarding CFs, Pokharel et al. (2005) explained that CF is a successful way to restore the forest coverage and improve overall forest conditions including biodiversity. However, Acharya, (2003) stated that the community managed forests are promoting a limited number of valuable forest trees through active forest management which is leading to reduce biodiversity. There is lack of consensus about the contribution of CF to biodiversity conservation.

Generally, forest biodiversity depends on good age class distribution, presence of various tree species and proper distribution of these species in the forest stand (HMG/N 2002). The variation in tree species distribution creates habitats for different plants, animals and organisms (Nadkarni et al. 2001;). CF has been a major forestry strategy in Nepal and is being adopted by several other countries in Asia e.g. Vietnam, Thailand, Cambodia, Lao PDR etc (Nurse & Malla 2005). It is important to find out the actual contribution of CF to biodiversity conservation.

The tree species diversity in logged forest contained as many tree species as unlogged forest (Cannon et al. 1998) where as, logging affects to the forest structures and domination of certain species. In case of intensive selective logging, the forest stand is dominated by certain species which is not selected

for logging (Rene & Clara 2003). It means logging intensity in the forest change the forest structure. Except the management, the tree species richness declines gradually from primary forests to secondary forests (Kessler et al. 2005).

Certain community forest managements are effective to promote preferred tree density, but not species diversity (Lawbuary 1999, Acharya 2003). The trends of the tree species diversity is predicted three different trends in different management practices i.e. (1) The increasing trend of tree shrub species under multiple products active forest management; (2) The decreasing trend in existing passive forest management; and (3) The rapid decreasing trend in timber oriented active forest management (Mikkola 2002 cited by Acharya 2003; Kartasubrata & Wiersum 1995). These trends show the possible development of tree species diversity and forest structures under different management practices. Currently, local communities are practicing forest operation in CF according to their own knowledge (Ojha 2002). Most of the CFs is moving towards active forest management (Khanal 2002; Dhital et al 1998). However, these kinds of operation can improve greenery and increase economic benefits to user groups but can lead to remove certain age group or certain functional class trees reduce the tree diversity and finally would threaten the species with a small population (Xiongwen & Bai Lian 2001). Therefore, if the CFUGs have been implementing active management system for a long time, than there is a risk dominance of the preferred species and possible extinction of the unwanted species.

There is ambiguity about the extent of CF contribution to improve biodiversity. Only limited studies are conducted to compare tree species biodiversity situation in CFs, where local people's activities and operations are being implemented and incorporated with other management systems (or non-management). This study is intended to explore the forest status and tree species diversity of different forest management systems.

Aim of the study

The aim of the study is to analyse in what way the existing community forests are different in comparison to government managed forest (GMF) and National park (NP) with regard to tree species richness, as well as the tree population distribution and number of desired tree species.

Specific objectives

- The following specific objectives were formulated to specify the research question.
- To assess the species richness of the tree species in CF, NP and GMF
- To assess the size (DBH) distribution and regeneration of the tree species in the forest
- To assess the forest management history, existing practices and aim of the local people to promote certain tree species

Hypothesis

- Three hypothesis were tested based on previous study reports, literature and own experiences.
- Community forests are less diverse than NPs but more diverse than GMF
- Boarder zone and inner zone of the forest has different tree species diversity
- Local people are promoting preferred timber tree species in CF which changes the species composition of the forest compared to the species composition of the undisturbed forest

Scope and limitation of the study

Limited time, financial and human resources, current transitional political situation of the country with bad security status and large ecological and geographic variation made it possible only to cover a limited area. The study was concentrated to analyse the current forest status in different forest management practices of the study areas. The major part of data collected was ecological. The forest management practices of local people and their motivation was collected as social data in order to see current forestry operation and ideas of the different peoples. However, the social data was not focused in-depth analysis of social values, norms, class differences etc which can play role to differ their practices.

Description of the study areas

Selection of the study areas

The study was conducted from August 2006 to March 2007. Different peoples who were affiliated with federations of community forestry user groups (FECOFUN), world conservation union (IUCN) Nepal, the national trust for nature conservation (NTNC), the department of forestry (DoF), the department of NP and wild life conservation(DNPWC) and individual experts who were working in Nepal were consulted in the selection of the sites. In consultation, the following criteria were made and discussed for the selection of study sites: a) existence of different forest management practices i.e. PAs, CFs and GMFs in the areas; b) different forest management systems are being practiced since at least 5 years back; c) located in the same ecological zones; and d) absence or limited effects from current political and security abnormality. Based on these criteria, seven central mid-hills sites were selected for the study. Protected areas, community forests and government managed forests with the following characteristics, were taken as samples of the study: a) the forest areas which are located to the central mid-hills with elevation 1500 to 2200 meters; b) have forest areas in the southern and eastern aspects; and c) have natural vegetation in the southern and eastern aspects of the forest.

A total seven sites, including Shivapuri NP, five CFs and one GMF were selected for the study (Fig.1 & fig.2). Shivapuri NP is only one national park of the areas and GMF is only found in the hill side of the Makawanpur district. There are more than 148 CFs in Kathmandu district (CFD/DoF 2005) but only ten CFs had matched the criteria. Out of ten CFs, five were selected randomly for the study. The southern aspect of the forest areas were selected for the study because this aspect is richer in biodiversity and is highly populated.

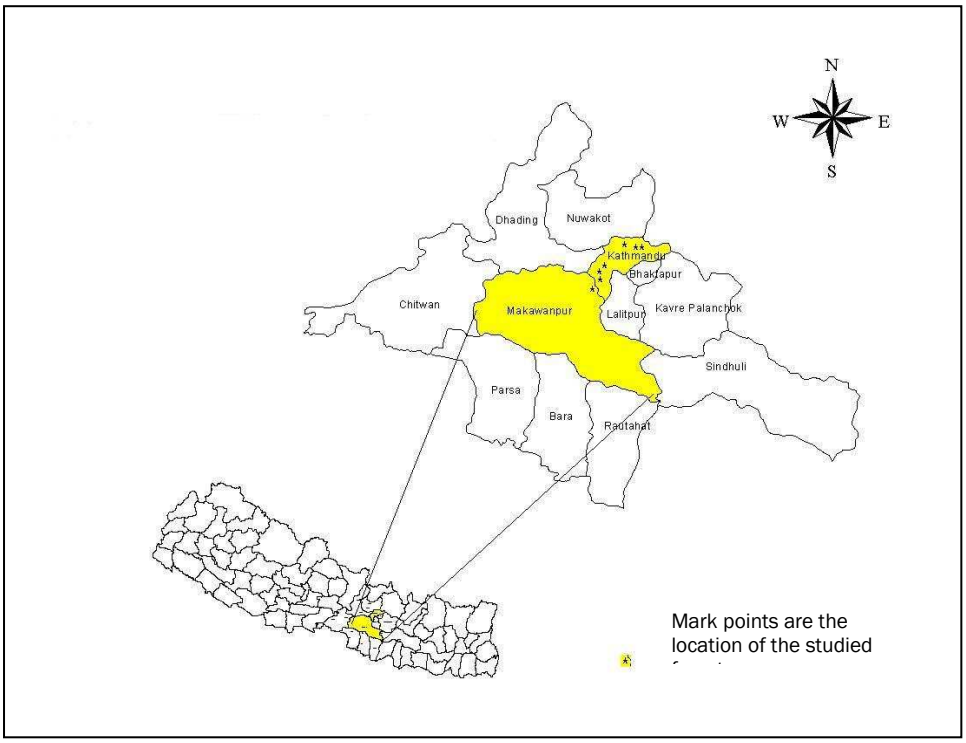


Figure 1. Map of the study areas and location of the sites included in this study

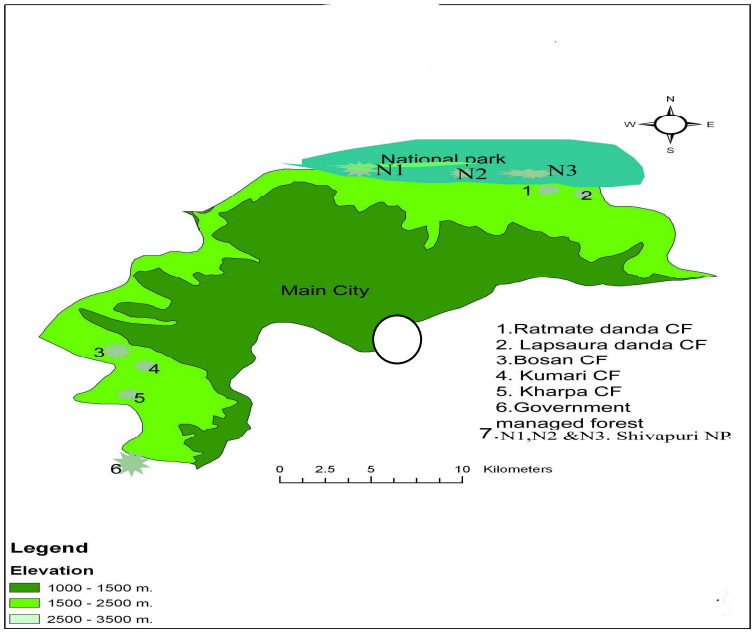


Figure 2. Map of the Kathmandu district and location of the study sites

Brief description of the study sites

Out of total seven study sites, Shivapuri NP was selected as a sample for undisturbed forest, five sites were selected for community managed forests with supposedly limited disturbances and one government managed forest (GMF) with high disturbances was selected for the study (Fig.2). Approximate distance between the sites from the NP and core city is shown in Table 1.

Table 1. Approximated distances from Kathmandu city and the Shivapuri NP to the different forests.

Description	Name of the forests						
	Shivapuri NP	Ratmate danda CF	Lapsaura danda CF	Kumari CF	Kharpa CF	Bosan CF	GMF
Approximate road distance to NP (km)	0	0	0	55	57	52	62
Tentative road distance to Kathmandu (km)	30	30	30	45	47	42	50

(Source: Key informant survey, 2006)

The study sites have the mixed hard wood forest types and have different tree species (Table 2).

Table 2. Major tree species occurring in the different forests of the study area

Species	Name of the Forests						
	Shivapuri NP	Ratmate CF	Lapsaura CF	Kumari CF	Kharpa CF	Bosan CF	GMF
Schima wallichii	*	*	*	*	*	*	*
Castanopsis species	*	*	*	*	*	*	*
Rhododendron species	*	*	*	*	*	*	*
Myrica Esculenta	*	*	*	*	*	*	-
Lyonia ovalifolia	*	*	*	*	*	*	*
Eurya acuminate	-	-	-	*	*	*	*
Aesculus species	*	-	-	-	-	-	-
Betuls utilis	*	-	-	-	-	-	-

(Source: Key informant survey 2006; DNPWC 2005)

The study sites are located near to the capital city but comparatively it is not yet reached by the urban development. Agriculture and forest is main source of livelihood options and the areas have no direct effect of urbanization impacts, but it had lost its natural forest due to the demand of forest products in Kathmandu earlier during urbanization.

The Tamang communities are dominant caste of the study sites. These groups originally live in the mid-hills of Nepal. They have their own language, culture and social norms (Bista 2004; CBS 2003). The livelihood options of the people are mainly agriculture productions such as vegetable production, fruits and dairy production. They are keeping few cattle and goat but there was no pressure of cattle grazing in the study areas.

Shivapuri NP

Shivapuri NP is the only NP which is located in central and mid-hills of Nepal and has been conserved after heavy human pressures and was selected for the study as a protected area. It encompasses 14 400 ha area of Kathmandu, Sindhupalchok, Nuwakot districts of central development region of Nepal. This NP is located between 1 000 and 2 732 meters from sea level which also constitutes the transition zone between subtropical and temperate climates in Nepal.

