1. INTRODUCTION

1.1 General Background

The galaxy of fungi and their importance occupy prime place in the biological world, and Nepal has been a cradle for such fungi due to its four broad phytogeographical provinces. The organisms commonly known as fungi (sing. fungus) are a tremendously diverse group ranging from microscopic forms to easily seen macro form. They are found virtually in all habitats and are commonly referred to as mushrooms, morels, truffles, molds, mildews, yeasts, earthstars, stinkhorns, rusts, smut and bracket or shelf-fungi etc. Fungi are a major component of biodiversity, essential for the survival of other organisms and are crucial in global ecological processes (Hawksworth 1991). Contributing to the nutrient cycle and maintenance of ecosystem fungi plays an important role in soil formation, fertility, structure and improvement (Hao-quin *et al.* 2008).

According to the size fungi have been categorized into macro and micro fungi. Macro fungi have a visible structure to the unaided eye and produce spores, such as a mushrooms or truffle (Boa 2004). Two main groups which contain macro fungi are the Ascomycotina and Basidiomycotina. Most of the Ascomycotina are macroscopic species which contains cup-fungi, morels and truffles. The Basidiomycotina is a small group mostly comprises toadstools, bracket fungi and puff balls.

Mushrooms are the fruiting bodies of macro-fungi which include both edible and poisonous species. However 'Mushroom' is used for the edible members of macro-fungi and 'Toadstool' for the poisonous ones. In a broad sense 'Mushroom is a macro-fungus with a distinctive fruiting body, which can either be epigeous or hypogeous and large enough to be seen with naked eye' (Chang & Miles 1992).

The structure that we call a mushroom in reality is only the fruiting body of the fungus. Surveys of this fruiting body does not adequately reflect the below ground Ecotomycorhizal fungal diversity because some species lack carpophores or have a sporulating strategy that is disproportional to their underground abundance (Gardes & Bruns 1996, Horton & Bruns 2001). Despite this limitation, fruiting body surveys are considered the primary basis for documenting

fungal diversity in a stand (Smith *et al.* 2002) since they can be easily identified at the species level (Richard *et al.* 2004).

1.2 Diversity

Defining the population of fungi globally has in recent times remained a challenge to mycologist all over the world (Wood 1992). Only a fraction of total fungal wealth has been subjected to scientific scrutiny and mycologist continue to unravel the unexplored and hidden wealth (Swapna *et al*. 2008). The number of fungal species has been estimated up to 13.5 million (Adl 2007, Kirk *et al*. 2008), however the currently accepted working figure is 1.5 million species (Hawksworth 2001). It is estimated that at the current rate of species description it will take 1170 years to complete the global fungi inventory. The total number of mushrooms forming species have been estimated in between 53,000 and 110,000 which suggest that only 18% to 38% of the total mushrooms have been documented (Mueller 2007).

In Nepal**,** the complex phytogeographic factors have played an important role in growth distribution and diversity of fungi. All these conditions in turn have made the country a natural house for mycodiversity (Adhikari 2000a). The collection and systematic study of macro fungi including mushrooms in Nepal have been started since the contribution of Llyod (1808) and Berkely (1838). Then the investigation, exploration and collection of macro fungi continued since the period of J. D. Hooker (1848-1854) from which M. J. Berkeley (1954) described 44 species of higher fungi. Since then many authors have contributed their knowledge on Nepalese Mycoflora.

Adhikari (2000a, 2007, 2009), Adhikari & Devkota (2007), and Manandhar & Adhikari (2009) are the major literatures concerned with the macro-mycoflora which gives the detailed reference on the fungi from Nepal. The book 'Mushrooms of Nepal' (Adhikari 2000a) includes all the macro fungi found from tropical to alpine regions of Nepal; a total of 776 species belonging to 213 genera and 77 families have been described. New description after 2000 has increased the total number of mushroom to 812 species (Adhikari 2009). Among them at least 228 species

have been used as food by people (Christensen *et al*. 2008), 73 species are medicinal and 65 species poisonous (Adhikari 2009).

1.3 Ecological Importance of Macro Fungi

Macro fungi play a principle role in recycling nutrients and influence plant community composition through symbiotic relationship (Dighton 2003). There have been a few studies on community ecology (Packham *et al.* 2002) and relationship of macro fungi with environmental variables (Zamora & Cecilia 1995).

Fungal diversity is a crucial component of biodiversity (Dix &Webster 1995). They are an exceptionally diverse group central to the functioning of ecosystem (Newbound 2009). They are the vital contributors of terrestrial ecosystems because of their involvement in nutrient cycling (Jordan 1985, Lodge 1992), and are the principal decomposers of dead organic matter, such as dead wood and litter (Harmon *et al.* 1986). Secondly, most of the tree species depend on mycorrhizal symbiosis with fungal species (Smith & Read 1997). Macro fungi have been shown to have a significant ecological function in the establishment and dynamic succession of plant communities, nutrient cycling and the protection of forest ecosystems, and are likely to be crucial to sustainable development, ecological construction and stability (Schmit 2005, Dighton *et al.* 2005, Lee *et al*. 2009). Parasitic, Saprophytic and Mycorrhizal fungi are high value forest resources (Wang & Hall 2004).

1.3.1 Mycorrhizal Fungi

Mycorrhizal symbiosis is a state of mutualistic association whereby the plant host and mycorrhizal fungus co-exists in a physiologically, ecologically and reproductively active state for long periods of time (Harley 1989). German mycologist, Frank (1885) was the first to find the mycelia of species forming mantles of fine hairs on the roots of their host and called it mycorrhizae (Krieger 1967). Most land plants forms association with mycorrhizal fungi (Dell 2002). These associations are found to be predominant in most of the natural terrestrial ecosystem (Brundrett 1991). Mycorrhizae increase the absorption capacity of the root system of the plant and help it to survive against disease; in return the non-photosynthetic fungus receives

translocated organic carbon as photosynthates (Smith & Read 2008). Mycorrhizal associations are regulated by features of the host plant and mycorrhizal fungus as well as by soil conditions and environmental factors (Mosse & Hayman 1980, Harley & Smith 1983). Many experiments have shown that mycorrhizal fungi can overcome nutrient limitations to plant growth by enhancing nutrient acquisitions, especially phosphorous (Clark & Zeto 2000).

An important ecological role of mycorrhizal fungi is the direct supply of mineral nutrients to their symbiotic plant through common mycelia network (Smard & Durall 2004, Nara 2006). In general, the presence and diversity of mycorrhizae can mediate the composition of plant communities and improve nutrient exploitation and overall plant productivity (Heijden *et al.* 1998).

1.3.2 Saprophytic Fungi

Saprophytic fungi are usually basidiomycetes and are capable of degrading lignin, the phenolic compound protecting the cell wall of the plant (Cairney & Meharag 2002). The decomposed materials may be used as energy or may be available for plant through absorption (Dighton 2003).These fungi are one of the most active decomposers of forest litter and therefore play an important role in the cycling of carbon, nitrogen and other soil nutrients (Smith & Read 2008). Different microhabitats and substrate could influence the diversity of decomposing fungi (Lodge & Cantrell 1995). Saprophytes are expected to be more dependent on their substrate (Gebaur & Taylor 1999). Saprophytic fungi play an important role in decomposition because they can attack the lignocellulose matters in litter that other organisms are not able to assimilate (Dix & Webster 1995, Adl 2003). Plant litter decomposition is a key process in nutrient recycling and humus formation in forest ecosystems (Berg 2000, Berg & McClaugherty 2003, Prescott 2005).

1.4 Ecological Factors and Macro Fungal Diversity

Ecologists have recently increased their efforts to understand below ground biological interactions. Interaction that occurs among plant roots, animals and micro-organisms are dynamic and substantially influence ecosystem processes (Hoff *et al*. 2004). They have just begun to study the biota contributing to these interactions (Copely 2000). Among the below

ground biota fungi are diverse and play wide role in forest ecosystem processes (Rossman *et al.* 1998).

Factors driving macro fungal diversity is unclear; climatic conditions such as rainfall, air, soil, temperatures, evapo-transpiration, relative humidity, and water deficits or excesses are generally regarded as major factors affecting macro fungal fructification (Brunner *et al.* 1992). Geomorphologic features as slope, aspect and altitude as well seems to influence the macro fungal communities (Yang *et al*. 2006). Only after the shower in rainy season and at the temperature between 15 to 25ºC favors the growth of different fungi in the sub-tropical and temperate belts (Adhikari 2000). Different species exhibit different fruiting phenologies varying from year to year and at different altitude & latitudes, maximum richness occurs only during brief periods and differs among years. Within a geographical region fruiting is influenced by elevation, latitude and their effect on temperature and precipitation (Ohenoja 1988). Increasing nitrate and ammonium inputs in forest ecosystems have been shown to reduce the ectomycorrhizal mycelium growth in the soil (Nilsson & Wallander 2003) and to decrease the species diversity and production of fruiting body by ectomycorrhizal species, whereas saprophytic species are much less affected (Peter *et al.* 2001, Trudell & Edmonds 2004).

