1. INTRODUCTION

1.1 Background of the Study

Our country has a peculiar topography representing the tropical, temperate and alpine climate. In these varying climates, different types of forests are found. Forest is the largest natural resource of Nepal. Out of total land area (14.72 million ha.) of Nepal, forest covers about 4.27 million ha. (29%) and shrub land covers 1.56 million ha. i.e. 10.6% (DFRS and FRISP, 1999). Forests provide timber, fuelwood, fodder, fiber, litter, foods, medicinal and aromatic plants etc. In the hills and mountains of Nepal, the forest products have played vital role in the livelihood and agricultural productivity while the forests of terai region have importance contribution in the economy of country.

According to the vegetation composition and distribution, there are thirty five types of forests in Nepal (Stainton, 1972). The Forest Act 1993 has classified Nepal's forest into private forest and national forest. National forest has been further classified into five categories: government managed forest, community forest, protected forest, leasehold forest and religious forest.

Community forest (CF) is the part of National forest handed over to the local user groups for its protection, management and utilization. The Forest Act 1993 has empowered the district forest officer to handover a part of national forest to user's group. This act has given the forest user's group legal rights to use forest products of their forests. The responsible institutions of community forest are the forest user groups. These forests are managed according to the forest operational plan approved by District Forest Office. So far, 14,413 Community Forest User Groups (CFUGs) have been formed and 12, 28,016 hectares of national forest has been handed over to them (CFUG Database, 2008) representing 21.07% community forest out of the total forest area. In community forestry, 16, 57,904 households are involved i.e. about 30% of the total population of the country is involved (CFUG Database, 2008). The main objective of community forest is the production of forest products and multipurpose use. The community forests have been able to supply the basic needs of local people mainly fuelwood, timber and fodder.

Community forestry programs focus on the protection and production of forestry related needs for users rather than conserving existing life forms in the forest (Belbase, 1999). Some of the management activities in community forests have reduced species richness. For example, during thinning, non-timber and low quality timber yielding species are indiscriminately removed and dominant species such as Sal is protected (Shrestha, 2005). This has increased the number of individual tree but reduced the species diversity. Forest community with low species diversity may be less stable (Chapman and Reiss, 1995).

Protected forest (PF) is the part of national forest declared by the government as in consideration with its special environment, scientific and cultural significance. The main management objectives of protected forests are the conservation of water, biodiversity and environment. The responsible institution for the protected forest is the Department of Forest. In the distribution of forests, protected forest managed by department of forest is 0.003% of the total forest area of Nepal (Shrestha, 2008). Rights to all activities like grazing, hunting etc. in protected forests are banned.

Shorea robusta (Sal) is found as dominant tree species in most of the terai forests of Nepal. Sal is a gregarious species, which is found on the southern slopes of the Himalayas and is distributed in Bangladesh, India and Nepal (Stainton, 1972). Sal forest grows from terai plain (<100m) to mid hills (up to 1500m). Sal forests are generally poor in species richness (Stainton, 1972). Sal is the most important timber species of Nepal. This species alone constitutes 28.2% of the total tree stem volumes of Nepalese forest (DFRS and FRISP, 1999). Sal is used for various purposes. For example timber for construction and furniture, fuelwood for domestic and industrial uses, fodders for domestic animals, seeds for extracting oil and leaves for making plates.

For the sustainability of forest, regeneration is important. The reproducing or regenerating capacity of plant is known as plant regeneration. The regeneration of plant depends mainly upon the average seed output, viability of seeds, seed dormancy, seed dispersal, seedling growth, vegetative growth and reproductive growth. Larger number and proper establishment of seedlings are the most suitable factors for the good regeneration.

1.2 Justification of the Study

In the community forest, people have been focused in the protection of timber yielding species. During the management practices, non-timber species and low quality timber yielding species have been removed. These activities may reduce species richness of forest and disturb the ecosystem balance. Continuous regeneration of plant is necessary for the sustainability of forest. When the forest lives for long time, the special environment, cultural and scientific value of the protected forest is saved for long time. As the protected forest is conserved in government level, illegal activities for the use of forest resources can take place in local level. Such activities may cause loss of biodiversity. There are limited data on the status of biodiversity and regeneration of dominant species of the community and protected forests. Hence it is necessary to know the status of biodiversity in the community and protected forests. The results of present study will help to determine the best management practices in the conservation of forests and hence to sustain the forest for long time.

1.3 Hypotheses

The main hypotheses of the research work are as follows:

- Current management practices in community forest are responsible for increasing density of a particular tree species, but not species diversity.
- Community forests are developing into monodominant type of forests.
- Protected forests have higher species diversity than managed forests.

1.4 Objectives

To achieve the goal of our study, following major objectives are proposed:

- To study vegetation composition of community managed and protected Sal forests.
- To compare regeneration of Sal in community managed and protected forests.

2. LITERATURE REVIEW

2.1 Vegetation composition

Upadhaya (1997) studied the vegetation of Bhadkhore community managed forest (CF) and Dulepani Government managed forest (GF) during 1996. He found that vegetation composition of GF was better than that of CF. Tree density and Basal area of community managed forest was less than Government managed forest. Regeneration in community forest was also less than Government forest.