The area was forested and a habitat for various animals and plants. After the unification of Nepal, the population of Kathmandu started to increase gradually which lead to an increased pressure on the surrounded hill forests of the Kathmandu valley. Before 1950, conversion of the forest into agricultural land was the strategy of the state (Rana regime) to generate national revenue. Agricultural land was seen as major source of income although it increased deforestation. After the 1950, urbanization, new infrastructure, encroachment by the increasing population was the main causes to change the forest status in the areas.

Conservation activities in the area started in 1976. The area was firstly designated as a watershed area and in 1984; it was made into wildlife reserve. At the same time conservation programmes in the adjacent villages was initiated. In 2002, it developed into a NP. In general, the forest in the Shivapuri NP is lower mixed hard wood forest (Table 2). The park is also home to 177 species of birds, including at least 9 threatened species, 102 species of butterflies with a number of rare and endangered species, and 129 species of mushroom (DNPWC 2005).

The park is the nearest NP to the capital city. The study site in the park is located at approximately 30 km from the city (Table 1).

Ratmate Danda CFUG

Ratmate danda community forest is located adjacent to the Shivapuri NP area. The area of the forest is 31 ha and it lies in the average elevation of 2 000 m. Local people have been managing the forest since 1996. A total 62 households are involved in this CF and majority are from tamang communities. Agriculture (Vegetables) is the main options of livelihoods except jobs in the city.

The forest fall under the category lower mixed hard wood forest (Table 1). This forest is located near both the NP and the city (Table 1).

Lapsaura Danda CFUG

Lapsaura danda community forest is situated near to the Shivapuri NP area but it is farther away from the park field office compared to the Ratmate danda CF. The forest covers 44 ha and lies in the average elevation of 1 800 m. The forest was previously under government control and conservation activities were initiated from the government through financial support of FAO in 1986. The area was handed over to the local community in 1995 when government started to focus participatory forestry practices through enforcing legislation. A total 64 households are involved in this CF and majority are from tamang communities. Agriculture (Vegetables) is the main options of livelihoods except jobs in the city. This forest is located almost at the same distance as Ratmate danda CF (Table 1). The forest can be categorized as lower mixed hard wood forest which encompasses various trees (Table 2).

Kumari CFUG

Kumari community forest is located in the southern hillside of the Kathmandu valley. The total area of the forest is 63.5 ha and it is situated in the average elevation of 1800 m. The government handed over the management of the forest to the communities in 2001. A total 320 households are involved in this CF and majority are from tamang communities. Agriculture (Vegetables and fruits) is the main options of livelihoods except jobs in the city. The forest is lower mixed hard wood type (Table 2).

Kharpa CFUG

Kharpa community forest is located in south north hill of the district. The total area of the forest is 309 ha. The forest is situated in the average elevation of 2000 m. Local communities have been managing the forest since 1995. A total 74 households are involved in this CF and majority are from tamang communities. Agriculture (vegetables, fruits, milk production) is the main options of livelihoods except jobs in the city. Kharpa CF is located away from the NP and major cities than the other CFs (Table 1). It is a lower mixed hard wood forest (Table 2).

Bosan CFUG

Bosan community forest is located in southern hills of the Kathmandu district. The total area of the forest is 57 ha. The forest is located in the average elevation of 1900 m. The forest is also located away from the NP and major cities than Ratmate danda CF and Lapsaura danda CF (Table 1). Local people have been managing the forest as community forestry since 1995. A total 350

households are involved in this CF and majority are from tamang communities among other caste. Agriculture (Vegetables, fruits) is the main options of livelihoods except jobs in the city. The forest consists of lower mixed hard wood forest (Table 2).

Government managed forest (GMF)

The forest which is located to the northern part of Makawanpur district has not been handed over to the local communities and it is under the management of government authorities. The forest area is currently under heavy pressure from the people and profession is similar as them. In 1986, a plantation of Pine (*Pinus patula)* was done. Even if the areas are partly degraded, there is natural vegetation in the southern aspect. The plantation areas were not included in the study. Tamang communities are living in this area.

This forest is located the farthest distance from major cities and the NP compared to the other community forests (Table 1).The forest situated in the average altitude of 2 000 m is a lower mixed hard wood forest (Table 2).

Methodology

Nature and sources of the data

All ecological data is in quantitative in nature which was obtained from inventory of the tree species where as the social data is qualitative. A major part of the study is based on the primary data sources which were collected directly from field during the study. Secondary data has been used which has been obtained from published, and unpublished literature.

Data collection tools and techniques

Group discussion

Total 10 group discussions, i.e. two group discussions in each CFUG, were made with the members of the CFUG. For a single group discussion, 5 to 12 members were invited (Bajracharya, 2004). Most of the participants of the group discussion were farmers and few were local teachers but they were active in forest management works. A larger group would be difficult to manage and facilitate during discussion. The views of the women groups and men groups regarding forestry issues were tested in separate group discussion in beginning, but I found similar outcomes views from both groups. Therefore, no gender

specification was done and both men and women attended the discussion during the last. Only the people over 35 years of age were invited and participated in focus groups because only mature people are involved in forestry decisions (Maskey et al. 2003).

Forest management history and current forest management operation is responsible to change the tree species composition in the forest (Kartasubrata & Wiersum 1995; Acharya, 2003; Kessler et al. 2005). A checklist (Annex 2) was developed with the themes to be discussed during the focus groups which were forest management history of sites, preferred tree species to promote, forest use practices, decision making process, time of forestry activities, their criteria to remove tree species during clearing, thinning during group discussion.

Key informants survey

A total twenty nine persons were surveyed to find additional data as well as triangulation of the data obtained by group discussions. Three persons in each forest and eight persons from other forestry related organizations were discussed to find the views on same theme of group discussion (Annex 2). Informal discussion with key informants including CFUG members, members of the executive committee; employees of the forestry organizations, conservationists, and individual experts were done regarding forestry practices.

Field observation

All study areas were visited with one research assistant and two local assistants from the study sites. The current management operation which was practiced by the CFUG and the forest structures was observed in the field to validate the statements of the participants of the group discussions. Observation method helps to validate the verbal statements by comparing them with actual activities in field (Nachmias & Nachmias 2004). This method was used by others authors also in their study to see the vegetation composition (Aravena et al, 2002, Bhuyan et al. 2003)

Forest inventory

Number of sample plots: Systematic cum Random sampling methods were used in this study. The NP is larger in its areas compared to other forests and could be more heterogeneous. To make more representative sampling in the NP, it was divided into three blocks on the basis of natural boundary (stream and ridge). Key informants' were consulted for block division. In each block, four nested sample plots (Adapted from DoF/HMG/N 2004) were taken for detailed measurements while, twelve plots were taken for each community

forest and government managed forest without blocking because they were comparatively small and more or less homogenous.

Design of the forest inventory: Topographic maps of the areas were used together with the information obtained from the consultation of people who were working at the study areas to find the location of the possible sample plots for the inventory. The first sample plot was fixed randomly at 15 m distance from the boarder that is place from where the village areas or personal land ended and forest started. Other consecutive sample plots were laid in 100m distance interval systematically. Sample plots were placed in two parts of the each forest; one was in 15 m distance from boarder (i.e. boarder zone) and the next in 100 m from the first plot (i.e. inner zone). It was located into two parallel transect by using compass and tape (Fig.3).

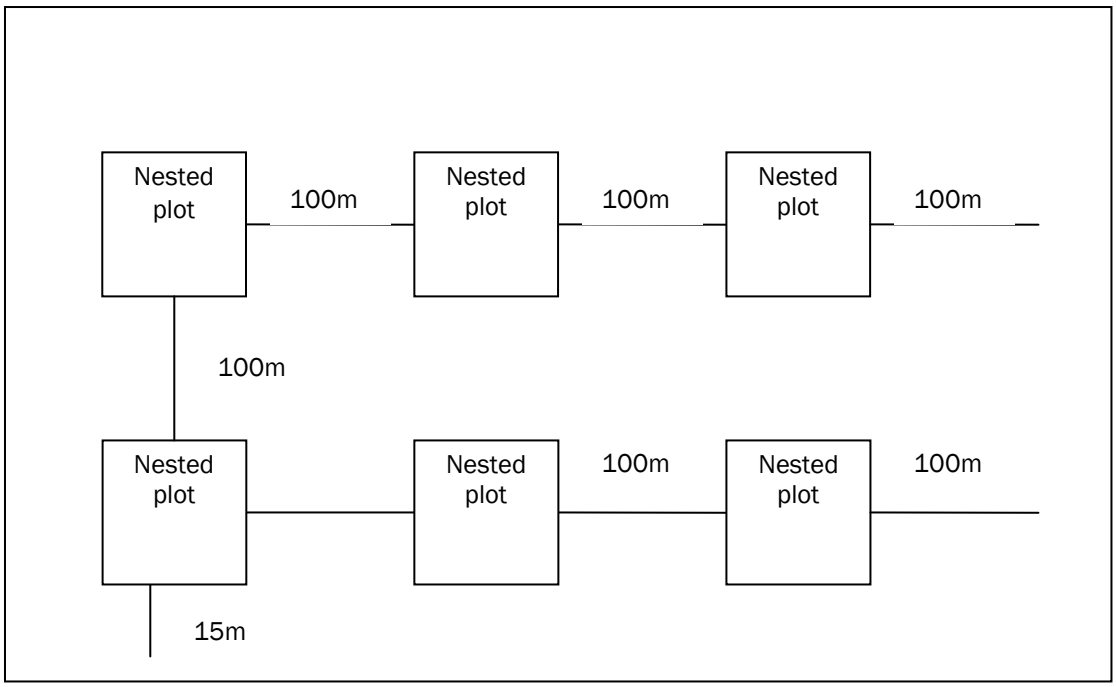


Figure 3. Sketch of the nested sample plots lay out for forest inventory in each forest

The global positioning system (GPS) was used to find the same altitudinal location of the forests and sample plots. Silva compass and distance measuring tape were used to locate the plots in the field.

Model of the sample plots: Square plots were designed for inventory purpose because it is easy to locate and easy to convert slope distance into horizontal distance to make the same plot size even in the landscape with various slope gradients (DoF/HMG 2004).