Plant species composition also influence the number and species of macro fungi present because plants constitute the habitat and energy source for most fungi and all fungi show some degree of host or substratum specificity. Trees are crucial for forest fungi, especially for mycorrhizal species as they depend on photosynthetically fixed carbon produced by their associated host trees to extend their vegetative mycelium in the soil and to form mycorrhizas as well as fruit bodies for sexual reproduction. Forest management tools (clearings, pruning, species selection, fire, fertilization) can also play a crucial role in shaping macro fungal communities since they can modify vegetation parameters like tree density, canopy cover, primary productivity, basal area, understory plant communities, soil conditions (Wiensczyk *et al*. 2002). Also, defoliation experiments indicate that the number of fruit bodies of ectomycorrhizal fungi decreases to as much as one third on defoliated trees compared with those on control trees (Kuikka *et al.* 2003). Mycorrhizal communities seem to be strongly shaped by forest composition, structure, age and soil nutrients due to their close relation with trees (Richard *et al.* 2004). Saprophytic fungi seem

to be more associated to the substrate and shows preference for a specific tree or shrub litter (Roberts *et al.* 2004).

1.5 Justification

Researches relating to the ecology of macro fungi, its role in the environment and the forest have been studied across the world. Many appreciable works related to the diversity and the conservation strategy has been well documented. But in Nepal, fungal ecology is relatively a less explored area of mycological research. Although mycological research in Nepal began since the period of Llyod (1808), most of them have been limited to documentation of the species (Adhikari 1991, Adhikari 1995, Adhikari 2000b). Only a few research works have been done relating to ecology and the effect of various environmental factors on the diversity of macro (e.g. Christensen *et al*. 2009). The present study is an attempt to understand the impact of the duration of forest management and the stand characteristics of hill *Shorea robusta* forest on macro fungi species richness. Together with similar information related to other life forms, the results of the present study can be helpful to access the impact of community forestry on biodiversity of the forests.

1.6 Hypothesis

• Species richness of macro fungi in forests increases with the duration of community management.

1.7 Objectives

- To document the macro fungi present in *Shorea robusta* forests of mid hills.
- To determine the variation of macro fungi species richness with environmental factors in *Shorea robusta* forest.
- To determine impact of duration of forest management by community on macro fungal species richness.

1.8 Limitations

Followings are the important limitations of the present study:

- Given the seasonal nature of mushroom growth, sampling in a single month could not represent the entire macro fungal community of the forest.
- Some of the specimens could not have been identified.

2. STUDY AREA

2.1 Geographical Location

The study area is situated in Dhading, a hilly district of Bagmati Zone, Central Nepal, having an area of 1925 sq km. It lies between 27°40' and 27°17'N latitude and 84°35' and 85°17'E longitude with great topographic variation from 300 (Jogimara) to 7110 m asl (Mt. Pawil) (DFO Dhading, 2009). Its unique geographic terrain is bounded by Kathmandu, Nuwakot and Rasuwa in the east, Gorkha in the west, Nuwakot district and China in the North and in the south is the Chitwan and Makawanpur. The district headquarter is Dhading Besi.

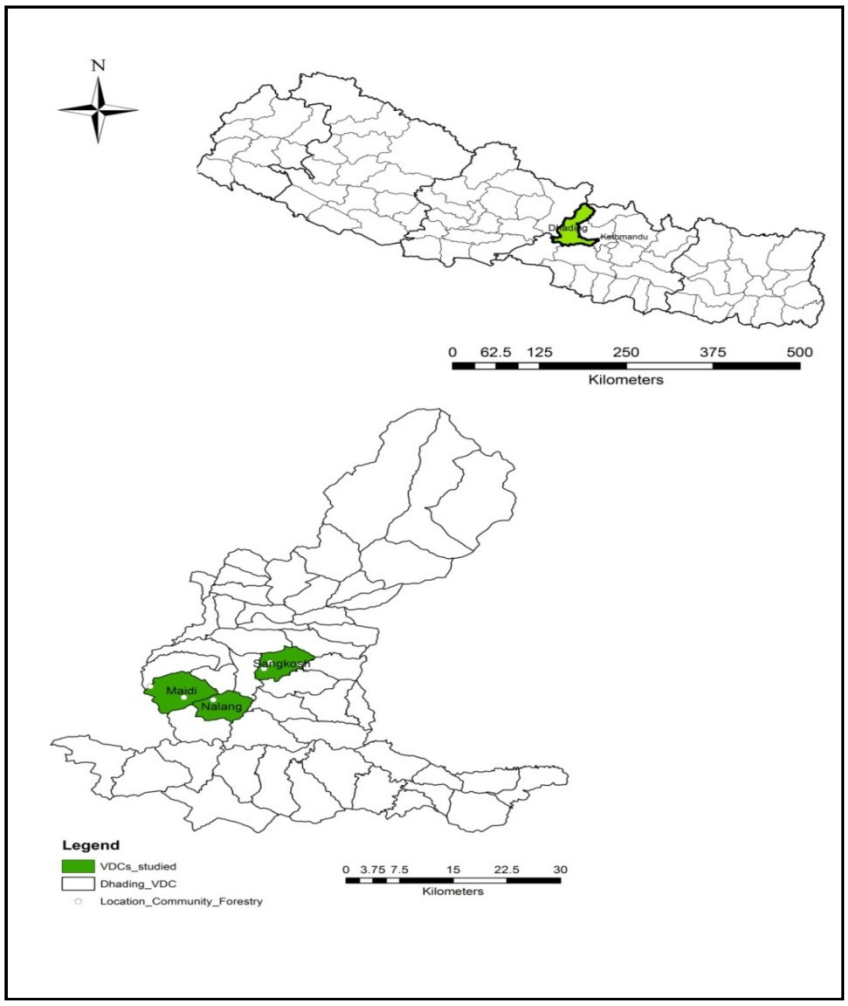

Figure 1: Location map of study area, showing position of Dhading district in Nepal,VDCs in District and studied forest in VDCs.

2.2 Climate

Due to topographic variation, the climate of the district range from tropical on the southern part to alpine and nival on the northern part. According to the record of nearest weather station (Dhuni Besi, 1085 m asl), the present study area receives 1569mm of annual rainfall with maximum monthly rainfall during July (Figure 2). The monthly mean temperature is maximum in June (31.54° C) and minimum in January (8.15° C)

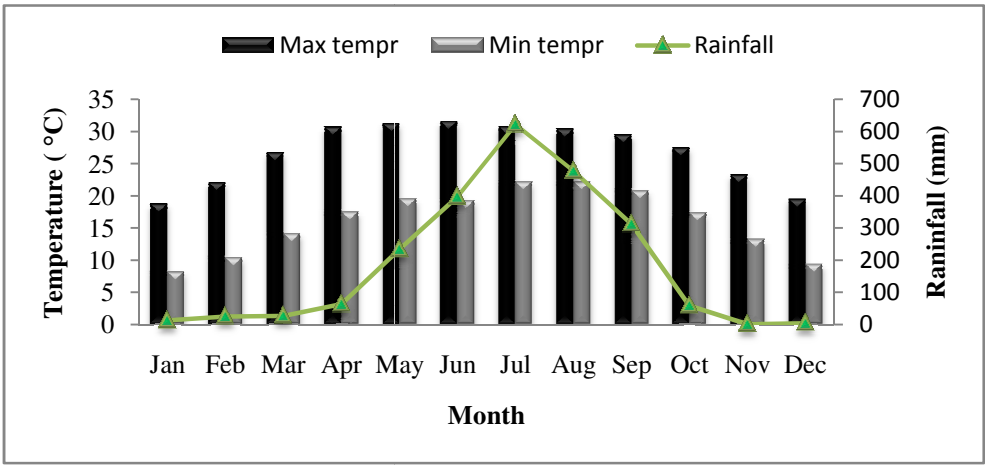

Fig 2: Monthly mean temperature and total rainfall recorded at Dhunibesi weather station.The values are mean of ten years from 2000 to 2009. Source: Department of Hydrology and Meteorology, Government of Nepal.

2.3 Study Forests

Dhading district has 602 community forest user groups (CFUGs) managing 25481.1 ha community forest (DFO Dhading 2009). The study was carried out in six hill sal (*Shorea robusta*) forests of Dhading district which has been managed by the community for 4-29 years (Table 1) [Details of the selection procedure has been described under Materials and Method section]. The other associated tree species of this forest are *Schima wallichiana, Lagerstroemia parviflora, Cleistocalyx operculatus,* etc. The six community forests (CFs) have been categorised into two groups based on management duration: short management, i.e. CFs managed by community for less than 10 years, and long management, i.e. CFs managed for more than 10 years (Table 1).