Vetaas (1997) studied the effect of canopy disturbance on species richness in a central Himalayan oak forest. His result showed that a small scale lopping regime will increase species richness of plants in such kind of forest.

Brockway (1998) studied the forest plant diversity in the cascade mountain of Southwest Washington. He reported that the old growth forests were know to support high level of plant diversity. The plant species richness and species diversity were generally lower in Community Forest.

Zhang (1998) studied the changes in species diversity and canopy cover in Mangolia. He found that the total canopy cover was higher in protected area but annual coverage was higher in grazed area.

Giri *et al.*(1999) studied the vegetation composition, biomass production and regeneration of tree species in Terai *Shorea* Forest (TSF) and *Shorea-Terminalia* Forest (STF) in south-western part of Bardia National Park. Total density and Basal area were higher for TSF. In TSF both density and Basal area were greatest for *Shorea robusta*, whereas in STF, density and Basal area were higher for *Terminalia alata* followed by *Shorea robusta*. The distribution of trees (>10cm dbh) among diameter class showed a higher density of stem with 10cm - 20cm diameter at breast height.

Pandey and Shukla (1999) studied the plant diversity and community patterns along the disturbance gradient in plantation Sal forest of Gorakhapur Forest Division, India.

Along the 30 km long disturbance gradient, they determined the disturbance index on the basis of number of cut or severed woody plants, expressed as the percentage of total number of woody plants per $100m^2$ area. The disturbance index decreased sharply from the periphery towards the core. They noted the highest disturbance index (94.5) in the periphery and lowest disturbance index in the core (<2.5). They observed a maximum Shannon Index of diversity (H) of 3.53 for the last three stands towards the core. They concluded that the disturbance helped for the maximum diversity.

Shrestha (1999) carried out the study of species diversity of *Castanopsis hystrix* forest of Makalu Barun National Park, East Nepal. He studied relatively undisturbed, moderately disturbed and disturbed forest of *Castanopsis hystrix* forest. The Basal area, density, importance value index and diversity index was found highest in relatively undisturbed forest. He found highest N, P and K in relatively undisturbed forest whereas the amount of N was least in disturbed site whereas P and K were found least in moderately disturbed forest.

Bauduni and Sharma (2001) conducted the research work on the community structure of the Sal savanna forest of the Kolagarh forest division at Pouri Garhwal district, India. They sampled on four different aspects i.e. north-east, south-east, north-west and south-west. They found maximum dispersion of trees on south-east aspect which indicated a more stable community than on other aspects.

Shankar (2001) studied tree diversity in a Sal dominated lowland forest (Mahananda Sanctuary Darjeeling) of India. The Sal forest had higher species richness and species diversity than other Sal forests in India. All the girth classes showed a multi species dominance with 21 species in mature (≥180 cm girth), 40 in elder (≥90 to <180cm), 55 in young (≥30 to <90cm) and 68 in juvenile class (≥10 to <30cm). Only six species were found in seedling layer (≥30cm height to <10cm girth). Rare species that contribute maximum to the tree diversity were at high risk of local extinction due to anthropogenic disturbance. The regeneration in this Sal forest was satisfactory at community level. There were 31,250 seedlings and 236 saplings for 248 adults per hectare.

Koirala (2003) analysed vegetation composition and plant diversity of piluwa micro watershed in Tinjure-Milke region, east Nepal. He found more tree species in the non-degraded Tanmafok forest than in the degraded Madimulkharka forest. He reported higher regeneration of plants in the degraded Madimulkharka forest than in the relatively undisturbed Tamafok forest. Seedling and sapling density was lower in undisturbed and mature forest with closed canopy.

Webb and Shah (2003) studied the structure and diversity of natural and managed Sal forests in the Terai of Nepal. They studied the Sagarnath block of the Sagarnath Forestry Development Project (SFDP), a commercial plantation project in Sarlahi district of Central terai in Nepal. They recorded the highest tree species richness in natural forest (37 species) followed by 20 years old successional Sal forest. There were only 9 tree species in 20 years old *Eucalyptus camaldulensis* plantation. They recorded the highest sapling species in the successional Sal forest (37 species) where there were only 15 tree species in the sapling stage in the *Eucalyptus* plantation. The ground flora was most diverse in successional forest (125 species*). Eucalyptus* plantation area included 108 species and natural forest contained 98 species. Shannon index of diversity (H) of tree was highest in the natural forest (2.3). Its values were 0.78 and 0.10 for successional Sal forests and *Eucalyptus* plantation respectively. Number of all trees except *Shorea robusta* was found to be decreased in managed forest. Successional Sal forest had recovered most of the species richness in 20 years.

Subedi (2004) analyzed the vegetation of community managed and government managed forest. She recorded larger number of plant species in community forest than in government forest. Community forest represented a good habitat condition and conservation. Government forest was relatively disturbed and exploited by local people for cattle grazing, fodder and fuel wood collection. Species diversity value for trees was higher in government forest than community forest because of utility driven management plan that maximize forest products than diversity in community forest. Community managed forest was regenerating and was comparatively in better condition than government managed forest.