The modified nested plots, recommended by department of forest Nepal (Figure 4) for forest inventory, were used in the study. The tree species within the sample plots were recorded separately according to the size of diameter at breast height (dbh). The dbh was measured at 1.3 m height from the ground (Chaturbedi and Khanna 1982). Different plots and sub plots were used to measure the tree species with different dbh (Table 3)

Table 3. Size of the plots and dbh classes which was used in the forest inventory

Name of the plots	Sample size	Enumerated tree (DBH class)
Plot	20m *20m	>30 cm :harvestable class
Sub plot1	10m*10m	10cm- 29.9cm:middle class
Sub plot2	2m*2m	• 5 cm-9.9cm: advance regeneration • <5cm and more than one year old*: regeneration

* The age of the plant was estimated by local people

Inventory sheet (Appendix1) was used to record the inventory data. The design of the nested plot was as shown in figure 4. The plot with dimension 20m*20m had divided into four equal square plots with 10m*10m. Two plots with dimension 10m*10m and two square plots with dimension 2m*2m were made in inside the opposite diagonal direction for inventory. The dimensions were converted to the horizontal distance by using formula:

Horizontal Distance = Slope distance* cosa

Where, a is slope angle between two points

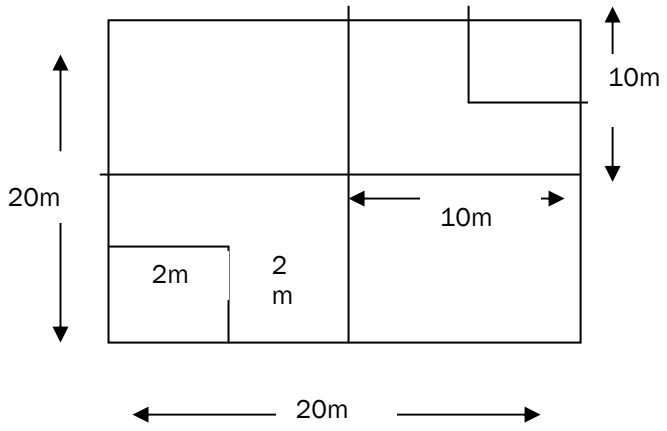


Figure 4. Design of a nested sample plot used for forest inventory (Adapted from DoF/HMG/N 2004)

Data analysis

Density calculation: Density of the tree species with different dbh size was calculated. It is a quantitative measurement of a stand in terms of number of trees per hectare (DoF/HMG/N 2004). The total numbers of harvestable trees, middle size trees and seedlings were calculated by formula:

$$\text{Density (numbers/ha)} = \frac{\text{Average number of individuals in plot} * 10000 \text{ sq m}}{\text{Area of the quadrant}}$$

Proportion of the certain tree species: The proportion of the individual tree species in different forests was calculated in percentage for the dominant tree species in each forest by using following formula:

$$\text{Proportion of individual tree species in forest (\%)} = \frac{\text{Total number of stems of individual tree species per ha} * 100}{\text{Total stems of all species per ha}}$$

Alpha diversity calculation: For the diversity of the tree species community, there is a need to account for both species richness and the evenness with which individuals are distributed among species. Out of different indices to measure the diversity, the Shannon Wiener index has been used for calculating the diversity index in this study which is most common to measure heterogeneity. The Shannon Wiener index assumes that all species present are represented in a sample and that the sample was obtained randomly (Magurran 2004). This index was calculated by:

$$H = -\sum pi \log pi$$

Where H is the index, pi=ni/N; ni is the number of stems of the i^{th} species; and N=the total number of stems of all species (Henderson& Seaby 1998; Magurran 2004). This index combines both the number of species and evenness distribution of the individuals. A greater number of species and a more even distribution of the species both increase the diversity as a measure of H.

The alpha diversity was used to investigate differences in tree species diversity between the forests, and between the inner and border zone of each forest. As a statistical test of differences in H-values, a randomization test supplied in the software package was employed (Henderson & Seaby 1998).

Beta diversity calculation: Beta diversity indices are used to measure the change in species compositions along transect, or between sites. There are different measures of b diversity. The evaluation made by Wilson and Shmida in 1984 (cited in Magurran 2004) found that Whittaker's measure fulfils most criteria with limited restrictions and this measure was used to calculate the species turnover between different forests and between the two zones (inner and border) of individual forest type. The software *species diversity and richness* was used to calculate this index (Henderson & Seaby 1998).

Results and discussions

Results of the study

Current forest management practices

The study shows that the forest management practices and approaches in the study areas have been changing with the national politics (Annex 3).

A. Shivapuri NP,

Objectives: Shivapuri NP is the nearest conservation area from Kathmandu. The main conservation goal of the park is to maintain the watershed which is the major source of drinking water for the people of Kathmandu, and to conserve local biodiversity (in general) of the areas (HMG/N/FAO 1992).

Management: According to park staff, the current plan and practices of park were not specific and had no long-term plan of action. The park guards are regularly patrolling against illegal harvesting and hunting. Local people are not allowed to go inside the park and collect any forest products, not even dead wood.

B. Five community forest user groups (CFUGs),

Objectives: Fulfil basic needs of the local people such as bedding materials for cattle, grasses for livestock, firewood, and timber in a sustainable way from the forest, and at the same time protect forest from further depletion.

Management: Each CFUG have their own plan of action which is prepared in consensus of all the members and then forwarded to the department of forest (DoF) for approval. The community controls the collection of gravel, soil and stone (which was common to collect and use as house building materials in the hill areas) to control soil erosion. They prevent unauthorized deforestation as well as developing the forest coverage by making plantations (both local and exotic trees species), clearing and thinning. However, different actors are involved in community forestry (Fig. 5), CFUG members are the main actor to implement forest management activities in their forest.

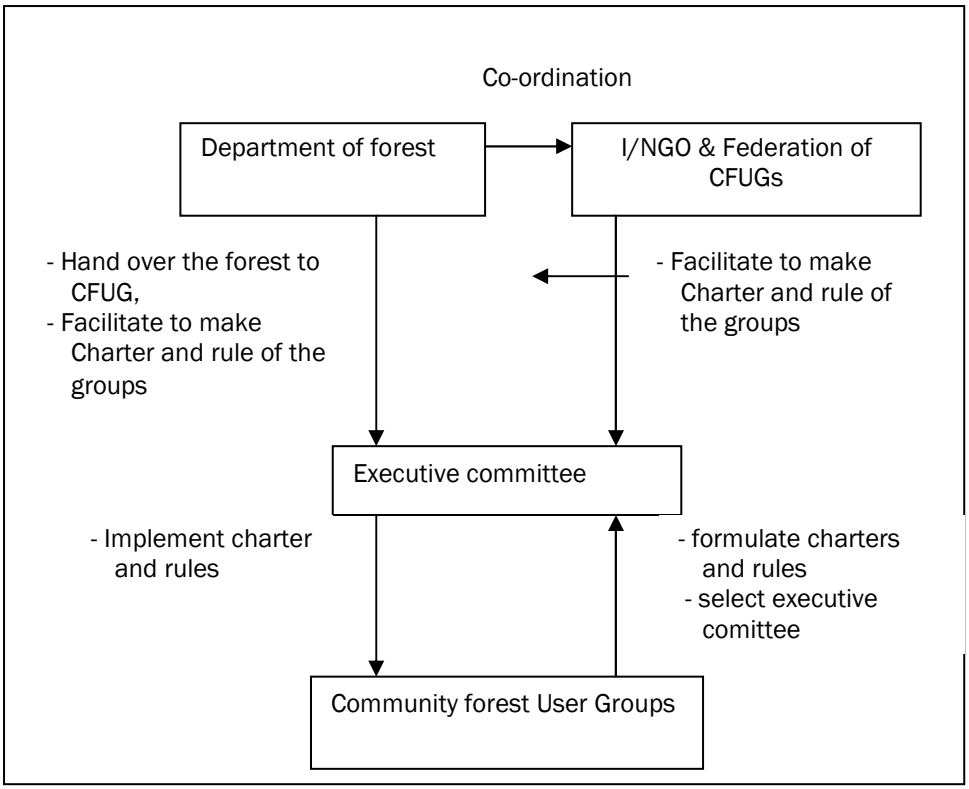


Figure 5. Different actors of community forestry and their roles in the study areas

A. The stand left after Jhadi Sudhar activities

B. The stand, where Jhadi Sudhar activities were conducted last year

C. People are doing Jhadi Sudhar activities

Figure 6(A-C). Jhadi Sudhar activities of CF and the forest stand after it, in Kathmandu areas in Nepal.

During the management activities (*Jhadi sudhar)*, they remove bent trees, thorny shrubs, vines; dead, diseased and dying trees (Figure 6A-C). *Jhadi sudhar is* made on yearly basis. They have divided entire forest area into different blocks to make sufficient areas of each block to accomplish the *Jhadi sudhar* in one year. All CFs from the study areas have made a five year cycle for *Jhadi sudhar* and they should come back to the same block after five years rotation. The operation is conducted during February and March, and one person who can do forestry work should participate from each member household voluntarily. A total 15 days to 1 month time is allocated for *Jhadi sudhar* in CFs and it is decided in executive committee meeting and informed to all members. The executive committee penalizes the same amount as one person wage to the absent member. The existing management activities were directed towards creating favourable environment to grow timber trees. Usually, they do not cut standing good trees but Kharpa CF, Kumari CF they are not operating *Jhadi sudhar*. In these two CFs they select and log the fire wood trees which are not growing well in their forest to cut.

It was observed that the Ratmate Danda CFUG, Lapsaura danda CFUG and Bosan CFUG were doing *Jhadi sudhar* in their forest stand. The latter two were doing it only in the bordering side of the forest and was not managing

according to the plan in the inner side of the forest. People explained the reason of that is if they let to grow dense stems in border side then there could hide leopards and Jackal and fox etc which could kill their domestic animals and chickens. In the other hand, Kumari CF and Kharpa CF were not doing it regularly. They said that some of the executive members are contractors, businessman and are busy. Additionally, the committee members think that their forest condition is good and they are not taking initiatives for operating forestry activities as their plan, although they still log some of the trees when needed.

Use practices: The CFUGs had their own rules and regulations to collect and conserve forest products. They had a specific time period to collect forest products in their plan but in case of Kharpa CF, all CFUG members who wanted dry wood, fallen branches for the fire wood and grasses could collect during entire year. Each household member who wanted to build a house has to give application to the executive committee. The executive committee decide and allow cutting certain numbers of timber trees to the applicants. In process, the executive committee and member goes to the forest and select trees to harvest from those trees which is standing in dense stand and have low possibility of growing. After having permission, applicant cuts and extracts trees from the forest stand. The numbers of trees are fixed on the basis of the requirements to build a house. The person would get more number of trees for a new house and less for maintenance only. Currently, they have practiced to give maximum 20 numbers of living trees to one household in case of Bosan CF, Kumari CF and Kharpa CF. Normally, one household does not make new house frequently, and there is generally one or two household application each year. They do not cut and sell trees to the city but still some illegal logging is occurring in the CFs.

Decision of forest management: The executive committee, which was formed by the selected members during the general assembly, was responsible to implement all decisions made by the user group assembly. The executive committee could take decisions related to forestry activities but they were obliged to get approval from assembly latter on.

Preferred tree species: Fodder and fire wood are needs of rural people, however, management is focused on timber trees, promoting certain species, which clearly can be seen in the results of the proportion of different trees, in comparison with the NP (Table 5 A-B). People collect fodder and grass from their own agricultural land and inclusions instead of the forest, and the timber trees also partly were used for fire wood. Currently, they were using dead, dying trees, bent trees and branches for fire wood, since people are not allowed to cut living trees for fire wood. Only living trees are allowed to cut by the

decision of executive committee, if a member of CFUG wants to build his own house.

Specific size of tree to cut: Ratmate danda CF and Lapsaure danda CF had limited numbers of larger size trees in their forest stand. They were only allowed to cut 5 to 10 trees per person after the decision of executive committee (the household should manage remaining timbers from other sources than CF). They select the trees mostly from those which are dying from the tip, comparatively with less probability to grow well and depending on the availability in the stand. Kumari CF, Kharpa CF and Bosan CF, executive committee allows cutting larger tree considering need and availabilities in forest stand.

C. Government managed forest (GMF),

Objectives: According to the existing plan, which was prepared by district forest offices and approved by the DoF, the major objectives of GMF was to conserve and develop forest areas of the district, manage the productive forests and extract forest products for national revenue, stop encroachments and promote natural regeneration.

Management: Kathmandu district is located in the mid-hills of Nepal and all forest areas of the district are under different management. However, there are no forest areas under GMF and district forest office is facilitating community forestry in this district. In the other hand, Makawanpur district has GMF forests in both hilly and flat areas, but DoF are concentrating on the productive tropical forest rather than hilly areas. The hill forest of the Makawanpur district is neglected in management and local people are cutting trees. District forest office only took action if they obtained information about deforestation and encroachment of the forest areas.

Tree density and structure of the forests

Species richness

The study found that the number of tree species were highest in Ratmade danda CF (Fig. 7), followed by NP and found lowest number of species in Kharpa CF and GMF. Total number of species encountered in all sites was 49 (appendix 4).