Table 1: Community forests (CF) selected for study

S.N	Name of CF	Area (hector)	No. of Plots *	Elevation (m asl)	Name of VDC	Management duration (years)	Category based on management duration
1.	Sikhrepakha	10.1	12	511	Maidi-9	6	CF<10 years managed
2.	Kirakhore	6.2	7	906	Sankosh-1	6	
3.	Bossikharka	12.5	13	993	Sankosh-5	4	
4.	Dhondre	30.6	5	896	Sankosh-8	11	CF>10 years managed
5.	Jungepakha	8.54	6	842	Nalang-1	22	
6.	Ratamata	18.2	8	787	Maidi-5	29	

*Size of each quadrat= 10m×10m

3. MATERIALS AND METHODS

3.1 Selection of Community Forests

The study has completely focused on the community managed sal (*Shorea robusta*) forest within the Neelkantha Range Post of the District Forest Office which supervises 181 CFs. From the 181 CFs, 30 CFs were randomly chosen by lucky draw method. In the preliminary study done during May 30 to June 13 the actual management duration of these 30 CFs were noted from the interaction with members of the individual CFUG. Forests dominated by species other than sal, and the plantation forests were excluded from the list. Then CFs were divided into two categories: CFs managed for less than 10 years, and those managed for > 10 years. From each category, three forests were selected randomly for sampling. On the basis of the forest area the number of plots to be sampled was determined so as to represent 0.12-0.5% of the forest area. The total of 32 plots was sampled in short duration managed forest and 19 plots in long duration managed forest. Altogether a total of 51 plots were sampled in the six CFs.

3.2 Sampling Process

Field sampling was done during August 4 to August 23, 2010. In each of the forest 5- 13 quadrat of size 10 m × 10 m were located by stratified random sampling method. In each quadrat, all species of macro fungi were collected and photographed. The collection of macro fungi in these studies was entirely based on their sexual reproductive structures, visible to the naked eye above ground. Along with it the vascular plant species have also been recorded from the same plot area.

The altitude, latitude and longitude of each quadrat were obtained from Global Positioning System (GPS) and slope was measured using clinometers. Litter cover (%) and canopy coverage (%) were estimated visually from the centre of each quadrat.

3.2.1 Collection

Digital camera was used for photography of the sporocarp in their natural habitat. Sharp knife was used for collecting sporocarps from soil with a great care to avoid damage to the base of the stipe and to reveal any volva or buried substrata that may include fruits or other fungi. Forceps with the help of hand lens was used for the collection of very small sporocarps. Collected sporocarp specimens were kept in individual paper bag to avoid the mixing of spores. Soil was

removed using a soft brush. The collected sporocarps were examined for the morphological characters like colour, size, shape, odour and texture. Accurate and consistent notation of sporocarps colour, including colour changes of mature sporocarps and colours of different development stages, presence or absence of texture, lamellae that are important for describing macrofungi were noted (Annex 1). Field labels were tagged to the specimens with the collection data which includes scientific name of the fungus, date, location, habitat, a brief note on distinguishing macroscopic features, collection number, microhabitat and the collectors code (SB/BBS) having a unique identity.

3.2.2 Preservation

As soon as they were brought to the resident in the field, the samples were dried; Sun-drying was suitable for drying mushrooms but it was always not possible. So, most of the samples were dried with the help of mushroom drier and in the hearth of the fire. After well drying the samples were packed in paper bag with some Naphthalene bulbs. The collected samples were kept in the wax paper bag along with their collection number.

3.3 Spore Print

Spore print is one of the most important identifying characters of macro fungi. For taking spore print, stipe of the fruiting body was cut and the cap was set on piece of paper turning the gills downwards. Black paper was used for the species having white spore and white paper was used for the species having black spore. To minimize drying out of tissues a drop of water was mounted on the cap and then incubated for some time (2-12 hours) on a container. Finally the cap was removed carefully and the color of the spore was noted.

3.4 Identification

The specimens were brought to the laboratory for the microscopic studies and identification. A very fine section passing through the epicuts to hymenial surface was taken with the help of razor blade. The section was covered with microscopic cover slip and gently tapped and observed under 15×40 magnification and compared with that of reference books like Fries 1938,

Thind 1961, Corner 1970, Bakshi 1971, Dickinson & Lucas 1979, Kibby 1979, Phillips 1981, Pacioni 1985, Imazeki *et al*. 1988, Kumar *et al.* 1990 and Adhikari 2000 for the exact identification of the collected samples. The voucher specimens were deposited in the Plant Pathology unit of Central Department of Botany.

3.5 Soil Sampling and Analysis

About 100 gm of soil was collected from the four corners of each quadrat from the depth of 15 cm, and mixed together thoroughly. From the mixture, 100 g soil was collected in plastic bag. The samples were air dried while in the field and the drying was continued for one week after returning back to the laboratory. Walkley Black method was used for determining the organic carbon present in the soil where oxidation of organic carbon in an acid dichromate solution followed by titration of the remaining dichromate with ferrous ammonium sulphate was done (Zobel *et al.* 1987).

3.6 Data Analysis

3.6.1 Species Richness and Trophic Group

The number of macro fungal species encountered in each quadrat (100 m^2) was considered as 'species richness' in this study. Each fungal taxa were included in one of the three main trophic groups: saprophytic, mycorrhiza and parasitic. Some taxa which could be included in more than one trophic category were included in the most likely group depending on their ecological and environmental conditions (http://www.indexfungorum.org/names/names.asp).

3.6.2 Frequency

Frequency gives the percentage of sampling units in which the species occurs. It was calculated using the following formula given by Zobel *et al.* (1987).

$$\text{Frequency (F)} = \frac{\text{No. of quadrats in which the species occurred} \times 100}{\text{Total no. of quadrats sampled}}$$

For calculating frequency, data of three CFs of each category (i.e. short and long duration managed) were pooled, and the value of frequency of individual species was calculated for each category, rather than individual forests.

3.6.3 Jaccard's Similarity Index

The similarity index is used to determine the degree of similarity in species composition of macro fungi between two categories of forests. Higher the index value more similar will be the forests to each other. Following formula are used for calculating Jaccard's Similarity Index,

Jaccard's Similarity Index (ISj)= $\frac{C}{A+B-C} \times 100$

Where, ISj= Index of Similarity

A= Total number of macro fungal species in forests managed for <10 years

B= Total number of macro fungal species in forests managed for >10 years

C= Number of species which occur in both forest categories

The similarity index ranges from 0% to 100% indicating no similarity to complete similarity.

3.6.4 Relative Radiation Index (RRI)

From the values of aspect (Ω), slope (β) and latitude (ϕ), RRI was calculated following the formula given by Oke (1987):

RRI = {Cos (180° -Ω). Sinβ. Sin ϕ} + Cos β.Cos ϕ

3.6.5 Statistical Analysis

Mean comparison for species richness of macro fungi between two categories of forest was done by using independent sample t-test. The χ^2 test was used to test if there is any relation between management duration of the forests and species composition based on trophic groups (mycorrhizal vs. saprophytic fungi). Only a few species were parasitic, therefore this trophic group was excluded from the analysis. To estimate the effect of different ecological factors like canopy, litter, RRI and organic carbon on the species richness of macro fungi, regression analysis was done. In regression, species richness was considered as response variable and other environmental factors as predictor variables. The software used in this study for statistical analysis is Statistical Package for Social Science (SPSS) version 11.0.

4. RESULTS

4.1 Macro Fungal Diversity

Altogether 88 species of macro fungi belonging to 35 families were encountered in the three sal forests which were managed for less than 10 years period. The largest family recorded from each of the forest categories is Polyporaceae followed by Clavariaceae. Among them, 27 species were mycorrhizal, 50 saprophytic and 3 parasitic; 8 species of recorded fungi could not have been identified. This category of forest was dominated by saprophytic fungi (56%) followed by mycorhizal (30%) and parasitic (3.4%).

Similarly, a total of 77 species of macro fungi belonging to 29 families were encountered from the three community managed *Shorea robusta* forest which were managed for more than 10 years. Among them 25 species were mycorhizal, 40 saprophytic, and 6 parasitic; 6 species could not have been identified. In this forest category, saprophytic fungi (52.56%) was found to be dominant followed by mycorhizal (32%) and parasitic (6%).

Species richness of macro fungi in two categories of forests did not differed significantly (Independent sample t test, $p>0.05$) (Figure 3).

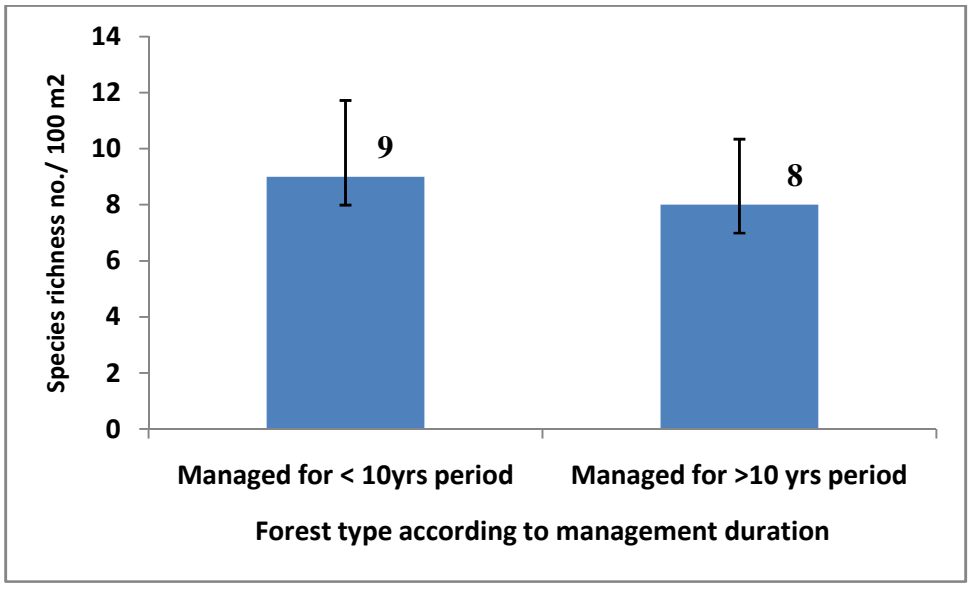

Fig 3: Mean species richness of macro fungi in two categories of forests.