Gautam and Watnable (2005) compared species composition, distribution and diversity of tree species in grazing/cutting control forest and grazing/cutting forest. Tree species diversity and evenness were higher in the grazing/cutting control forest than in the grazing/cutting forest. They concluded that controlled cutting and grazing is more effective than grazing and cutting in conserving the diversity of tree species.

Duwadee *et al.* (2006) studied species richness of woody species in *Shorea robusta* forest of lower Arun River Basin. They sampled a total of 24 ha forest area. They found altogether 90 plants species belonging to 44 families. They reported the highest number of species in intermediately disturbed area and lowest number in relatively undisturbed site. They concluded that an intermediate level of disturbance particularly the canopy opening can play an important role in maintenance of higher plant diversity.

Kumar *et al.* (2006) analyzed phyto sociological characteristics and diversity patterns of tree species in tropical forests of Garo hills, Western Meghalaya, Northeast India.The main vegetation of the region included Primary Forests (PFs), Secondary Forests (SFs) and Sal plantations. Tree species recorded by the researchers in PFs, SFs and Sal Plantations were 162, 132 and 87 respectively. Primary forests had more tree species rich and diverse than the secondary forests and Sal plantations.

Mishra *et al.* (2006) studied about the evaluation of regeneration of Sal forests under joint forest management (JFM) in West Bengal India. They found that the tree densities have increased tremendously in the JFM protected forests due to coppicing *Shorea robusta* which dominates the forest. Slight protection would enhance the tree density. Sal, being a fast growing species, subsequently enhances Basal area and biomass.

De (2007) studied about the patterns of vegetation diversity in the various strata (trees, shrubs and herbs) in the Rajaji Corbett corridor forest, Uttaranchal, India. In her study the seedlings and saplings showed weak correlation with herbs and shrubs proving that some species of herbs and shrubs are detrimental for regeneration of

trees. The α-diversity was highest for trees, while shrubs showed the highest β-diversity.

Sahu *et al.* (2007) carried out phyto sociological study of Tropical dry deciduous forest of Boudh district of India. Mean tree density was found to be 591 ha^{-1} and mean Basal area 25.50 m^2 ha^{-1}. Tree density and species richness have consistently decreased with increasing girth class of tree species.

Timilsina *et al.* (2007) analyzed Sal forests in the western terai of Nepal. They selected three sites two inside protected areas (Bardia National Park and Shuklaphanta Wildlife Reserve) and third included two proposed community forests (Birendra and Jagdamba Forests of Kanchanpur district). All three areas were at similar elevation. They identified three different associations of Sal forests by cluster analysis. Sal forests were separated on the basis of site ordination. They concluded that rainfall and past disturbances (fire and anthropogenic use) were mainly responsible for different community.

2.2 Regeneration

Rautiainen (1996) studied the regeneration status of Sal (*shorea robusta* Gaertn.) in Bara District, Nepal. He found abundant Sal regeneration throughout the study area. Eighty five percent of the plots in pure Sal and mixed Sal forest had Sal seedlings. Forty one percent of the plots had more than 10,000 Sal seedlings per hectare. Number of seedlings of other timber species was much lower than the number of Sal seedlings in both types of forest. He concluded that there was no problem in germination of Sal seedlings in bhabar zone of Nepal.

Bhattarai (1997) studied the regeneration status of tree species in Sal *(Shorea rubusta)* forest of Bardia national park. He found sustainable regeneration of Sal in terai pure *shorea robusta* and terai mixed *shorea robusta* forest but most of the associated species were without seedlings and saplings.

Chettri (1997) did the research work on vegetation structure and natural regeneration of a protected terai mixed Sal forest in Chitwan National Park. He found higher

seedling density (2, 72,400 ha^{-1}) of Sal in summer but density reduced to 53,600 ha^{-1} in winter due to fire. He suggested control of forest fire and grazing of animal to increase natural regeneration of Sal forest.

Dhungana (1997) studied the regeneration of Sal in Panchkhal, Central Nepal and found more Sal seedlings in private plantation forest (3434 seedlings ha^{-1}) than in community and natural forest. According to her, the higher regeneration of Sal in private plantation forest was due to less human interference. She concluded that natural regeneration of Sal was more in hilly region.

Schnitzer *et al.* (2000) studied the impact of lianas on regeneration of trees in tropical forest of Colorado island, Panama. They studied total of 428 gaps of varying ages 65, 10 and 13^{+} years old. They found positive correlation of liana abundance with pioneer tree abundance and density while negative correlation with non-pioneer tree abundance and density. Density and Basal area of lianas were higher in low canopy gap than in high canopy gap.

Shrestha *et al.* (2000) analysed the vegetation of natural, degraded, Sal regenerating and mixed regenerating forests in chitrepari in siwalik region of central Nepal. In their study, Sal was found to be the dominant species of the plant community except in mixed regenerating forest. Sal sapling was found increasing in the forest where there was less number of other species. Total volume and biomass of trees were higher in natural forest.