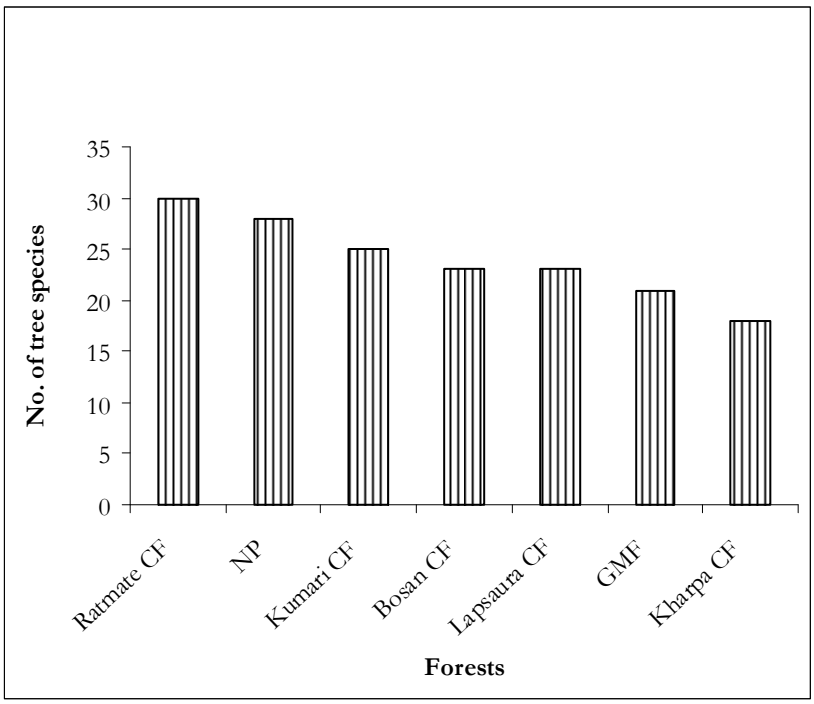


Figure 7. Number of tree species found in different forest management system in different mid-hill forests, in Nepal

Kruskal-Wallis test was used to measure the variation of tree species richness between forests. The results showed that the species richness were significantly different in the studied forests (H = 31.93, DF = 6, P = <0.0001). But, the highest median values of species richness were observed in NP, Ratmate CF and Lapsaura CF; and show the similar pattern of species richness. But it was lowest in GMF and medium in the remaining CFs (Fig. 8).

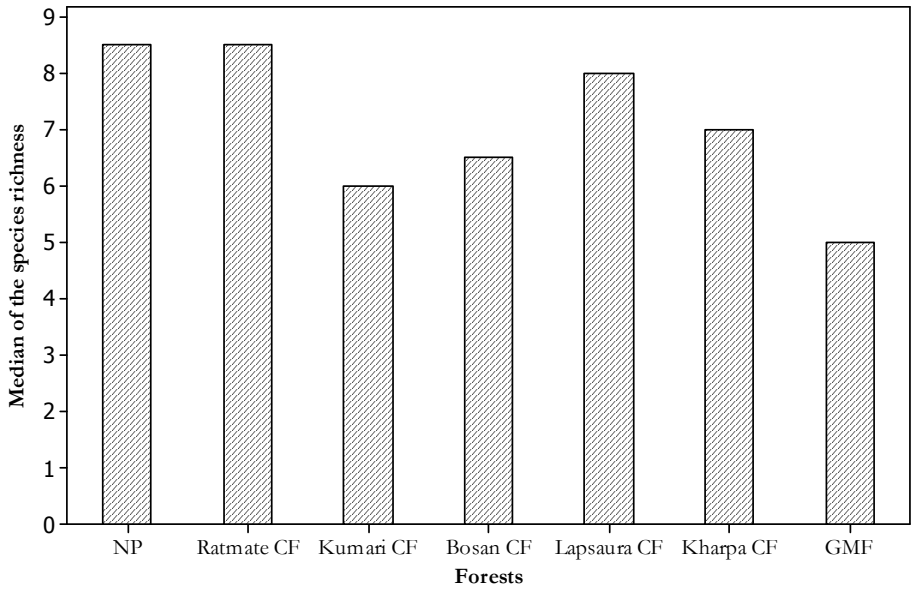


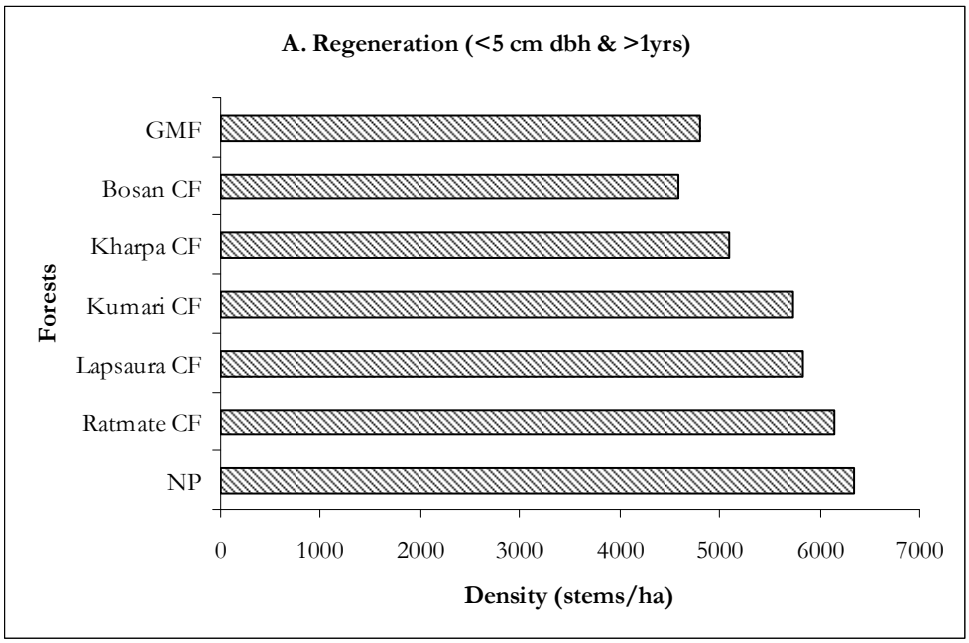
Figure 8. Median of the tree species richness found in the studied forests in Nepal

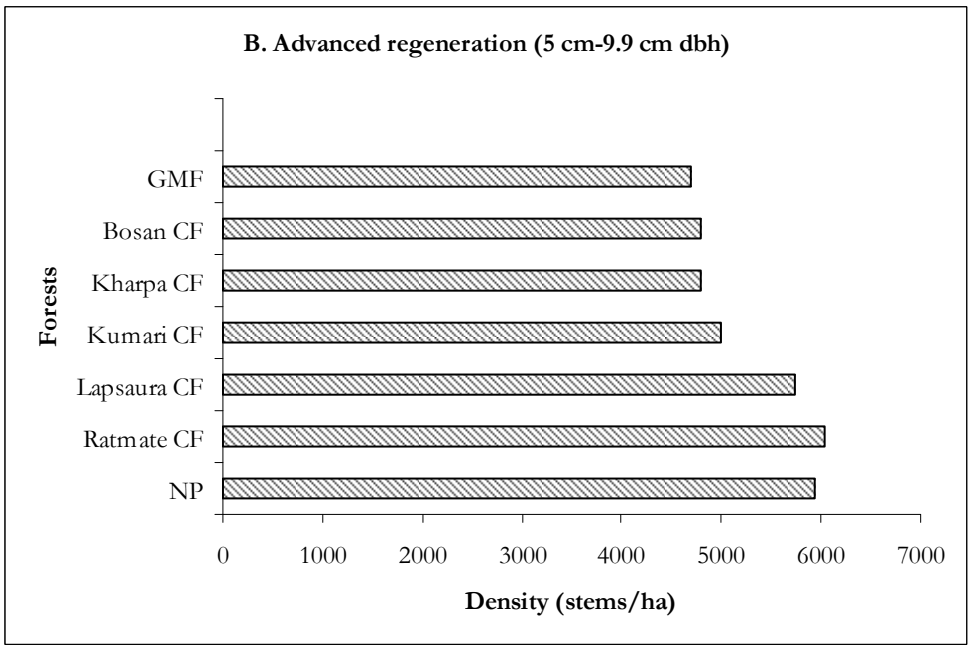
Size distribution of the trees in the forests

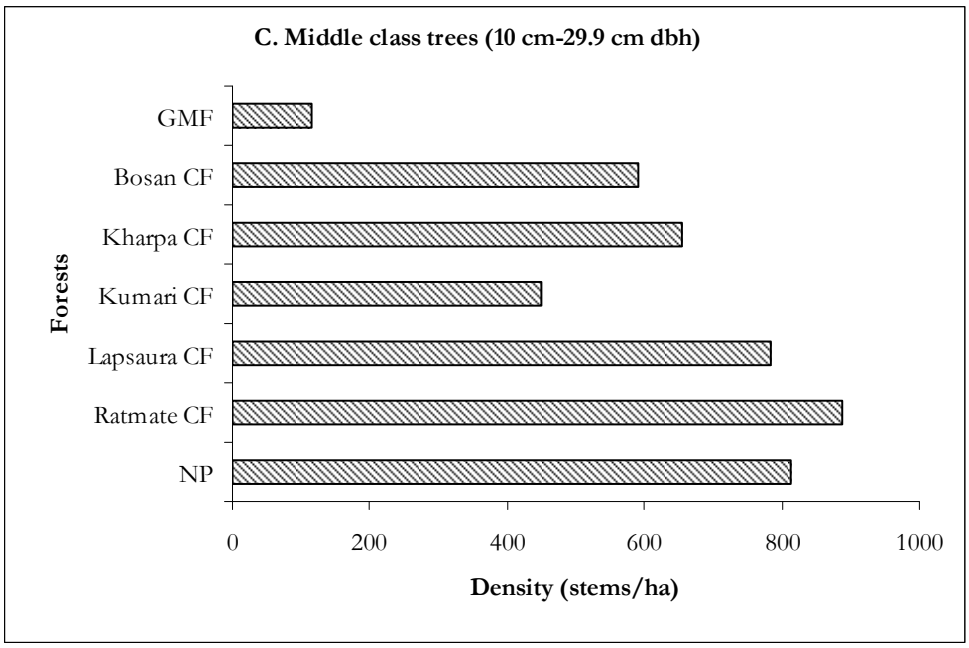
The density of trees with the different size classes were calculated (fig.8A-D). Figure 9(A) shows that the density of the regeneration sizes was highest in NP followed by Ratmate CF as compared with a lower density in Bosan CF and the GMF. Figure 9(B) shows that the abundance of the advanced regeneration was almost similar to the younger regeneration class, which was highest in the NP and Ratmate danda CF.

The density of the middle class trees (Fig. 9 C), was clearly different then the younger size classes, with significantly lower number in the GMF and Kumari CF. The other forests showed a similar pattern as in the smaller classes.

In case of harvestable trees (Fig. 9 D), the patterns changed again, showing that the Lapsaura danda CF and Ratmate danda CF contained very few harvestable trees. The situation in GMF was quite bad, with no harvestable trees at all. Kumari CF had highest number of harvestable trees, although the middle size classes were much lower. The NP had all size classes and the existing structure shows good possibility of having old growth trees in NP.