4.2 Similarity index

Jaccards Similarity Index between the community managed *Shorea robusta* forests of two different management duration was found to be 33.84%. Out of 88 species of macro fungi recorded in forests managed for <10 years and 77 species in forest managed for >10 years, only 42 species were common. It shows that 46 species were present only in forests managed for <10yrs and 35 species in forest managed for >10yrs.

4.3 Frequency

Frequency of macro fungal species ranged from 3 to 44% in short duration managed forests, and from 5 to 42% in long duration managed forests (Appendix III and IV). Most of the species having high frequency were found in both the forest categories. The species like *Coltricia cinnamomea, Cantharellus leucocomus, Laccaria* sp., *Clavaria vermicularis, Russula aurora, Campenella caesia* and *Scleroderma cepa* were the most frequent species present in both categories of forests. The most frequent occurring species with their frequency in the forest with different management year is given below in the Table 2.

Table 2: Most frequent species in two different community managed forest

Forest managed for <10 years			**Forest managed for >10 years**		
S.N	**Name of the species**	**Frequency (%)**	**S.N**	**Name of species**	**Frequency (%)**
1.	*Coltricia cinnamomea* Jacq.: Fr.) Karst.	43.75	**1.**	*Coltricia cinnamomea* (Jacq.: Fr.) Karst.	42.10
2.	*Russula aurora* (Krombh)	40.625	**2.**	*Cantharellus leucocomus* Bigelow.	31.57
3.	*Cantharellus leucocomus* Bigelow.	40.62	**3.**	*Laccaria* sp.	31.57
4.	*Scleroderma cepa* (Pers.)	31.25	**4.**	*Lactarius volumus* (Fr.) Fr.	26.31
5.	*Clavaria vermicularis* Swartz: Fr.	31.25	**5.**	*Marasmius siccus* (Schwein.) Fr	26.31
6.	*Campenella casea*	31.25	**6.**	*Clavaria vermicularis* Swartz: Fr.	26.31
7.	*Collybia cirrhata* (Sesu Cooke)	28.12	**7.**	*Clavaria acuta* Sch.: Fr.	26.31
8.	*Laccaria* sp.	25	**8.**	*Clavariadelphus pistillaris*(L.) Donk	21.05
9.	Lactarius volemus (Fr.) Fr.	25	**9.**	*Russula aurora* (Krombh)	21.05
10.	*Cantharellus* sp.	25	**10.**	*Scleroderma bovista* Fr.	21.05

4.4 Trophic Diversity

Any shift in trophic groups (mycorrhizal vs. saprophytic fungi) with management duration of the forest was tested using χ^2 test. On doing calculation calculated value of χ^2 was smaller than the tabulated value of χ^2 at p = 0.05. This result showed that there was no relation between management duration of the forests and the species of different trophic behavior in the present study system.

4.5 Variation of Macro Fungi Species Richness with Environmental Variables

4.5.1 Tree Canopy Coverage

In relation to the canopy coverage, at the significant level of $p<0.05$, the species richness of macro fungi was found to be increasing with increasing coverage of the tree canopy (Figure 4). This showed a positive relation with the canopy coverage.

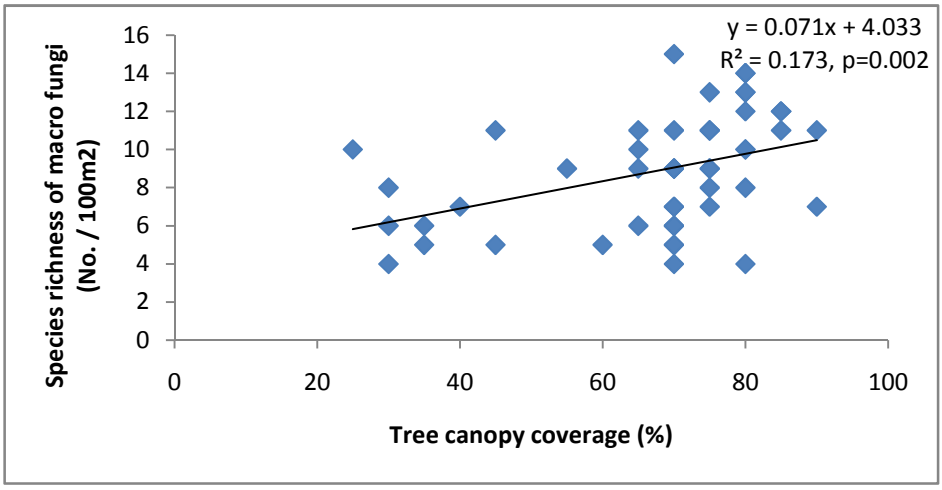

Fig 4: Variation in Species Richness of Macro Fungi with Tree Canopy

4.5.2 Litter Coverage

The regression analysis between species richness of macro fungi with litter cover indicated that richness of macro fungi is positively related to litter coverage at the significant level of $p<0.05$ species (Figure 5).

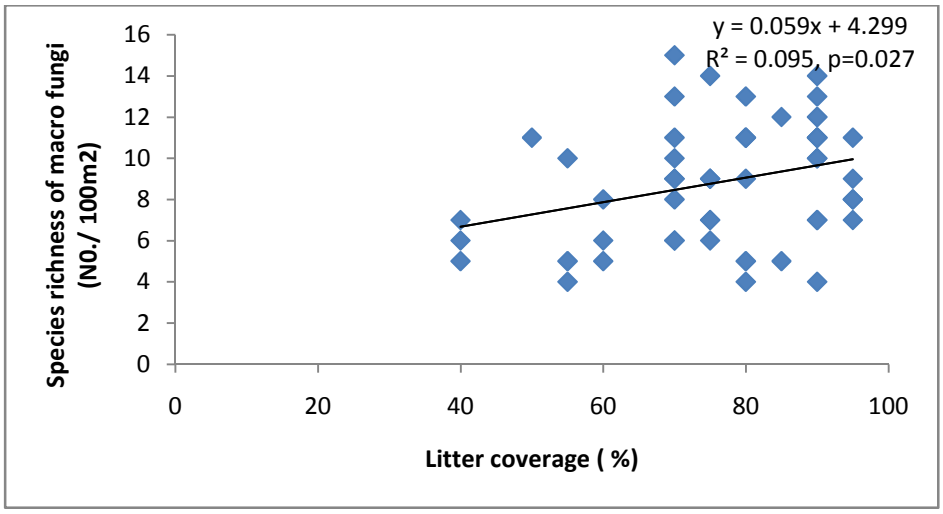

Fig 5: Variation in Species Richness of Macro Fungi with Litter Coverage

4.5.3 Relative Radiation Index (RRI)

The regression analysis of the species richness of macro fungi with the relative radiation index (RRI) indicated that at the significant level of $p<0.05$ the number of macro fungi were positively related to RRI (Figure 6).

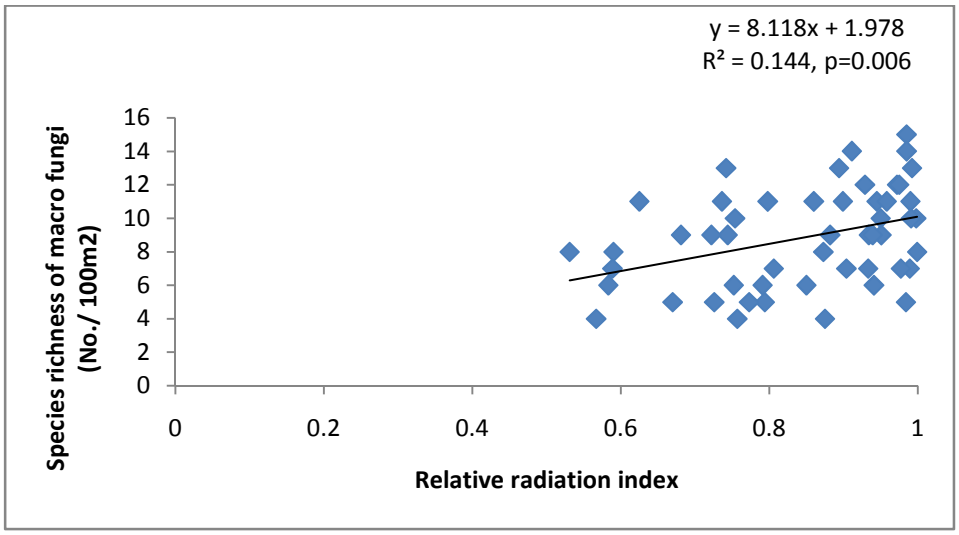

Fig 6: Variation in Species Richness of Macro Fungi with Relative Radiation Index (RRI)

4.5.4 Soil Organic Carbon

The regression analysis of the macro fungi with soil organic carbon is not found to be significant at $p> 0.005$.