Pandey and Shukla (2003) studied the in managed Sal forest (Sohagibarawa Wildlife Sanctuary), Gorakhpur, India to analyse plant diversity, regeneration pattern and status of species conservation. Density of Sal was found highest in the studied forest. In addition to the usual regeneration by seed, a number of species also showed non-seed regeneration through storage roots, sprouts or ramet proliferation. The individuals regenerating as sprouts from underground stem or storage organs contributed significantly to the sum total of individuals/ha. 45% of the total individuals were of ramet origin and shared 10.6% of the total species richness of the forest.

Shrestha (2003) studied the phytoecology of Barandabhar forest at Chitwan, Central Nepal. He recorded a total of 123 flowering plants belonging to 44 families and 99 genera along with the four species of pteridophytes. Sal was the most frequent species with 100% frequency. Sal had good regeneration with high sapling and seedling density in the rainy season. He found negative correlation of density of herbs and seedling with the density of trees.

Bashyal (2005) studied the quantitative analysis and regeneration of *Shorea robusta* and *Terminalia alata* in tropical forests of Palpa district. She recorded 26 tree species in the northern slope of Thuloban forest of Dobhan VDC in Palpa district. Sustainable regeneration of *Shorea robusta* with reverse J-shaped size class distribution was obtained while regeneration of *Terminalia alata* was only sporadic with bell shaped size class distribution. She recorded 1375 Pl/ha seedlings and 562.5 Pl/ha saplings for 209.37 Pl/ha trees of *Shorea robusta*. The density of *Terminalia alata* was lower at seedling (59.37 Pl/ha) and sapling (18.75 Pl/ha) stage than at tree (78.13 Pl/ha) stage.

Sagar *et al.* (2005) examined the impact of disturbance on the diversity pattern, forest structure and regeneration of tree species in the Vindhyan dry tropical forest of India. The site-wise and species wise regression analyses of the number of individuals in different stages of the species revealed that both the level of disturbance and the nature of species strongly affect the regeneration. They concluded that although the forest is relatively species poor, the different species composition on different sites and the temporal dynamics lend a unique level of diversity to the tropical dry deciduous forest.

Shrestha (2005) studied the impact of forest resource use and management practices on community structure and regeneration of locally managed *Shorea robusta* in the mid-hills of central Nepal. He found fair regeneration of *Shorea robusta* with a typical inverse J-shaped size class distribution but the regeneration of *Schima wallichi*, the second dominant species was poor. He suggested that thinning of Sal and restriction in exploitation of other species such as *Schima wallichi* can prevent the forest from becoming monodominant type.

Felton *et al.* (2006) studied vegetation structure, phenology and regeneration in natural and anthropogenic tree fall gaps of a reduced impact logged subtropical Bolvian forest. They recorded higher seedling densities in logging gaps. Members of genus *Heloconia* a common plant of that area characterized by high solar radiation had significantly higher densities in logging gaps. There was lack of shade tolerant species in logging gaps of forest of Bolivia.

Acharya (2007) about vegetation structure, natural regeneration and community management of forest along with physico-chemical characteristics of soil in Parroha Community Forest in Rupandehi district, Nepal. He recorded a total of 125 plant species belonging to 55 families including 36 trees, 50 shrubs and 39 herbs from a total of 0.7 ha. sampling area. He recorded sustainable regeneration of *Shorea robusta* and *Terminalia alata* because density increased from trees, saplings to seedlings with a typical reverse 'J' shaped size class diagram at southeast and southwest slope. The soil was sandy loam and acidic in nature. He found that forest management activities like singling, pruning, thinning etc. were almost passive in the studied forest.

Gautam *et al.* (2007) studied indicator species for the natural regeneration of Sal. They found that soil pH was positively correlated with Sal at seedling stage, slightly negative at sapling stage and negative at mature stage. Soil temperature was negatively related with Sal at seedling and sapling stage and positively (non-significant) related at mature stage. In shrub layer, most of the species (nearly 62%) were positively associated with Sal saplings.

Kandel (2007) studied the vegetation structure and Sal regeneration in two community managed forests of inner Terai (Bandevi Barandabhar Forest, Bharatpur, Chitwan and Dhuseri Community Forest at Rajhar, Nawalparasi, Central Nepal). He found that low quality timber yielding and non-timber species had been overlooked and generally indiscriminately removed during thinning practices. Thus, both forests have been developing into monodominant Sal forests. He found more plant species in weakly managed forest (Dhuseri forest) than actively managed forest (Barandabhar forest). The regeneration of Sal was fairy high in both forests.

Chauhan *et al*. (2008) studied the regeneration status of different Sal forests of Doon valley at Dehradun Forest Division. They classified the studied forests according to regeneration potential. The forests were classified as good regeneration site, fair regeneration site, poor regeneration site and promising regeneration category.

Sapkota *et al.* (2009) investigated the diversity and regeneration of woody species in two ecological niches viz. gap and intact vegetation in old-growth seasonally dry Sal forests in Nepal. They found that stem density of trees and shrub components was higher in the gap than in intact vegetation. Seedling densities of *Shorea robusta* and *Terminalia alata* were higher in the gap than in the intact vegetation. They concluded that gaps maintain species diversity by increasing seedling density and favor regeneration of Sal forests.