A. Regeneration (<5 cm dbh & >1yrs)
Forests
GMF
Bosan CF
Kharpa CF
Kumari CF
Lapsaura CF
Ratmate CF
NP
0
1000
2000
3000
4000
5000
6000
7000
Density (stems/ha)


B. Advanced regeneration (5 cm-9.9 cm dbh)
Forests
GMF
Bosan CF
Kharpa CF
Kumari CF
Lapsaura CF
Ratmate CF
NP
0
1000
2000
3000
4000
5000
6000
7000
Density (stems/ha)



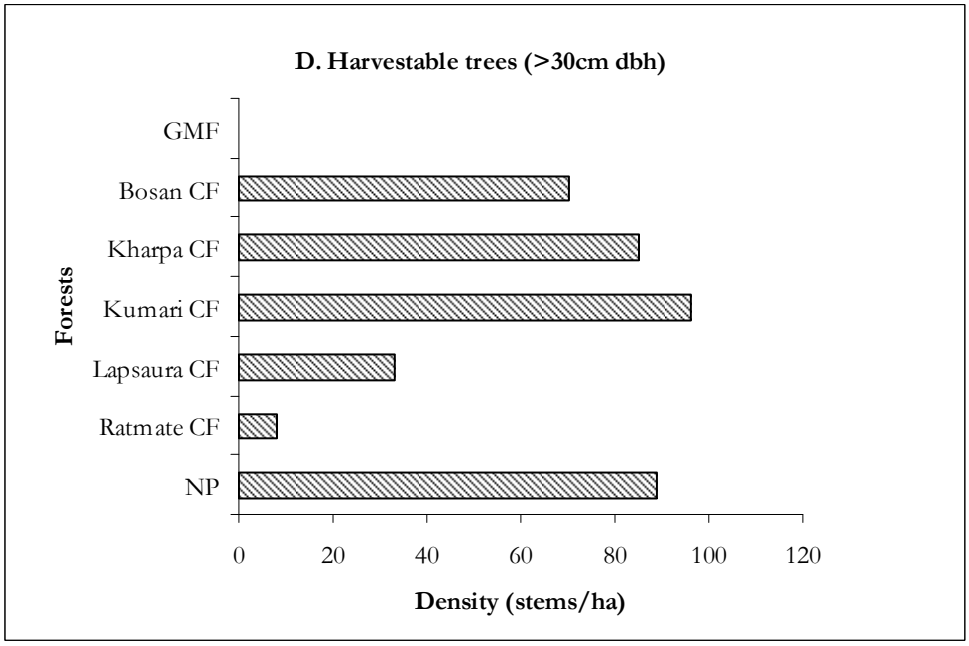


Figure 9 (A-D). Abundance of the different tree size classes as mentioned in table 3 in mid-hill forests, in Nepal. The scale of figures A & B are in same scale while figures C & D are in different scales.

Proportion of the individual species

According to the group discussions and key informants survey, the wood of *Lyonia ovalifolia, Rhododendron arborium, Camellia kissi, Symplocos pyrifolia, Myrsine semiserrata, Viburnum cotinifolium,* were used as firewood for cooking energy in the study areas where as the wood of *Schima wallichii, Castanopsis histrix, Castanopsis indica, Myrica esculenta, Eriobotyra dubia* was used as timber in these areas (Table 4-A, B & Annex 4 for more details).

Table 4 (A) shows that more than 36% stems were timber trees in case of Bosan CF, Lapsaura danda CF, Kumari CF, Kharpa CF, while it was lower in case of NP, GMF and Ratmate danada CF. These results indicate that people are successfully managing the forests for desired species, particularly *Schima wallichii* and *Castanopsis histrix*. However, Ratmate danda CF was the only CF which was not able to promote timber tree species. One the other hand, Table 4(B) shows that fire wood trees were highest in the NP followed by GFM and Ratmate danda CF, where as all remaining CFs had lower percentage of these species.

The results of the species occurrence shows that every forest was dominated by a few tree species and the majority of these species were timber species in case of CFs, but in case of GMF and NP, fire wood trees were found to be more common (Table 4 -A, B), where the NP probably reflects the more natural conditions.

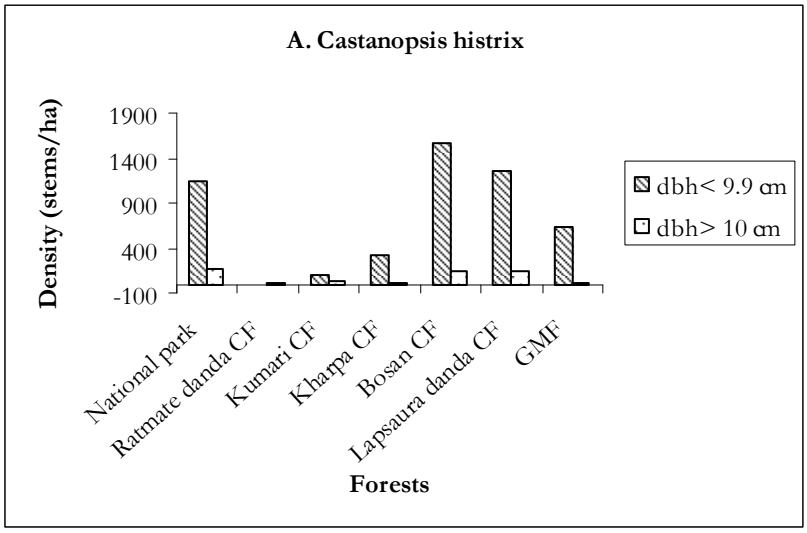
Table 4 (A). Proportion of timber tree species in different mid-hill forests, which are preferred by local communities to promote in CFs, in Nepal.

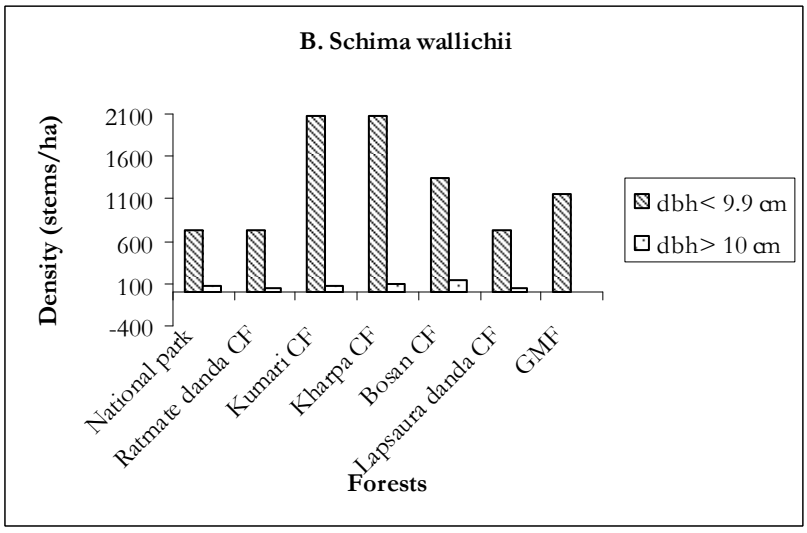
Local name	Scientific name	Use	% in NP	%Ratmate danda CF	%Kumari CF	%Kharpa CF	%Bosan CF	%Lapsaura danda CF	%GMF
Chilaune	Schima wallichii	Timber, Firewood	7	6	20	22	16	16	12
Dhale Katus	Castanopsis indica	Firewood, Timber	4	6	21	5	3	3	3
Jure Kaphal	Eriobotyra dubia	Timber, Firewood	3	1	0	2	7	7	6
Kaphal	Myrica esculenta	Timber, Firewood	3	8	0	3	2	2	0
Patle Katus	Castanopsis histrix	Firewood, Timber	11	0	1	3	18	18	7
Champ	Michelia kisopa	Firewood, Timber	0.04	0	0	1.24	0	0	2.20
Total			28	21	42	36	45	45	28

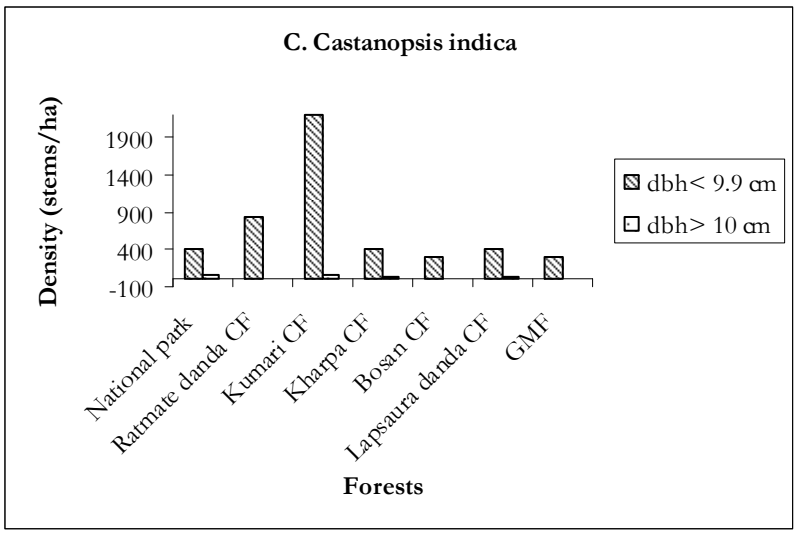
Table 4 (B). Proportion of firewood tree species in different mid-hill forests, which are not preferred by local communities as timber trees, in Nepal

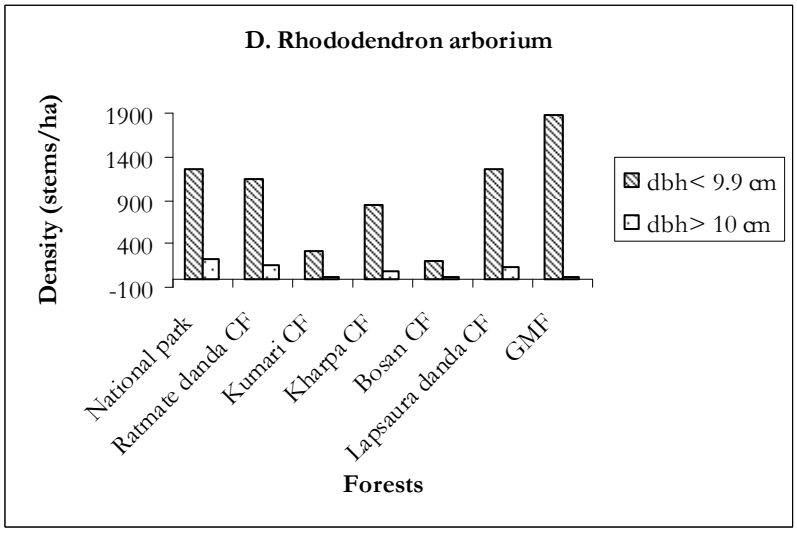
Local name	Scientific name	Use	% in NP	%Ratmate danda CF	%Kumari	%Kharpa CF	%Bosan CF	%Lapsaura danda CF	%GMF
Angeri	Lyonia Ovalifolia	Firewood	15	9	1	9	6	6	11
Kali Kath	Myrsine semiserrata	Firewood	5	7	9	2	8	8	9
Hinguwa	Camellia kissi	Firewood	6	4	3	0	3	3	1
Gurans	Rhododendron arborium	Firewood	12	10	3	10	2	2	20
Total			38	30	16	21	19	19	41

The stem density of the promoted timber trees of the areas (Table 4A) such as *Castanopsis histrix, Schima wallichii* and *Castanopsis indica* is shown in Fig. 10 (A-C). The density of those of small trees/advance regeneration (dbh < 9.9 cm) was much higher than dbh >10 cm (larger trees) for most species in most forests (Figure 10 A-E). It shows that the regeneration for the future harvesting is abundant and obviously managed for. However, *Castanopsis histrix* has no regeneration in three of the CF forests (Fig 10 A) which shows a potential problem either in the management of this species (lack of regeneration) and for future harvesting. NP and GMF had comparatively higher density of fire wood trees such as *Lyonia ovalifolia* and *Rhododendron arborium* (Fig. 10D, E).