5. DISCUSSIONS

5.1 Macro Fungal Species Richness and Composition

There was no significant difference in species richness of macro fungi between the forests managed for shorter (<10 years) and longer (>10 years) duration (Figure 2). Our hypothesis is being rejected in this study. In a general concept, as the management duration increases there will be increase in the total biomass of the forest. This increase in biomass of the forest will lead to more leaves falling and accumulation of more twigs and logs. Litter layer being considered as the suitable condition for the growth of macro fungi there should be the increment in richness of macro fungal species in the forest managed for longer duration than in the forest which was managed for shorter duration. But this common perception was not supported by the present result. This result might be due to the practices of litter collection, thinning, pruning, etc. which have generally been prevalent in the community managed forest. Work done mainly in the 2nd half of the 20th century has shown that human activities and interferences with the natural environment may threaten fungal biodiversity and even cause the extinction of some species (Arnolds 1988). This similarity in the richness of the macro fungi between two categories of forest can be explained by the fact that the fungal species are dependent on the type of litter covering the forest soil and the dominant species of the tree community (Senn-Irlet & Bieri 1999). In order to examine the proportion of fungi in the forest we have chosen only the *Shorea robusta* forest and this might have lead to the relative structural similarity. More over the practices of litter collection, thinning, pruning which are prevalent in the community managed forest has led to the relative proportion of species richness similar.

Similarity index of the macro fungi between the forests managed for shorter and longer duration was found to be relatively low (33.84%). The types of fungi found in the forest are generally host and the litter specific. Since the vegetation is similar along with other factors beside the year of management duration we can conclude that the species varies according to the management practices. The forest which were selected in our study were all the degraded forest before the management practice so as the year of management increases the maturity of the forest also increased and this difference in the maturity of the selected forest might have been the cause for less number of similar species. The result of the present study was similar to previous ones (e.g.

Smith *et al.* 2002, Straatsma & Krisai-Greilhuber 2003, Bonett *et al*. 2004, Richard *et al.* 2004) where they also collected a lot of species only once. In Mexico, among the 3 selected sites 22% species were shared by two sites and only 11% were common in all the three sites (Reverchon, *et al*. 2010). This highest number of singletons may also be due to the limited survey period or these species are rare or they do not fruit frequently.

Coltricia cinnamomea, *Cantherellus leucocomus, Russula aurora, Laccaria* sp.*, Clavaria* sp.*, Campenella caesia, Collybia cirrhata, Lactarius volemus* were the most frequent taxa in the present study forests. They were found to be frequent in both categories of the forests (i.e. short duration and long duration managed forests). The most frequently occurring species in both categories of the forest was *Coltricia cinnamomia.* It is the saprophytic fungi and is previously reported from various part of the country inhabiting on dead wood to leaf litter in pine forest to the mixed forest in the tropical to the temperate belts. The species has been reported from Taglung (Bafour-Browne 1968), Godawary (Lalitpur Dist.) (Singh & Nisha 1976), Roha goan (Lulo Khola, Jumla Dist.) (Balfour-Browne 1955), Naya Odar Topu (Bajhang Dist.) (3110 m) (Adhikari 1988), in *Pine* afforested areas, Kakani (1780 m), Lele (1610 m), in mixed forest, Matathirta (1650 m) and Pokhara (920 m) (Adhikari *et al.* 1996). But collection of this species from hill sal forest has not been reported.

The other frequent species *Cantharellus leucocomus* has been reported of growing in the heap of *Shorea robusta* mixed forest in Pokhara (Adhikari 1996 *et al.*). Other mycorhizal species like *Russula aurora, Scleroderma cepa* were also reported in significant number from the moist shady places of *Quercus* forest in Baitadi district and Bajhang district (Adhikari 1996). This indicates that these species can form good mycorhizal association with *Shorea robusta* trees. Saprophytic fungi like *Mycena* and *Marasmius* were also reported . These saprophytic fungi which were frequent in forest were all the litter inhabiting fungi. They were very small in size and were frequently found in all the forests having litter in considerable amount. It is unfortunate that there has been no previous, systematic work done on the mycoflora of these community managed forests for making a comparison between past and present data.

5.1.2 Trophic Diversity of Macro Fungi

It is well established fact that the overall role of mycoflora (parasitic, mycorrhizal & saprophytic) contributes to the balance and normal function of healthy, natural eco-systems. The relationship between mycorrhizal vs. saprophytic species could constitute a real parameter for measuring the degree of maturity and the level of conservation for certain communities (Ortega & Navarro 2006). The ecto-mycorrhizal fungi dominate in number over the saprophytic species when the forest is healthy (Perini *et al.* 2000, Zervakis *et al.* 2002). In the both categories of forests under our investigation, the proportion of saprophytic fungi was found to be higher than that of the mycorrhizal. Therefore our study showed that saprophytic rather than the mycorrhizal species were dominant in term of number of species in the *Shorea robusta* forest. This type of result was also reported by Ortega and Lorite (2007) in the holm-oak forest which showed the higher proportion of saprophytic than the mycorrhizal. From this result we can also conclude that *Shorea robusta* forests in this area have not been better conserved. According to Dell (2009), even the minor soil disturbance can impact on the function of mycorrhizae. As a consequence of the close dependency of mycorrhizal mushrooms on the growth of associated trees, it is evident that silviculture interventions must have influenced the growth of these fungi. The most striking example is clear-cutting. The elimination of the photosynthetically active green part of the tree leads to an immediate interruption of the carbohydrate flow from the host tree into the roots which result is an immediate disruption of ecto-mycorrhizal fruit-body formation (Ohenoja 1988, Kropp & Albee 1996). As a part of silviculture, thinning and pruning were observed in these community managed forests. Litter collection was less common in the study forests, which might have created favorable condition for the growth of more saprophytic species than the mycorrhizal.

From the above discussion it can be concluded that in the healthy forest which is managed properly, the proportion of the mycorrhizal species is found to be dominant over the saprophytic fungi. But in the present study forest, proportion of saprophytic fungi was high, indicating poor forest health. This result showed that the management practices done here is not scientific. Arnolds (1988) claimed that in most healthy forest ecosystems, the fruit bodies of ectomycorrhizal fungi ranged from 45 to 50% of all the fruit bodies found.

5.1.3 Variation of Macro Fungal Species Richness with Environmental Variables

Significant relation was found with the canopy coverage of the trees with the macro fungal species richness. The species richness increased with the increasing canopy coverage (Figure 4). Light level on the forest floor increases with canopy opening including small gaps (Chazdon & Fetcher 1984, Canham *et al.* 1990). This coincides with the observation made by Dighton *et al*. (1986) that the greatest species diversity seems to occur where there is canopy closure. Luoma *et al.* (2004) showed that thinning of trees caused a decline in fruit-body production of mushroom, but this effect varied greatly according to the season and to the pattern and level of thinning. Similar result was found by Ayer *et al*. (2006), while doing work in Mexico where he observed that the ecto-mycorrhizal species produced twice as many fruit bodies in stands with medium density, whereas saprotrophic species did not differ significantly. This is quite significant with our result as more number of saprophytic taxa was collected from the forest and that of the number of taxa increased with increasing canopy closure. It also shows that as the level of canopy coverage goes on increasing the richness of macro fungal taxa also goes on increasing. It is clear that cutting, thinning and pruning are the part of silvicultural practices which are generally prevalent in the community managed forest. In contrast to this result Kropp & Albee (1996) and Buée *et al*. (2005) found that the fruit body production of some fungi was adversely affected by thinning while others were positively affected.

Litter is an important component of all eco-system being major source of organic matter. According to Eaton *et al*. (2004) and Sayer (2005), the removal of litter affects fungal growth and diversity. Similar case was observed in our study. Species richness of the macro fungi was observed increasing with increasing litter cover (Figure 5). If the amount of litter increases the number of saprophytic community tends to increase as they are the important food source for those communities. When the forest floor is covered with layer of well rotted leaves, saprophytic fungi are favoured by this resource which maintains temperature & moisture and is rich in organic matter (Fernánde-Toirán *et al*. 2006). Earlier works done by Donnelly and Boddy (1998), Zakaria and Boddy (2002), and Harold *et al*. (2005) reported that soil nutrient status affects mycelia development and hence sporocarp occurrence. So as the level of the litter coverage increases the number of mycelia development goes on increasing and thus the fructification of the species increases.

With the increase in the light radiation (measured as RRI), richness of the fungal species was found to be increasing (Figure 6). Temperature is also one of the important factors to determine growth of the fungi. In sub alpine and alpine regions as the temperature falls below 15ºC the population dynamics of the fungi are found to be retarded (Adhikari 2000a). The light radiation falling on the land in turn affects soil temperature, soil nutrients and soil moisture (Mehus 1986, Mc Carthy 2001). This effect of temperature on the forest floor will in turn provide the good habitat for the macro fungal species.

In present study the richness of macro fungal species did not vary significantly with the soil organic carbon. The reason might be that in the soil, carbon is not only the responsible factor to determine the richness of fungal taxa. It is also possible that the effect of soil organic carbon on species richness might have been override by other factors such as disturbances. There may be other soil attributes which play equally important role. In the study done by Engola (2007) in Southwest of Uganda and West of Lake Victoria, organic matter, potassium, sodium, magnesium, sand and clay were significantly correlated with the abundance of macro fungal species. Similarly, Zamora & Cecilia (1995) also noted that sandy loamy texture, high organic matter and pH were the properties that stimulated the development of fungi. The soil carbon to nitrogen (C-to-N) ratio, together with acidity, has been shown to determine the soil microbial community composition (Högberg *et al.* 2007).