2.3 Soil characters

Sollins (1998) studied the possible factors of the soil that influence the species composition in tropical lowlands rain forest. According to him, the soil properties mostly

influencing species composition in lowland tropical rain forest are in decreasing order of importance of P-availability, Al-toxicity, drainage, water holding capacity and availability of K, Ca and Mg.

Malla *et al.* (2001) carried out the research to study in amelioration of soil of degraded forest by regenerated trees in a community forest at Kavrepalanchowk district. The study was carried out at Bokse community forest in 3 plots i.e. degraded plot, plantation plot and regeneration plot. It was concluded that the variations in the soil properties is closely related to their tree densities. The regenerating plot with higher tree density had relatively better soil characteristics while the area with other two plots with lower tree densities had poor soil.

Paudel and Shah (2003) analysed physicochemical characteristics of soil in tropical Sal forests in Udayapur district. They found sandy loam soil in both the pure Sal and mixed Sal forests. The soil pH was lower in pure forest (4.33) than in mixed forest

(5.26). Phosphorous and water holding capacity were also lower in pure forest than in mixed forest. They found higher humus (7.34%), organic matter (2.42%) nitrogen (0.117%) and potassium content (267.73 kg/ha) in soil of pure Sal forest than in mixed Sal forest. According to them, the higher levels of soil nutrients in the pure Sal forest were due to reduction in the loss of top soil and also due to increase in supply of nutrients in the form of leaf litter and biomass from the large number of Sal trees and their saplings. They concluded that the nutrient poor soils found under those forests represented the degraded status of the forest. They suggested that the proper management of the forest will increase the quality of soils and forests.

Shrestha (2003) studied the phytoecology of Barandabhar forest, Chitwan, Central Nepal and found that soil of forest was acidic (pH 4.5-5.5) in all sites with sandy loam texture. The amount of soil nutrients (C, N, P and K) was highest in the rainy season. Soil C, P and K were negatively correlated with pH, tree density and shrub/sapling density while positively correlated with herb and seedling density.

Timilsina *et al.* (2007) analyzed pH, N, organic matter, available P, K and texture of soil of Sal forests in the western terai of Nepal. They identified three different associations of Sal forest (*Shorea robusta* - *Buchhania latifolia* association, *Terminalia tomentosa* - *Shorea robusta* association and *Shorea robusta* - *Cleistocalyx operculatus* association). These associations were clearly separated in the site ordination. None of the environmental variables measures by them (pH, organic matter, nitrogen, phosphorous, potassium and soil texture) explained distribution of plots in the site ordination.

3. STUDY AREA

The study was carried out from October 2007 to August 2008 in community forest named Neware Community Forest (NCF) and protected forest named Kakrebihar protected forest (KPF) in Surkhet district.

3.1 Neware Community Forest (NCF)

Location

Neware community forest lies at $28^0$35' N latitude and $81^0$38' E longitude with elevation range from 690m to 774m asl. The area has sandy loamy soil of yellow colour. The forest covers an area of 124.5 hectares. The forest lies in Jarbuta Village Development Committee (VDC) area, ward no. 4 but the peoples of Neware Village, ward no. 12 are the user's groups of this forest. Towards the east of the forest, the boundary is the source of Gangate Khola along the Salleri Danda. The western boundary is Neware Khola and Guptipur Basti. The northern boundary is the old Devisthan (Dovan of Neware Khola). In the southern region, the boundary is Ambika Community Forest, Bastipur.The forest is in the distance of about 3 km from district headquarter of Surkhet i.e. Birendranagar Municipality.

Social Aspect

There are 422 households in the Forest User's group (FUG) of this community forest. The forest was handed to local community in 1992.Community forest user's group committee constituted members from various ethnic groups such as Brahaman, Chhetry, Magar, Damai and Kami are present. The main occupation of members FUG is agriculture. Most of the FUGs are Hindus.

Climate

The study area has tropical monsoon climate. On the basis of average climatic data of last five years (2003-2007) of nearest weather station i.e. Birendranagar (figure 2), the rainfall was highest in July (577.54mm) and there was no rainfall in November with average annual rainfall 153.33mm. The highest average maximum temperature was recorded in May (34.22^0C) and the lowest average minimum temperature in January (20.56^0C).