C. Castanopsis indica
Density (stems/ha)
1900
1400
900
400
-100
dbh< 9.9 cm
dbh> 10 cm
National park
Ratmate danda CF
Kumari CF
Kharpa CF
Bosan CF
Lapsaura danda CF
GMF
Forests


D. Rhododendron arborium
Density (stems/ha)
1900
1400
900
400
-100
dbh< 9.9 cm
dbh> 10 cm
National park
Ratmate danda CF
Kumari CF
Kharpa CF
Bosan CF
Lapsaura danda CF
GMF
Forests

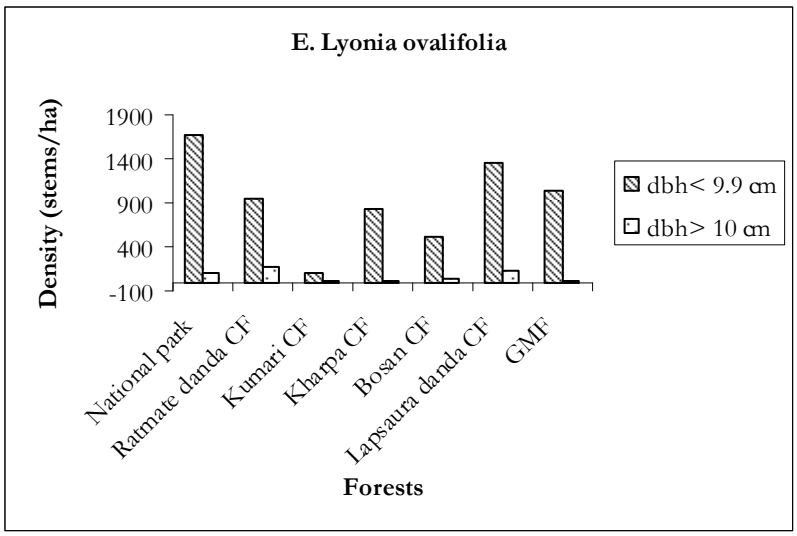


Figure 10(A-E). Density of individual tree species with different size found in different mid-hills forests, in Nepal. The figure A-C shows the timber trees while the figure D-E is firewood tree species. The figures A-E all have different scales.

Tree species diversity

A. Alpha diversity: Tree species diversity of the different forest management system has been estimated by using the Shannon Wiener biodiversity indices and equitability J.

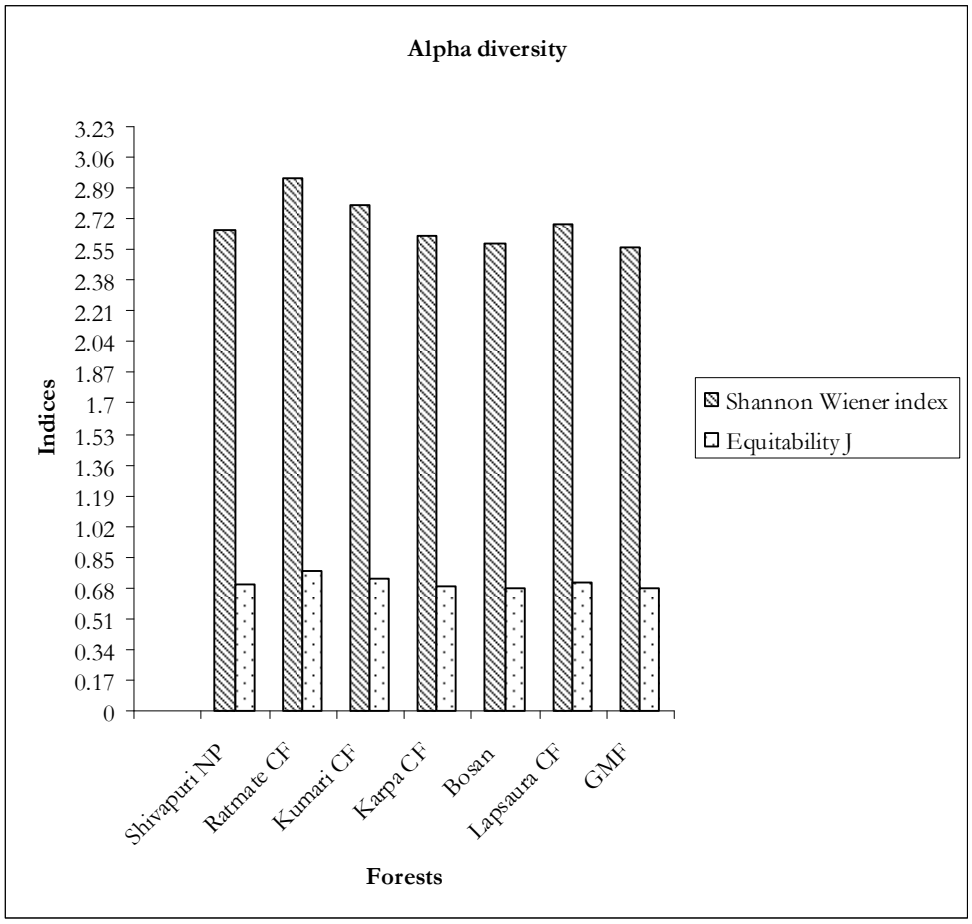


Figure 11. Shannon Wiener index showing tree species diversity and distribution patterns of tree species in different forest management systems in mid-hills, in Nepal.

The Ratmate danda CF had highest tree species richness with high value of the Shannon Wiener index CF (Fig. 11) and most even distribution of the species with high equitability index J. Similarly, the Shannon Wiener index, pair-wise comparisons between forests (Table 5) showed that Ratmate danda CF was significantly different from all other forests. In the other hand, the species richness was lowest and distribution pattern of the species was also uneven in the case of GMF (Fig. 11). The Kumari CF also had significantly different tree

species diversity compared to all other sites, except to Lapsaura danda CF. No other forests were significantly different from each other. However, Bosan CF and GMF reported very similar with P>0.80, although they are quite far away from each other (Table 5).

Table 5. Estimated probability matrix showing the probability that Shannon Wiener H-indices are identical, in pairwise comparisons.

Name of the forests	Ratmate CF	Kumari CF	Karpa CF	Bosan CF	Lapsaura CF	Government managed forest
Shivapuri NP	0.0001	0.051	0.59	0.32	0.64	0.34
Government managed forest	<0.0001	0.002	0.43	0.80	0.14	
Lapsaura CF	<0.0001	0.08	0.24	0.13		
Bosan CF	<0.0001	0.005	0.56			
Karpa CF	<0.0001	0.005				
Kumari CF	0.02					

B. Beta diversity: The pair-wise comparison with the NP shows that the Lapsaura danda CF and Ratmate danda CF have comparatively lower beta (b) diversity (Table 6), which means they had similar species composition. Between Kumari CF and GMF, and the NP, higher beta diversity is indicated, showing larger differences in species composition. Similarly, the beta diversity index shows that GMF is more similar to the Kharpa CF, while it is less similar to the NP in terms of species composition.

Table 6. Whittaker's beta diversity index (Bw), showing pair-wise estimates of species turnover rate between mid-hill forests in Nepal

Forests	Government mgt	Ratmate danda CF	Lapsaura danda CF	Kumari CF	Bosan CF	Kharpa CF
NP	0.41667	0.29825	0.19231	0.43396	0.32	0.3617
Kharpa CF	0.23077	0.33333	0.26316	0.40909	0.36585	
Bosan CF	0.38095	0.37255	0.41463	0.48936		
Kumari CF	0.33333	0.40741	0.40909			
Lapsaura CF	0.33333	0.20833				
Ratmate CF	0.34694					

Diversity differences between inner and boarder zone within a forest

The Shannon Wiener index shows that the NP, Kumari CF, Kharpa CF, GMF had more diversity in the inner zone compared to the border zone, but the opposite pattern was seen in Boson CF and Lapsaura danda CF. The patterns in Lapsaura danda CF, Kumari CF, Kharpa CF and Bosan CF were significantly different (Table 7). However, beta diversity index shows highest species turn over rate in Kumari CF where as it is less in Bosan CF. In the other hand, the probability matrix shows that the species diversity is similar in border and inner zone in GMF but these species are not identical with high beta diversity index (Table 7).

The Equitability index J shows that the Boson CF and Lapsaura danda CF had less even species distributions in the inner zone, as compared to the border zone, a pattern that was not seen in other forests (Table 7).

Table 7. The Shannon Wiener indexes, Equitability J, probability of having similar diversity in the two zones and Whittaker Bw, showing differences between inner and border zones of mid-hill forests in Nepal

Forest	Zone	Shannon Wiener index	Equitability J	Probability	Whittaker Bw
NP	Inner	2.5425	0.77144	P=0.1364.	0.31707
	Border	2.3627	0.71687		
Ratmate	Inner	2.8366	0.834	P=0.5858	0.2
danda CF	Border	2.7874	0.81952		
Lapsaura	Inner	2.4856	0.78211	P=0.0116	0.23077
danda CF	Border	2.6777	0.84255		
Kumari CF	Inner	2.7473	0.8535	P= <0.001	0.42857
	Border	2.3817	0.73991		
Bosan CF	Inner	2.3659	0.7444	P=0.007	0.2973
	Border	2.6594	0.8368		
Kharpa CF	Inner	2.6148	0.88804	P=0.001	0.1875
	Border	2.3792	0.80802		
Government	Inner	2.4423	0.80218	P=0.1062	0.4
managed					
forest	Border	2.2275	0.73165		

Discussion

Opinion of the people

The opinion of the people regarding forest management practices were similar among the people who participated in discussions. Previously, it was assumed that the opinion of the women and men might differ and they could have different views regarding forest management strategies and uses. To test this statement, women groups and men groups were invited separately for discussion in Ratmate Danda CFUG in beginning, but I found similar opinions regarding forest management practices in their CF from both groups. That the purpose of this study was not on depth analysis of social norms and values and was focused on current forestry practices of the areas. Since all study areas were dominated by Tamang communities both men and women were invited for group discussion in other CF sites. In group discussions all participants of the study areas expressed their interest to promote timber trees in their CF. Local people were happy with CF practices and they expressed management of "our forest". They have ownership feeling and are managing the forest which helped to increase density of the valuable stems in forest. The Executive committee was responsible to give timber trees to applicants according to agreed criteria. The possible unfairness of the executive committee to distribute trees was not discussed in this study but another study has showed some bias decision in the favor of richer people (Timsina, 2003). This could potentially increase conflicts between poorer and richer groups within a community. A forest official said that the department has limited manpower and the post-formation support to CFUGs is extremely limited. They added the lack of an effective support services mechanism; the knowledge about importance of biodiversity conservation has not reached down to the user level. Department staff said that the forest conditions are improved in case of greenery and coverage but in case of species diversity and forest structure is not clear for them.

The GMF studied is not really managed but is like open access forest and have no ownership of local communities. Both local and people from surrounded areas even from CFs are coming for forest products and illegal cutting. However, government is responsible for management, the location of the office is far from the forest areas and it is not possible to visit frequently to control illegal cutting. They take action only if someone appeals them about ongoing illegal activities.