6. CONCLUSIONS

The present research demonstrated that community managed *Shorea robusta* forest of Dhading district consisted of diverse macro fungi with 88 species in short duration managed forests and 77 species in long duration managed forests. There was no significant difference in species richness of macro fungi between forests managed for short and long duration However low similarity index indicated that there was difference in the species composition due to the management duration. The proportion of saprophytic fungal species was higher than mycorrhizal which is the indicative of poor forest health. Most of the species have been recorded from the family Polyporaceae and Clavariaceae. Forest canopy, litter cover and relative radiation were found to be the important environmental factors which varied positively with the species richness of macro fungi in the study forests.

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APPENDIX

Appendix 1. Macroscopic field observation of macro fungi

Col. No……. Altitude…… Locality……

Habitat:

Substrate: Soil, leaves, humus, tree, stumps, branch, others……

Condition: Moist, dry, open, dark, single, group, chain, others……

Fruit body: Fleshy, tough, corky, woody, leathery, membranous, cartilaginous, membranous, cartilaginous, auricular, clavaroid, spathulate, round, convoluted, others……

Pileus: Present, Absent

Size:……cm, ……mm **Colour:** ……..

Shape: Ovoid, hemispherical, conical, convex, concave, campanulate, umbonate, umbillicate, infundibuliform, turbinate, didiminate, resupinate, applanate, others…….

Surface: Dry, viscid, sticky, smooth, powdery, granular, scaly, cracked, glabrous, hairy, wrinkled, others……

Margin: straight, incurved, entire, torn, waxy, striate(finely, strongly, terbecular,) externally beyond hymenial layer, others……

Stipe: Present, Absent

Size…….cm, …….mm, **Colour…**…….

Shape: Straight, curved, cylindrical, swollen below, tapering above/below with or without rhizoidal stands and others……..

Surface: Smooth, scaly, powdery, hairy, dotted, lined, netted, pitted, others…….

Nature: Cartilaginous, ridged, twisted, solid, stuffed, hollow, compressed, brittle.

Annulus: Pendent, sheathing, cobwebby, superior, inferior, smooth, straight, single, double, entire lobed, color…….

Volva: Present, Absent Size: …… cm ……. mm Color: …….

Nature: Entire, divided, scaly, circumsessile, friable, lobed

Hymenial surface

Color:…….

Nature: Lamellate, poried, smooth, spiny, corolloid, within peridium

Lamellae: Color:…….. Color change:…….

Attachment: Free, adnexed, sinuate, adnate, decurrent or mixed

Length: Uniform, interspaced with shorter ones, forked, bifurcate(below or above), equal,

Unequal.

Margin: Entire, serrate, dentate, torn.

Poried surface:

Color: ……. And color changes……

Pore size:…….. mm]

Shape: Round, angular, hexagonal, elongate, rectangular, not definite or mixed

Nature: Papillate, tubular, single layered, satratified

Attachment: Free, adnate, decurrent

Thickness: …….mm …….cm

Spore Print: Color……

Other Characteristics:

Flesh(Pileus and stipe): Thickness…… softness……. Color……

Taste(gills and stipe): Mild, acrid, pleasant, bitter……..

Smell of fruiting body: Fruity, rotten fish, radish, corn, garlic…….

Latex: Color…… Amount……. Taste…….

Remarks……

Appendix II. List of Macro fungal species in the community forests managed for < 10 years [BCF: Bossikharka Community forest, Kirakhore Community forest and Sikhrepakha Community Forest**]**

S.N	Scientific Name	Family	Trophic group	Col. N.	SCF	KCF	BCF	TOTAL	Frequency
1	*Auricularia auricular-judae* (Bull.: Fr.) Wettst.	Auriculariaceae	Parasitic	0002	1	0	0	1	3.13
2	*Campenella casea*	Marasmiaceae	Saprophytic	0001	3	2	5	10	31.25
3	*Clavulina* sp. *1*	Clavariaceae	Saprophytic	0003	2	0	0	2	6.25
4	*Geastrum* sp.*1*	Geastraceae	Saprophytic	0005	1	3	1	5	15.63
5	*Marasmius siccus* (Schwein.) Fr	Marasmiaceae	Saprophytic	0006	3	2	0	5	15.63
6	*Polypore* sp. *1*	Polyporaceae	Saprophytic	0007	1	0	0	1	3.13
7	*Polypore* sp. *2*	Polyporaceae	Saprophytic	0004	2	0	0	2	6.25
8	*Unidentified* sp. *1*			0008	1	0	0	1	3.13
9	*Xylaria filiformis* (Alb.& Schwein)	Xylariaceae	Saprophytic	0017	1	0	1	2	6.25
10	*Trichoglossum hirsutum* (Pers.: Fr.) Bound.	Geoglossaceae	Saprophytic	0016	1	1	2	4	12.50
11	*Clavaria* sp. *1*	Clavariaceae	Saprophytic	0009	4	0	0	4	12.50
12	*Thelophora palmata* Fr.: Fr	Thelophoraceae	Mycorrhizae	0011	1	0	0	1	3.13
13	*Clavaria rosea* Fr.	Clavariaceae	Saprophytic	001	1	0	0	1	3.13
14	*Polypore* sp. *3*	Polyporaceae	Saprophytic	022	1	0	0	1	3.13
15	*Russula* sp.	Russulaceae	Mycorrhizae	019	1	0	0	1	3.13
16	Unidentified sp. *2*			021	1	0	0	1	3.13
17	*Russula aurora* (Krombh)	Russulaceae	Mycorrhizae	018	5	1	7	13	40.63
18	Unidentified sp. 3			027	3	1	0	4	12.50
19	*Cantharellus leucocomus* Bigelow.	Cantharellaceae	Mycorrhizae	024	5	1	7	13	40.63
20	*Coltricia cinnamomea* Jacq.: Fr.) Karst.	Hymenochaetaceae	Saprophytic	031	3	2	9	14	43.75
21	*Clavaria fragilis* Fr.	Clavariaceae	Saprophytic	03	3	0	0	3	9.38
22	*Bolete* sp.1	Boletaceae	Mycorrhizae	032	1	0	3	4	12.50
23	*Scleroderma cepa* (Pers.)	Sclerodermataceae	Mycorrhizae	037	2	3	5	10	31.25
24	*Schizophyllum cummuni* Fr: Fr.	Schizophyllaceae	Saprophytic	038	1	0	1	2	6.25
25	Unidentified sp. 4			039	1	0	0	1	3.13
26	*Clavaria* sp. 2	Clavariaceae	Saprophytic	033	1	0	0	1	3.13

27	*Lepiota* sp.	Agaricaceae	Saprophytic	034	1	0	0	1	3.13
28	*Marasmius androsaceus*	Marasmiaceae	Saprophytic	04	1	0	1	2	6.25
29	*Lepiota cristata* (Alb.& Schw.)	Agaricaceae	Saprophytic	042	2	0	2	4	12.50
30	*Clavaria vermicularis* Swartz: Fr.	Clavariaceae	Saprophytic	048	1	1	8	10	31.25
31	*Russula delica* (Fr.)	Russulaceae	Mycorrhizae	049	1	0	4	5	15.63
32	Lactarius volemus (Fr.) Fr.	Lactariaceae	Mycorrhizae	05	4	1	3	8	25.00
33	*Russula* sp.	Russulaceae	Mycorrhizae	052	1	0	0	1	3.13
34	*Inocybe* sp.	Inocybaceae	Mycorrhizae	057	2	0	0	2	6.25
35	*Polypore* sp. *4*	Polyporaceae	Saprophytic	054	1	0	0	1	3.13
36	*Pholiota terrestis* (Overh.)	Cortinariaceae	Saprophytic	059	1	0	1	2	6.25
37	*Clavulina* sp. *2*	Clavariaceae	Saprophytic	058	1	3	4	8	25.00
38	*Cortinarius* sp. *1*	Cortinariaceae	Mycorrhizae	06	1	0	0	1	3.13
39	Microporus Xanthopus (Fr.) Kuntze.	Polyporaceae	Saprophytic	061	1	1	2	4	12.50
40	*Collybia cirrhata* (Sesu Cooke)	Tricholomataceae	Saprophytic	062	1	1	7	9	28.13
41	*Ramaria flaccida* (Fr.: Fr.) Bourdot	Ramariaceae	Saprophytic	063	2	0	0	2	6.25
42	*Russula flavida* (Frost.)	Russulaceae	Mycorrhizae	064	1	0	0	1	3.13
43	*Cantharellus* sp.	Cantharellaceae	Mycorrhizae	065	1	4	3	8	25.00
44	*Mycena galericulata* (Scop.: Fr) S.F. Gray.	Mycenaceae	Saprophytic	066	1	0	0	1	3.13
45	*Bolete* sp2	Boletaceae	Mycorrhizae	067	1	0	0	1	3.13
46	*Irpex* sp.	Meruliaceae	Saprophytic	068	1	0	0	1	3.13
47	Unidentified sp.6			069	1	0	0	1	3.13
48	*Laccaria* sp.	Tricholomataceae	Mycorrhizae	087	0	2	6	8	25.00
49	*Peziza* sp	Pezizaceae	Saprophytic	24	0	1	0	1	3.13
50	*Rhizopogon* sp.	Sclerodermataceae	Mycorrhizae	25	0	1	0	1	3.13
51	*Hydnum repandum* L.: Fr.	Hydnaceae	Mycorrhizae	077	0	5	0	5	15.63
52	*Scleroderma bovista* Fr.	Sclerodermataceae	Mycorrhizae	5	0	2	2	4	12.50
53	*Microporus* sp.	Polyporaceae	Saprophytic	26	0	3	0	3	9.38
54	*Halvella* sp.	Helvellaceae	Saprophytic	27	0	1	0	1	3.13
55	*Polypore* sp. *5*	Polyporaceae	Saprophytic	29	0	2	0	2	6.25
56	Unidentified sp. 11			30	0	3	0	3	9.38