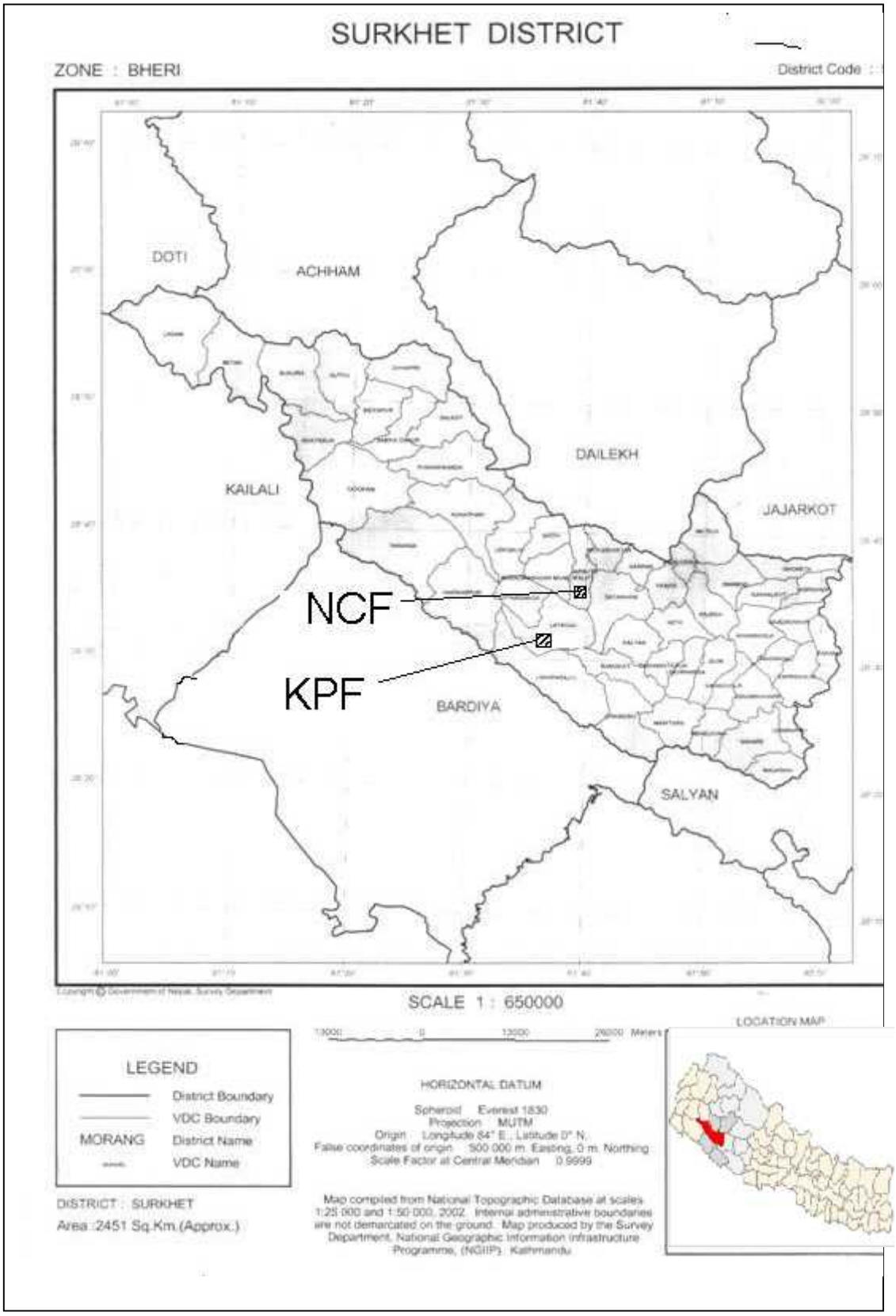

Figure: 1. Map of Surkhet district showing study area

Vegetation

The forest is dominated by Sal (*Shorea robusta*). The major associated species are *Terminalia alata, Syzygium cumini, Lagerstroemia parviflora, Woodfordia fruticosa, Desmodium oojeinense* etc. Some of the planted species are *Dalbergia sissoo, Pinus roxburghii, Melia azederach, Eucalyptus* species etc. Members of FUG have been extracting timber, fodder, litter and fuelwood. Only the fallen trees have been used as the source of timber. Thinning and pruning has been done as a part of forest management. The major fauna found in this forest are jackal, rabbit, snake, lizards, peacock, dove, deer etc.

3.2 Kankrebihar Protected Forest (KPF)

Location

Kankrebihar protected forest lies at $28^0$34' N latitude and $81^0$38' E longitude with height range from 700 m to 750 m asl. The forest has an area of 167.16 hectares. The area has sandy loamy soil of yellow colour. This forest was declared as protected forest by the government of Nepal by publishing in Nepal Rajpatra on 2059/01/30. This is the unique niche of archeology, culture and ecosystem. In this forest, there are the broken parts of huge Kakrebihar temple. The stones scattered there are carved with beautiful images of Hindu and Buddhist Gods and animals. It is also considered as the centre of art and culture. The forest lies among ward no. 2, 6, 8, and 9 of Latikoili Village Development Committee (VDC) area. Northern boundary of Kakrebihar forest is Kunti village. Southern boundary is Patalganga area. Eastern boundary is Nayagaun and Kalimati. Latikoili village forms the western boundary of the forest. The forest is at the distance of 4 km from Birendranagar Municipality.

Social aspect

Most people of this area are Tharus. Peoples of other caste belong to Brahaman, Chhetry, Kami, Damai, Sarki, Raji etc. Agriculture and animal husbandry are the main occupation of the inhabitants of this area. 'Kankrebihar Women Forest Protection major Committee', 'Kankrebihar Protection and Conservation Centre',

Sustainable Development Facility' and other local committees have been established to help in the protection of forest in the local level.