Changing structure of the forests in CF

There were differences in structure between the CFs but it is difficult to generalize from my results. It is probably caused by the different location of the forest areas, the time when CF management started and the applied management practices. The community forests, which are located near to the city, lost larger trees during 1970s. At that time, the local people were not involved in the forest management process and government authority was sole responsible to manage forest resources. But the department of forest had not enough institutional set up to protect forest. During the 1980, government started to involve local people to manage forest resources. Forest law was reformed only after 1991 in order to give management authority of state forest to local communities legally. Now they have high regeneration compared to the CFs which is located far away ((Fig. 8A-D). Kumari CF, Kharpa CF and Bosan CF which are located far from the city has higher numbers of larger trees and lower numbers of regeneration compared to Lapsaura danda CF and Ratmate danda CF which are located close to the city. Moreover, the situation of Kumari CF shows a gap in the middle sized class. It is due to high removal of unwanted tree species during forestry operations and it is may be due to other natural factors which is limiting the regeneration of the preferred species. If the situation continues it may lead to the possibilities of gaps for future harvesting. The CFUG activities are not being monitored by the supporting organizations such as the department of forest and NGOs to give proper knowledge about the long-term impact of forestry operations.

The NP which was supposed to be a more undisturbed forest had higher density of regeneration similarly as the CFs. However, other studies show that undisturbed forest should have comparatively higher density of large trees than other forests (Parthasarathy 1999; Chittibabu and Parthasarathy 2000). This is shows that the NP is a secondary forest although it have had more than two decade of non-disturbance, where the CFs had 10-20 years of forest management. The Shivapuri NP is the youngest NP in Nepal (DNPWC, 2005) and there was openness in the canopy, with a high density of small trees, compared to a pristine forest with a closed canopy of larger trees.

The GMF had higher density regeneration as similar as CFs and NP but has the lowest numbers of middle classed trees and a negligible harvestable size class, caused by high illegal logging in the absence of DoF guards in the area. The GMF is facing high pressure on forest resources by both local and neighbouring villagers. The CFUG people from the surrounding areas are also using the GMF while conserving their own CF, which also is found by Baral and Subedi (2000). The GMF will lose its trees within short, if the situation is continued. It could be better option to restock the GMF; either government has to focus their efforts to manage this forest or to involve local people to manage this forest as CF by giving ownership to local communities.

Tree species diversity

A high number of tree species and its even distribution (i.e. high alpha diversity indices) are found in Ratmate and Kumari CFs (Fig.11), but the NP has also a good diversity. The history of forest management, conservation programs of the NP and forest structure of the stand has played role to differ tree species diversity in CFs. The numbers of tree species is higher in Ratmate danda CF, which is located near to the NP (even near to the park unit office). This CF may have been influenced by the conservation programmes of the park, increasing awareness of conservation and sustainable management and also less illegal cutting due to fear from park staff instead CF patrol. The relatively low density of larger trees in Ratmate danda CF in combination with thinning is creating an open canopy structure, allowing for abundant regeneration with many different species, which has been reported elsewhere (Hutching 1986). Similarly the CFs located near the NP (Ratmate danda CF and Lapsaura danda CF) had begun management activities almost at same time as in the park by the help of NP staff. This may be encouraging people to keep many trees in the forest stand compared to the CFs which are located far from NP. Additionally, the open canopy in these forests, as mentioned above, has helped to regenerate and establish different tree species to a high alpha diversity. Undisturbed forests have been reported to have the lower species richness compared to moderately disturbed forests (Bhuyan et al 2003; Chittibabu & Parthasarathy 2000). However, the presented study shows on the contrary that relatively high number of tree species found in the NP. In this case the numbers of species has depended on the history of the forest management and management practices of the people. The initiation of conservation activities in NP (23 years ago) is fairly short time for recuperation when the disturbances ended and relatively short time in a forest cycle. In the long run it may reduce number of species if natural processes have been taken place continuously without human interferences.

Alpha diversity index shows that Ratmate danda CF is significantly different than all forests whereas the smaller beta diversity index in pair wise comparison shows the species found in this CF is more identical as NP. It may be caused by the location of the park office close to this CF and protection system was started at similar time period except ecological similarity. The closer location is an extra advantage in the control of illegal logging, which to some extent also occurs in CFs. Mostly illegal cutting was occurring from both community members and outsider. The executive committee may not allow cutting trees to all applicants but they want it which may lead illegal cutting. To address these issues, willingness to follow the rules and make enough participation of all user groups during decision making process help to reduce illegal cutting by members (WATCH, 2003). Except the human factor, diversity is normally (if the human factor is constant) changed with environmental heterogeneity and spatial configuration (Dufour et al 2006). I tried to control for environmental

differences by choosing the same altitudinal range and aspect of the forest stands for all study sites, but local heterogeneity did definitely contribute to both variation in tree density and diversity. I found quite low species richness in the most disturbed area (GMF) which is supported by other studies (Bhuyan et al 2003; Chittibabu & Parthasarathy 2000), but differences between the GMF and other CFs were not very large. One would have expected a much lower diversity since it can be regarded as quite degraded. Although the illegal logging of large trees has occurred during the last three decades in the southern aspect of the forest and broad leaved trees, the regeneration of the same species is abundant. This could be caused by a general limited grazing pressure in the GMF, and lower extraction of the smaller trees.

The study showed that current forest management practices of some CFUGs are creating a different tree diversity within their forest stand. The inner zone of all forests had higher diversity than the border zone, except in Bosan and Lapsaura danda CF which had comparatively more diverse border zones. The latter two were conducting *Jhadi sudhar* in the border zone only, because they want to keep their forest open in border side from the fear of wild life such as leopard and jackal which can hide and kill their livestock. This management practices is in some cases contributing to increase tree diversity there. Similar results were found in the study carried out by Bhuyan et al (2003) in India. If they conduct their operation only in the border zone may create forest with different species composition which may create mosaic forest with high biodiversity. Similarly, the probability matrix of alpha diversity indices reported the significant differences in tree species diversity between the border and inner zone of most of the CFs which have higher number of larger trees and located far from the city. The difference is not observed in the NP and GMF; this is because there are no management interventions. However, the species found in inner and outer zone in GMF is not identical (with high beta diversity index) due to more exploitation of trees in the outer zone; this could actually contribute to the fairly high species richness in the GMF however the structure is different.

Status of the tree species domination in different forests

Most of the CF management is motivated by economic benefits promoting the tree species which mainly are useful for timber. This is because, the forest products of the CF is legally owned by CFUG and all income which is generated from it, is their properties to utilize into forestry as well as development work within the CFUG. They should spend at least 25% of total income for the forestry operations e.g. seedlings, tools, etc. The other remaining amount goes to the community development work, such as schools support, drinking water supply, bridge & road constructions etc. (HMG/N 1991; 1995). The most of the CFUGs want to have more timber trees in their

stand to generate income for their community fund. Therefore, most of the CFUGs are successfully promoting timber trees in their forest and they create good environments to grow these trees during forestry operations of the CFUGs (Figure 8A-F), although selling timber was not in practice in my study sites. However, they are doing forestry activities to the benefits of future generations because forestry is long term business and existing forest law of Nepal has given perpetually inherited property right to the local users (HMG/N 1993).

However, the study reported comparatively more fire wood than timber trees in the NP in GMF and Ratmate. In the NP, it may just reflect the natural pattern in a more undisturbed forest. This difference in the proportion between timber and firewood species in the other CFs is probably caused by more cutting of firewood species in the *Jhadisudhar* activities (management) and a limited extraction of timber species. Similarly, in the GMF the larger sized timber trees have all been cut, and have also high numbers of small sized timber trees. This is due to high regeneration capacity of the timber tree species and that people did not extract them from the forest due to their small sizes. However, in Ratmate danda CF it seems that the present management is selectively favouring the timber trees, but there was no large timber trees or regeneration present in whole forest stand, thus people maintain some firewood species to avoid a totally open forest. This differed from the management in the other CFs, where small areas with no desirable regeneration were cleared, creating a more open forest. Even if Ratmate danda CF manage their forest for timber trees it may take time before timber trees are more dominating, as they only have managed it for 10 years and the larger trees of the forest had been logged when they took over management. In GMF, timber trees are only in regeneration stages because of over exploitation of it. It could be possible to restock it if conservation measures (allowing no human impact for a certain time) will be applied.

CFUG will conserve endangered and rare tree species if they can see the direct economic benefits from that particular species. The study found that GMF and Kharpa CF have *Michelia kisopa* except NP*,* the species is banned by forest laws of Nepal for commercial harvesting from each and every forest. This species is one of the non-endemic trees, which is regarded as threatened in Nepal (Shrestha & Joshi 1996). However, local people are not aware about the conservation status of the tree; they are conserving this as it has a high economical value. However, there is a chance of loosing such tree species if awareness and management programmes for conservation are not implemented in the area.

Current forest management practices

Forest management can restore, maintain, or reduce biological diversity depending on how it is operated (Groombridge & Jenkins 2002; Schelhas & Greenberg 1996; Putz & Blate 2001). The study found that certain management regimes such as thinning, selective cutting compared to non-management generates changing tree species diversity. The management system of GMF in the mid-hills is not functioning and is in no control situation, which leads to deforestation and species loss. On the other hand, community forestry is taken as successful forestry practice to restore the forest coverage, species richness and reduce soil erosion in Nepal (Gilmour et al. 2004; Pokhrel et al. 2005). However, this study found that the CF practices partly seem to increase tree species diversity, although there are differences within and between a CF. However, they could increase tree species diversity by doing careful forestry activities allowing many tree species in the entire forest (Mikkola 2002 cited by Acharya 2003). Currently the local people have been practicing forestry activities on their own local knowledge which may not always be favourable to tree diversity (Ojha 2002). The study found that the CFUGs are managing their forest for timber species, not for a high species number as such, although the broad range of species used give a comparatively diverse forest in this management system. Now most of CFs is promoting different timber trees not only one or two species which can follow the increasing trend of tree species as a multiple products active forest management as mentioned (Mikkola 2002 cited by Acharya 2003; Kartasubrata & Wiersum 1995). But if their goal is changed to limited species selection it may reduce biodiversity. It could be more effective to incorporate knowledge of the scientific and biodiversity friendly forestry operation such as creating proper gaps during forestry activities as per need of the flora and fauna of the forest, giving space for all trees, giving emphasis to rare trees, proper harvesting mechanism, maintaining a certain percentage of the larger and old trees in the forest. However, such forestry practices may not give immediate benefits to the people today, and all community based biodiversity conservation activities are always linked with livelihood options of the local people in the areas (Pandey & Gurung 2003). Alternative income sources, economic values of the all tree species has to be searched for its conservation along with considering the interests of local people. Similarly, technical input to the local communities about forestry operations, raising awareness on importance and measures of biodiversity conservation could be effective.

Conclusions and recommendations

Conclusions

Tree species diversity depends on the forestry activities along with natural variation. Proper management intervention is important to maintain tree species diversity. GMF in the mid-hills has high illegal extraction of forest products and finally has reduced tree diversity.

Some of the community forests are more diverse regarding to tree species than NP and GMF but CFUGs are conducting forestry operations differently, and some are operating forestry activities only to the boarder side of the forest which is contributing to create different diversity than inner zone. Current CF management is motivated by economic benefits and they are promoting the tree species which mainly are useful for timber. However, community forestry can play an important role to conserve tree species diversity, and probably also other biodiversity and unique ecosystems in mid hills. Current community forestry practices reflect the gaps of some technical skills of forestry operations, knowledge of biodiversity and its importance to the CFUGs.

Recommendations

As a result of this study, it is possible to forward some recommendations to the government and non government organization of Nepal and also to the international communities who are involving in forestry and conservation programmes.

- The government of Nepal should focus community forestry approach to protect the remaining forest areas of mid-hills from further degradation;
- Proper guidelines should be made to keep and/or remove the trees to maintain tree species diversity in community forestry;
- Awareness raising programs about benefits of the tree diversity at the CFUG level should be implemented to maintain diversity in community forestry.
- CFUG are motivated to manage timber trees which are connected to economic benefits, therefore, alternative options of economic benefits should be searched by using non timber trees which can motivate CFUG to conserve non timber trees as well.