57	*Clitocybe* sp.	Tricholomataceae	Saprophytic	31	0	2	1	3	9.38
58	*Flamulina* sp.	Dermolomataceae	Saprophytic	088	0	3	3	6	18.75
59	*Geastrum* sp. *2*	Geastraceae	Saprophytic	32	0	1	0	1	3.13
60	*Pycnoporus cinabarinus* (Jacq.: Fr.) Karst.	Polyporaceae	Saprophytic	33	0	2	2	4	12.50
61	*coprinus disseminatus* (Pers.:Fr)	Coprinaceae	Saprophytic	081	0	2	0	2	6.25
62	Unidentified 12			35	0	1	0	1	3.13
63	*Polyporellus brumalis* (Pers.) P. Kumm.	Polyporaceae	Saprophytic	6	0	1	1	2	6.25
64	*Marasmius candidus* Fr: Fr.	Marasmiaceae	Saprophytic	074	0	1	5	6	18.75
65	*Anthracobia macrocystis* (Cke.) Bound.	Pyronemataceae	Saprophytic	40	0	0	4	4	12.50
66	*Cudonia* sp.	Cudoniaceae	Saprophytic	41	0	0	1	1	3.13
67	*Tricholoma* sp.	Tricholomataceae	Mycorrhizae	37	0	0	1	1	3.13
68	*Lactarius* sp.	Lactariaceae	Mycorrhizae	43	0	0	1	1	3.13
69	*Hygrophorous lanecovensis*	Hygrophoraceae	Mycorrhizae	38	0	0	3	3	9.38
70	*Bisporella citrina* (Batsch.: Fr.) Korf. & Carp.	Helotiaceae	Saprophytic	45	0	0	5	5	15.63
71	*Mycena galopus* (Pers.) P. Kumm	Mycenaceae	Saprophytic	14	0	0	2	2	6.25
72	*Daldinia concentrica* (Bull.: Fr.) Ces. & De	Xylariaceae	Saprophytic	098	0	0	3	3	9.38
73	*Lactarius* sp.	Lactariaceae	Mycorrhizae	39	0	0	1	1	3.13
74	*Clavariadelphus pistilaris*(L.) Donk	Clavariaceae	Saprophytic	078	0	0	2	2	6.25
75	*Thelophora* sp.	Thelophoraceae	Mycorrhizae	084	0	0	2	2	6.25
76	*Mycena sp.*	Mycenaceae	Saprophytic	071	0	0	1	1	3.13
77	*Tremella mesentrica* Ritz.: Fr.	Tremellaceae	Parasitic	53	0	0	1	1	3.13
78	Unidentified 18			54	0	0	1	1	3.13
79	*Russula* sp.	Russulaceae	Mycorrhizae	56	0	0	1	1	3.13
80	*Exidia glandulosa* (Bull.: Fr.) Wettst.	Auriculariaceae	Parasitic	57	0	0	1	1	3.13
81	*Tremitomycetes* sp.	Lyophyllaceae	Mycorrhizae	59	0	0	4	4	12.50
82	*Paneolus* sp.		Saprophytic	60	0	0	1	1	3.13
83	*Lactarius* sp.	Lactariaceae	Mycorrhizae	62	0	0	1	1	3.13
84	*Boletellus* sp.	Boletaceae	Mycorrhizae	63	0	0	1	1	3.13
85	*Mycoraphium adjustum*		Saprophytic	096	0	0	1	1	3.13
86	*Xylaria hypoxylon* (L.) Grev.	Xylariaceae	Saprophytic	097	0	0	1	1	3.13

87	*Calocera cornea* (Batsch.: Fr.) Korf. & Carp.	Dacrymycetaceae	Saprophytic	65	0	0	1	1	3.13
88	*Lentinus* sp.	Pleurotaceae	Saprophytic	66	0	0	1	1	3.13
					77	60	137	274	

Appendix III. List of Macro fungal species in the community forest managed for more than 10 years [DCF: Dhondre Community Forest, JCF: Jungepakha Community Forest, RCF: Raatamata Community Forest**]**

S.N	Scientific name	Family	Trophic group	Col. No.	RCF	JCF	DCF	Total	Frequency
1	*Xylaria filiformis* (Alb. & Schwein)	Xylariaceae	Saprophytic	017	2	0	1	3	15.79
2	*Russula flavida* (Frost.)	Russulaceae	Mycorrhizae	064	1	0	2	3	15.79
3	*Mycena* sp.	Mycenaceae	Saprophytic	071	1	0	0	1	5.26
4	*Collybia cirrhata* (Sesu Cooke)	Tricholomataceae	Saprophytic	062	1	1	1	3	15.79
5	*Clavaria vermicularis* Swartz: Fr.	Clavariaceae	Saprophytic	048	1	0	2	3	15.79
6	*Clavulina* sp. *2*	Clavariaceae	Saprophytic	058	1	3	1	5	26.32
7	*Clavaria sp.*	Clavariaceae	Saprophytic	033	1	0	0	1	5.26
8	*Clavaria acuta* Sch.: Fr.	Clavariaceae	Saprophytic	073	1	0	0	1	5.26
9	*Marasmius candidus*	Marasmiaceae	Saprophytic	074	4	1	0	5	26.32
10	*Cantharellus leucocomus* Bigelow.	Cantharellaceae	Mycorrhizae	024	3	1	2	6	31.58
11	*Tramates versicolor* (L.: Fr.) Llyod.	Polyporaceae	Saprophytic	075	2	0	0	2	10.53
12	*Russula aurora* (Krombh)	Russulaceae	Mycorrhizae	018	4	1	0	4	21.05
13	*Hydnum repandum* L.: Fr.	Hydnaceae	Mycorrhizae	077	2	0	0	2	10.53
14	*Inocybe* sp.	Inocybaceae	Mycorrhizae	057	1	1	0	2	10.53
15	*Clavariadelphus pistillaris*(L.) Donk	Clavariaceae	Saprophytic	078	3	0	1	4	21.05
16	*Mycena pura* (Pers.) P. Kumm.	Mycenaceae	Saprophytic	079	2	1	0	3	15.79
17	*Dacrymyces stillatus* (Nees)	Dacrymycetaceae	Parasitic	08	1	0	0	1	5.26
18	*Marasmius androsaceus*	Marasmiaceae	Saprophytic	04	1	0	0	1	5.26
19	*Coprinus dissiimatus* (Pers.:Fr.)	Coprinaceae	Saprophytic	081	1	0	1	2	10.53
20	*Kobayasia nipponica* Imai & Kawam	Sclerodermaceae	Mycorrhizae	083	3	0	0	3	15.79
21	*Thelophora* sp.	Thelophoraceae	Mycorrhizae	084	1	0	0	1	5.26
22	*Campanella caesia*	Marasmiaceae	Saprophytic	0001	1	1	1	3	15.79
23	*Russula delica* (Fr.)	Russulaceae	Mycorrhizae	049	1	0	1	2	10.53
24	*Polyporous* sp.	Polyporaceae	Saprophytic	085	1	0	0	1	5.26
25	Unidentified sp. 7			086	1	0	0	1	5.26
26	*Laccaria* sp.	Tricholomataceae	Mycorrhizae	087	3	2	1	6	31.58