Vegetation

The forest is dominated by Sal (Shorea *robusta*). The major associated species are *Terminalia alata, Syzygium cumini, Salix* species, *Grevillea robusta*, *Lagerstroemia parviflora*, *Woodfodia fruticosa*, *Flemingia* species etc. Some of the planted species are *Pinus roxburghii, Mangifera indica, Psidium guajava* etc. Forest resources are not allowed for using in this forest. Grazing of domestic animals has been banned. There are no silvicultural practicess in the forest. The fauna found here are samber deer, leopard, jackal, rabbit, dove, peacock etc. The climatic data for the Kankrebihar Protected Forest is similar to that for the Neware Community Forest (Figure 2).

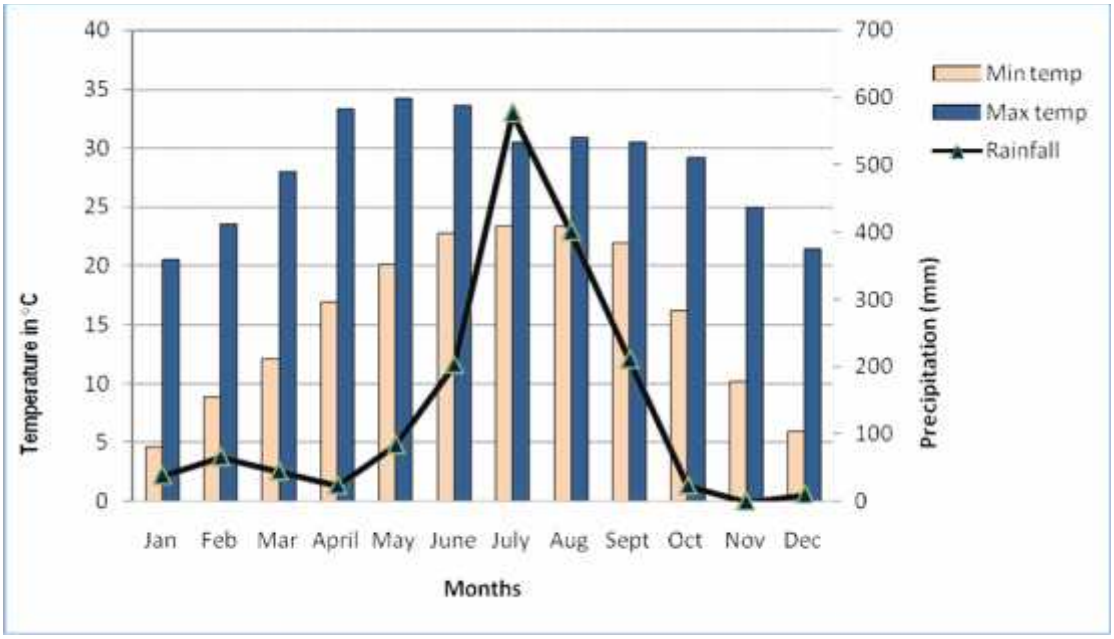

Figure: 2. Five years (2003-2007) average monthly temperature (°C) and rainfall recorded at Birendranagar weather station (28˚36' N, 81˚37', 720m asl, Source: Department of Hydrology and Meteorology, Government of Nepal).

4. MATERIALS AND METHODS

4.1 Field Samplings

4.1.1 Vegetation

For the vegetation sampling systematic random sampling was used in both forests. Square quadrat of 10m×10m was sampled for trees, shrubs (including woody climbers) and herbs (including herbaceous climbers and pteridophytes). Plants were divided into different habitats (tree, shrub and herb) according to Press *et al.* (2000). Quadrats were located in different horizontal strata of forests. The horizontal distance between successive quadrats was about 200m. Fifty quadrats were sampled in each forest. Each 10m⏐10m quadrat was divided into four quarters. Two of them lying diagonally were selected randomly to sample tree saplings and tree seedlings. Herbaria of the plant species were prepared. For the identification of plants, different literatures were used (Siwakoti and Verma, 1999; Storrs and Storrs, 1990 and Hooker, 1885).

In each 10m⏐10m quadrat, tree species [diameter at breast height 1.37m; dbh ≥ 10cm] were noted and dbh of each tree species was measured, shrubs (dbh<10cm, height>1.37m) and herbs (height<1.37m) were noted at each quadrat. Saplings (dbh<10cm, height>1.37m) and seedlings (height<1.37m) of each species were counted in each 5m⏐5m quadrat within large plot of 10m⏐10m in each study site.

4.1.2 Soil

From each quadrat (10m×10m), 200 g soil sample was collected from the four corner of quadrat at a depth of 30cm and mixed them. Soil samples, collected from each study site were air dried in shade for one week and packed in air tight plastic bags until laboratory analysis.