Acknowledgements

First of all I would like to express my sincere gratitude and deep respect to my research supervisor Karin Gerhardt, Swedish Biodiversity centre, Sweden for her valuable guidance, suggestions and encouragements. I am indebted to Prabhu Budhathoki, IUCN Nepal and Professor Tej B. S. Mahat for their encouragement and support not only this study but more to encourage me to develop myself in the conservation field in Nepal.

I am grateful to all CBM staff for their support and cooperation. Especially, Malin Almstedt, director of the study, for her support and guidance on social part of the study, Torbjorn Ebenhard and Ake Berg for their suggestion on ecological part of the study. I want to acknowledge Charlotta Warmark, her cooperation and support was praiseworthy during the whole course period.

Many thanks to the CFUG members and executive committee members specially, Aliba Lama, Netra lama, Renu Kumari Tamang, Rudra Bahadur Kuwar, Ram Bahadur Lama, Shyam Lama for their support during field studies. I am also grateful to the CFUG member of the five CFs for their trust to me and valuable information.

I am grateful to government staffs who were working in Shivapuri national park, especially in the Manitud, Kakani and Sundarijal post. Similarly, I am grateful to the department of forest staff especially, Balaram Kandel, Subhash Sharma, N. Chaudhari for their support and information about community forests. I would like to express my gratitude to Narayan Kaji Shrestha, WATCH for his encouragement. Similarly, I would like to acknowledge Mr Bhabani Prasad Kharel, IUCN Nepal, Bhola Khatiwada, COFSUN Nepal, Chudamani Joshi, department of botany, Ram Bahadur Lo FECOFUN, Kathmandu district chapter for his commendable supports.

Last but not least, I would like to appreciate the contribution and encouragement of my parents, brothers, sisters and whole members of the family which was praiseworthy for my whole academic career.

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Appendix 1. Forest Inventory Sheet

Forest Name and add:

Date: Crew Name:

Plot no (Mark: R-reg, M-Middle class and H for harvestable)	Tree Name	DBH Size			Remks(core/boarder)
		Reg. -less than 5cm and more than 1 yr Adv. Reg. -5 to 9.9cm	Middle class 10cm-29.9cm	Harvestable 30 cm and above	

Appendix 2. Check List for group discussion

A. History of the Forest Management and species composition

Time line by using format

Time	Event related to forest management	Impacts

B. Present forestry practices

Which species do you use for timber, fodder, fire wood?
Which specific size do you cut?
Why do you choose that specific tree to harvest?
Why do you choose that size?
Why do you choose that specific tree during operation?
What is the objective of forest management?
Is it necessary to conserve all tree species?
Is it good to conserve useful tree species only?
Which tree species would you want to conserve ?
How do you decide to remove /keep some species?
Who use to do such kind of decision?

Appendix 3. Forest management history of the study areas

Date	Events	Impacts
Before 1950	▪ Rana regime, Verbal Laws ▪ Forest was under the control of elites in the name of Mukhiya, Jimuwal and Dittha	▪ Forest condition was good but illegal harvesting was increasing ▪ Local forest dependent people were cutting forest illegally in haphazard ways to fulfil their needs ▪ Gradual increasing population and increased pressure to the surrounding forests
In 1950	Democracy and changed the ruling system(Rana to multiparty system)	Started to develop written rules and regulations
During 1957	▪ Private forest nationalization act 1957, ▪ Nationalized all forest which was under the control of limited people during Rana regime.	▪ Government staff and infrastructure was not sufficient to manage all these forest and increase encroachment and local people started to harvest forest products illegally and haphazardly ▪ Started to see the shortage of forest products and stated to go neighbouring areas for forest products
During 1977	▪ Fire wood supply to Kathmandu and increased illegal cutting ▪ Government helped to form forest protection committee at local level ▪ Conservation program was initiated in Shivapuri areas	▪ Forest was almost gone ▪ Difficult to get firewood for cooking ▪ Started patrolling forest and reduced deforestation

During 1984	▪ Declared Shivapuri watershed conservation area (1976); and Shivapuri watershed and wildlife reserve(1984) ▪ Started conservation programmes in surrounding of the conservation areas	▪ Still difficult to overcome deforestation and kept continue deforestation due to low awareness level and lack of proper rules of the country ▪ Local people initiated forest conservation in Lapsaura danda and Ratmate danda
After 1988	Formation of the Master Plan for forestry sector 1988, Forest Act 1993 and Regulation 1995	Emphasized the participatory approach in forestry and provisioned to give government managed forests to local people for management
1995	▪ Started to implement Community Forestry, according to existing forest laws in the mid-hills including study areas ▪ Started to protect, develop and use forest by local people according to national and their own local laws	▪ Local people took ownership of the forest management and started to manage it independently ▪ Increased social cohesion ▪ Improved forest conditions ▪ Controlled illegal harvesting and systematic harvesting mechanism
After 2002	▪ Declared Shivapuri as NP	Staffing is changed but there is no specific impacts afterwards
After 2004	▪ Government brought a policy 2003 with provision of handing over the protected areas to capable non governmental organization. ▪ NTNC, a non government organization, has drafted Shivapuri management plan as proposal plan to takeover the park management but it is not approved yet.	

Appendix 4. Relative abundance of the different tree species in forests

S.N	Local name	Scientific name	Use	% in NP	%Rat	%Kuma	%Kha	%Bos	%Lap	%Gov
1.	Angeri	Lyonia Ovalifolia	Firewood,	14.87	8.52	1.05	8.80	5.79	5.79	11.18
2.	Gurans	Rhododendron arborium	Firewood,	12.46	10.00	3.14	9.53	2.47	2.47	20.03
3.	Chilaune	Schima wallichii	Timber, Firewood	6.68	6.01	19.97	22.47	15.70	15.70	12.19
4.	Kali Kath	Myrsine semiserrata	Firewood,	5.31	7.49	9.10	2.19	8.24	8.24	8.80
5.	Dhale Katus	Castanopsis indica	Firewood,Timber	4.10	6.50	20.91	4.76	3.35	3.35	3.30
6.	Patle Katus	Castanopsis histrix	Firewood, Timber	11.01	0.13	1.18	3.30	18.12	18.12	6.69
7.	Hinguwa	Camellia kissi	Firewood	6.33	4.18	2.98	0.00	3.30	3.30	1.14
8.	Jhingane	Eurya acuminata	Firewood, Fodder	4.61	4.95	0.00	7.55	5.88	5.88	3.30
9.	Bhalayo	Rhus wallichii	Firewood but not often	4.50	0.16	0.00	0.00	8.02	8.02	0.00
10.	Kaphal	Myrica esculenta	Timber, Firewood	3.08	7.78	0.00	3.39	1.54	1.54	0.00

11.	Jure Kaphal	Eriobotyra dubia	Timber, Firewood	2.74	0.80	0.00	2.27	6.78	6.78	5.55
12.	Kholme	Symplocos pyrifolia	Firewood	2.74	0.90	0.00	0.00	0.00	0.00	2.20
13.	Seti Kath	Myrsine capitellata	Firewood	2.71	6.72	3.99	4.70	0.00	0.00	0.00
14.	Paiyo	Prunus cerasoides	Firewood, Fodder	2.67	4.05	2.09	4.33	0.00	0.00	0.00
15.	Banj	Quercus leucotrichophora	Firewood, Fodder	2.09	0.00	0.00	7.60	2.36	2.36	4.40
16.	Khasru	Quercus semicarpifolia	Firewood, fodder	2.00	3.44	3.02	7.08	0.00	0.00	2.20
17.	Bakalpate	Viburnum cotinifolium	Firewood	1.83	9.07	0.97	0.00	0.00	0.00	1.10
18.	Hakulal	Symplocos sumunta	Firewood	1.76	0.00	0.00	0.00	1.23	1.23	0.00
19.	Kanda	Rosa brunonii	Firewood	1.76	0.00	0.00	0.00	0.00	0.00	0.00
20.	Kharane	Symplocos ramosissima	Firewood	1.76	0.00	0.00	0.00	0.00	0.00	0.00
21.	Mayal	Sorbus cuspidata	Possible for grafting with apple shoot but now not in use	1.76	3.38	0.00	0.00	0.00	0.00	1.23
22.	Sulsing	NA	Firewood,	1.20	0.13	0.00	0.00	3.30	3.30	0.00
23.	Utis	Ulnus nepalensis	Firewood, Timber	0.93	0.00	1.94	0.00	0.00	0.00	0.00
24.	Syungan	NA	Firewood	0.88	3.25	0.00	0.00	0.00	0.00	0.00
25.	Puwale	Ilex excelsa	Firewood, Fodder	0.11	0.00	1.01	0.00	0.00	0.00	0.00

26.	Tikhru	NA	Firewood	0.05	1.67	0.00	0.00	0.00	0.00	0.00
27.	Champ	Michelia kisopa	Timber, Firewood	0.04	0.00	0.00	1.24	0.00	0.00	2.20
28.	Khrumasing	NA	Firewood,	0.04	0.80	0.00	0.00	0.00	0.00	0.00
29.	Anka Taruwa	Trichilia cannaroides	Firewood	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30.	Arkhaule	Lithocarpus fenestrata	Firewood, Fodder	0.00	0.80	0.00	3.48	0.00	0.00	3.30
31.	Banset	Quercus lamellosa	Firewood, Fodder	0.00	0.00	0.19	0.00	0.00	0.00	0.00
32.	Chinya	NA	Firewood,	0.00	0.00	1.94	0.00	0.00	0.00	0.00
33.	Dudhilo	Ficus neriifolia	Firewood,Fodder	0.00	0.03	0.00	0.00	0.00	0.00	0.00
34.	Hadbed	NA	Firewood	0.00	0.00	0.00	0.00	2.20	2.20	0.00
35.	Hatti paile	NA	Firewood	0.00	0.00	1.01	0.00	0.00	0.00	0.00
36.	Kabro	Ficus lacor	Fodder	0.00	0.93	0.00	0.00	0.00	0.00	0.00
37.	Kanike	Ligustrum indicum	Firewood	0.00	0.90	1.22	0.00	0.00	0.00	0.00
38.	Kaulo	Persea duthiei	Firewood, Fodder	0.00	1.32	4.45	0.00	0.13	0.13	2.20
39.	Lankuri	Fraxinus floribunda	Firewood, Fodder	0.00	0.80	0.00	0.00	1.23	1.23	0.00

40.	Lapsi	Chorieospondis axilaries	Fruits, Timber, Firewood	0.00	0.00	0.02	0.00	0.18	0.18	0.00
41.	Mahuwa	Engelhardtia spicata	Firewood	0.00	0.00	0.00	0.00	2.29	2.29	0.00
42.	Mayalu	NA	Firewood,	0.00	0.00	0.12	0.00	0.00	0.00	0.00
43.	Musure Katus	Castanopsis tribuloides	Timber, Firewood, Fodder	0.00	4.21	8.48	4.74	0.00	0.00	2.20
44.	Pahele	NA	Firewood	0.00	0.00	0.04	0.00	0.00	0.00	0.00
45.	Phalant	Quercus glauca	Timber, Firewood	0.00	1.03	4.22	2.55	5.68	5.68	1.10
46.	Phirphire	Acer oblongum	Firewood,	0.00	0.00	6.97	0.00	0.00	0.00	2.20
47.	Rakchan	Daphniphyllum himalense	Firewood,	0.00	0.00	0.00	0.00	0.00	0.00	0.00
48.	Sanchothanbo	NA	Firewood	0.00	0.00	0.00	0.00	0.00	0.00	3.48
49.	Siris	Albizia chinensis	Firewood	0.00	0.00	0.00	0.00	2.20	2.20	0.00