27	*Daedaleopsis* sp.	Polyporaceae	Saprophytic	028	1	0	0	1	5.26
28	*Lactarius volumus* (Fr.) Fr.	Lactariaceae	Mycorrhizae	05	2	1	2	5	26.32
29	*Marasmius siccus* (Schwein.) Fr	Marasmiaceae	Saprophytic	0006	2	2	1	5	26.32
30	*Flamulina* sp.	Dermolomataceae	Saprophytic	088	2	0	1	3	15.79
31	Unidentified sp. 8			089	1	0	0	1	5.26
32	*Ganoderma resinaceum* (Bound.)	Ganodermaceae	Parasitic	09	1	0	0	1	5.26
33	*Polypore* sp. 3	Polyporaceae	Saprophytic	091	2	0	0	2	10.53
34	*Lepiota cristata* (Alb. & Schw.)	Agaricaceae	Saprophytic	042	1	0	1	2	10.53
35	*Amanita falva*	Amanitaceae	Mycorrhizae	092	1	0	0	1	5.26
36	*Mycena* sp.	Mycenaceae	Saprophytic	076	2	0	0	2	10.53
37	*Coltricia cinnamomea* (Jacq.: Fr.) Karst.	Hymenochaetaceae	Saprophytic	031	3	3	2	8	42.11
38	*Trichoglossum hirsutum* (Pers.: Fr.) Bound.	Geoglossaceae	Saprophytic	0016	1	0	0	1	5.26
39	*Inonotus* sp.	Hymenochaetaceae	Parasitic	093	1	0	0	1	5.26
40	*Cortinarius* sp.	Cortinariaceae	Mycorrhizae	094	1	0	0	1	5.26
41	*Laccaria amesthesia* (Hunds.) Cooke	Tricholomataceae	Mycorrhizae	095	1	0	0	1	5.26
42	*Xylaria hypoxylon* (L.) Grev.	Xylariaceae	Saprophytic	097	1	1	0	2	10.53
43	*Daldenia concentrica* (Bull.: Fr.) Ces. & De	Xylariaceae	Saprophytic	098	1	0	0	1	5.26
44	*Ganoderma lucidum* (Curtis) P. Karst.	Ganodermaceae	Parasitic	1	1	0	0	1	5.26
45	*Irpex* sp.2	Meruliaceae	Saprophytic	2	1	0	0	1	5.26
46	*Scleroderma bovista* Fr.	Sclerodermaceae	Mycorrhizae	5	0	3	1	4	21.05
47	Polyporellus brumalis (Pers.: Fr.) Karst.	Polyporaceae	Saprophytic	6	0	1	0	1	5.26
48	Unidentified sp. 8			7	0	1	0	1	5.26
49	*Bolete* sp.	Boletaceae	Mycorrhizae	032	0	1	0	1	5.26
50	*Bolete* sp. *3*	Boletaceae	Mycorrhizae	8	0	2	0	2	10.53
51	*Leotia lubrica* (Scop.) Pers.	Leotiaceae	Saprophytic	9	0	1	0	1	5.26
52	*Scleroderma* sp.	Sclerodermaceae	Mycorrhizae	10	0	1	0	1	5.26
53	*Microporus xanthopus* (Fr.) Kuntze.	Polyporaceae	Saprophytic	061	0	2	1	3	15.79
54	*Clavulina* sp.*3*	Clavariaceae	Saprophytic	13	0	1	0	1	5.26
55	*Schizophyllum cummuni* Fr: Fr.	Schizophyllaceae	Saprophytic	038	0	1	0	1	5.26
56	*Mycena galopus* (Pers.) P. Kumm.	Mycenaceae	Saprophytic	14	0	2	1	3	15.79

57	*Geastrum* sp.	Geasterace	Saprophytic	0005	0	1	0	1	5.26
58	*Clavaria* sp.	Clavariaceae	Saprophytic	15	0	1	0	1	5.26
59	*Unidentified* sp.*10*			17	0	1	0	1	5.26
60	*Lactarius indigo* (Schew.) Fr.	Lactariaceae	Mycorrhizae	18	0	1	0	1	5.26
61	*Amanita pantherina* (DC.: Fr.) Kromb.	Amanitaceae	Mycorrhizae	16	0	1	0	1	5.26
62	*Cantherellus* sp.	Cantharellaceae	Mycorrhizae	065	0	2	1	3	15.79
63	*Bolete* sp. *4*	Boletaceae	Mycorrhizae	20	0	1	0	1	5.26
64	*Oudmensiella sp.*	Dermolomataceae	Saprophytic	4	0	1	0	1	5.26
65	Unidentified sp.3			027	0	1	0	1	5.26
66	*Rhizopogon* sp.2	Sclerodermaceae	Mycorrhizae	19	0	1	0	1	5.26
67	Unidentified sp. 15			42	0	1	0	1	5.26
68	*Cudonia* sp.	Cudoniaceae	Saprophytic	41	0	0	1	1	5.26
69	*Polyper* sp. 7	Polyporaceae	Saprophytic	71	0	0	1	1	5.26
70	*Polyper* sp. 8	Polyporaceae	Saprophytic	72	0	0	1	1	5.26
71	*Pholiota terrestis* (Overh.)	Cortinariaceae	Saprophytic	059	0	0	1	1	5.26
72	*Lactarius* sp.	Lactariaceae	Mycorrhizae	39	0	0	1	1	5.26
73	*Bolete* sp.4	Boletaceae	Mycorrhizae	78	0	0	1	1	5.26
74	*Pycnoporus cinnabaris* (Jacq.: Fr.) Karst.	Polyporaceae	Saprophytic	33	0	0	1	1	5.26
75	*Ganoderma* sp.	Ganodermaceae	Parasitic	81	0	0	1	1	5.26
76	*Scleroderma cepa* (Pers.)	Sclerodermaceae	Mycorrhizae	037	0	0	3	3	15.79
77	*Tremella mesentrica* Retz.: Fr.	Tremellaceae	Parasitic	53	0	0	1	1	5.26
					71	48	37	155	815.79

Appendix IV. Plots detail of the Study area [Plot 1-12, Sikhrepakha CF; Plot 13-21, Raatamata CF; Plot 22-27 Jungepakha CF; Plot 28-34 Kirakhare CF; Plot 35-46 Bossikharka CF; Plot 47-51 Dhondre CF**]**

Plot No.	Altitude (m)	Aspect	Slope	Latitude	Longitude	Litter Cover (%)	Canopy Cover (%)	RRI	Mushroom Species No.
1	515	360	30	27.90	84.74	60	30	0.531	8
2	462	290	18	27.90	84.74	70	35	0.791	6
3	466	274	24	27.90	84.74	55	60	0.794	5
4	443	254	20	27.90	84.74	55	30	0.875	4
5	480	287	24	27.90	84.74	70	70	0.752	6
6	520	270	16	27.90	84.75	40	30	0.850	6
7	515	302	22	27.90	84.75	40	35	0.726	5
8	535	260	30	27.90	84.75	90	70	0.806	7
9	519	300	32	27.90	84.75	80	75	0.625	11
10	538	316	24	27.90	84.75	85	70	0.670	5
11	564	264	36	27.90	84.75	80	75	0.744	9
12	581	268	30	27.90	84.75	80	70	0.773	5
13*	761	164	24	27.88	84.79	95	90	0.990	11
14	752	110	27	27.88	84.79	90	70	0.860	11
15	760	46	26	27.88	84.79	90	80	0.899	11
16	765	68	2	27.88	84.79	95	75	0.999	8
17	812	246	12	27.89	84.79	90	75	0.904	7
18	782	208	30	27.89	84.79	85	85	0.972	12
19	839	88	30	27.89	84.79	90	80	0.757	4
20	828	68	22	27.89	84.79	90	80	0.754	10
21*	772	292	24	27.89	84.83	90	85	0.736	11
22	793	322	22	27.89	84.83	95	70	0.681	9
23	800	218	30	27.88	84.83	90	80	0.950	10
24	890	330	28	27.88	84.83	95	80	0.590	8
25	889	346	28	27.88	84.83	80	70	0.567	4

26	911	334	28	27.88	84.83	75	65	0.583	6
27*	825		26	27.93	84.89	75	70	0.589	7
28	912	188	20	27.93	84.89	75	70	0.989	7
29	919	152	26	27.93	84.89	90	80	0.975	12
30	894	134	28	27.93	84.89	95	90	0.933	7
31	915	262	30	27.93	84.89	70	65	0.798	11
32	948	240	32	27.93	84.89	70	75	0.873	8
33	930	128	34	27.93	84.89	70	80	0.894	13
34*	1056	160	30	27.94	84.90	70	70	0.985	15
35	1081	172	29	27.94	84.90	70	65	0.998	10
36	1044	232	20	27.94	84.90	90	85	0.929	12
37	1034	258	42	27.94	84.90	75	70	0.722	9
38	1018	222	38	27.94	84.90	75	80	0.911	14
39	893	198	32	27.94	84.90	90	80	0.985	14
40	906	280	28	27.94	84.90	80	75	0.742	13
41	907	230	38	27.94	84.90	70	70	0.882	9
42	1046	220	30	27.94	84.90	80	75	0.945	11
43	940	224	30	27.94	84.90	75	75	0.934	9
44	956	168	32	27.94	84.90	90	80	0.992	13
45	966	220	18	27.94	84.90	75	55	0.951	9
46*	1070	226	20	27.94	84.90	60	70	0.941	6
47	811	196	26	27.94	84.94	55	25	0.991	10
48	955	186	18	27.94	84.94	60	45	0.984	5
49	1024	172	16	27.94	84.94	40	40	0.977	7
50	830	222	30	27.94	84.93	70	65	0.939	9
51	862	144	28	27.93	84.94	50	45	0.958	11

Appendix V: Chi square test between the trophic group of the macro fungi and the management duration of the community managed forest.

List of saprophytic and mycorrhizal species of macro fungi

	Mycorrhizal (%)	**Saprophytic (%)**	**Total**
CF Managed for < 10yrs	**34(35.42)**	**62(60.57)**	**96**
CF Managed for >10yrs	**35(33.57)**	**56(57.42)**	**91**
Total	**69**	**118**	**187**

$\chi^2 = 0.178$