4.1.3 Information about Forest Management

Information about forest management was obtained from Forest User Group committee members of Neware community forest (NCF). The discussion was done to know about the

status of the community forest before and after handover to the community, the activities done to conserve the forest, the problems faced by them in forest management. In case of Kankrebihar protected forest (KPF), discussion was done with the forest protectors, staffs of Department of Forest, members of protection units to know about the status, management activities, problems during protection etc. Discussion was also held with forest user groups of the NCF and local people of KPF area about the complaints and perspectives towards studied forests.

4.2 Soil Analysis

The collected soil was analyzed for pH, nitrogen and organic carbon at Ecology laboratory of Central Department of Botany, Tribhuvan University, Kirtipur, Kathmandu.

4.2.1 Soil pH

The pH is a measure of the hydrogen ion activity of the soil water system. It determines the availability of nutrients, microbial activity and physical condition of the soil. Soil pH was determined by using Fischer's digital pH meter. pH meter was calibrated to buffer solution of pH 7.0, 4.0 and 9.2 before pH measurement.

4.2.2 Soil Nitrogen

Soil nitrogen is the most importance inorganic substance, which is found in different forms in soil like ammonia, nitric acid, nitrate etc. The soil nitrogen was determined by Micro-Kjeldahl method (Gupta, 2000). This method includes the following steps: Digestion, Distillation and Titration.

4.2.2.1 Digestion

1 g air-dried and sieved soil (using 0.5 mm sieve) was taken in a dry Kjeldahl digestion flask (300mL).Then 3.5 g potassium sulphate and 0.4 g copper sulphate (i.e. catalyst) were added to the Kjeldahl flask containing soil. 6ml conc. H_2SO_4 was added to the same flask and shook gently. Then the flask was placed on the preheated (30^0C) heating mantle for digestion. The temperature was raised to about 310^0C. Near the

end of digestion process, the color changed from black to brownish and at the end it became greenish. Then the flask was removed immediately from the mantle and allowed to cool down. 50mL distilled water was added to the digest and the mixture was shook. A blank without soil sample was prepared for each 10-soil samples as reference solution.

4.2.2.2 Distillation

The diluted digest was transferred to Kjeldahl distillation flask. A beaker (100 mL) with 10 mL boric acid indicator was placed below the nozzle of the condenser in such a way that the end of the nozzle dipped into the indicator. After the digest became warm, 30 mL 40% NaOH was added. The distillate began to condense and the colour of boric acid indicator changed from pink to green. The distillation was continued until the volume of distillate in beaker reached to about 50 mL.

4.2.2.3 Titration

The distillate was titrated with 0.1 N HCl. The volume of HCl consumed was recorded. The volume of acid consumed by both blank and samples were noted and the total nitrogen content (N %) was calculated by using following formula:

$$\text{Soil N (\%)} = \frac{14 \mid N \mid (S Z B) \mid 100}{M}$$

Where, N = Normality of HCl

S = Volume of HCl consumed with sample (mL)

B = Volume of HCl consumed with blank (mL)

M = Mass of soil taken (mg)

4.2.3 Organic Carbon

Soil organic carbon (OC) is a major constituent of soil organic matter. It was determined by Walkely and Black rapid titration method (Gupta, 2000).

In this method, 0.5 g air-dried soil was taken in a dry 500 mL conical flask. Then 5mL of 1N $K_2Cr_2O_7$ was pippetted in and swirled a little. Then 10 mL of conc. H_2SO_4 was

added and swirled again two to three times. The flask was allowed to cool down for 30 minutes and then 100 mL distilled water was added. After that 5 mL orthophosphoric acid and 0.5 mL diphenylamine indicator were added in the conical flask containing the mixture. Finally, the content was titrated with 0.5 N ferrous ammonium sulphate till the colour changed from blue violet to green. A blank (without soil) was also run for each 10 soil samples.

$$\text{Soil OC (\%)} = \frac{0.3 \times 5(\text{Blank reading} - \text{Titrating reading})}{\text{Blank reading} \times \text{Soil Mass (g)}} \times 100$$

4.3 Numerical Analysis

4.3.1 Vegetation Structure

The field data was used to calculate Frequency, Relative Frequency, Density, Relative Density, Basal Area, Relative Basal Area and Importance Value Index of tree species following the method described by Zobel *et al.* (1987). The formulae used to calculate these attributes are given below:

$$\text{Frequency (\%)} = \frac{\text{Number of quadrats in which individual species occured}}{\text{Total number of quadrats studied}} \times 100$$

$$\text{Relative Frequency (\%)} = \frac{\text{Frequency of individual species}}{\text{Sum of frequencies of all species}} \times 100$$

$$\text{Density (Pl/ha)} = \frac{\text{Total Number of individual species in all quadrats}}{\text{Total number of quadrat studied} \times \text{area of a single quadrat}(m^2)} \times 10000$$

$$\text{Relative Density (\%)} = \frac{\textit{Density of individual species}}{\textit{Total density of all species}} \times 100$$

$$\text{Basal Area of single tree } (m^2) = \frac{\pi \text{dbh}^2 \times \theta}{4}$$

Where, dbh = diameter at breast height

$\pi = 3.14$

Basal area of a species in each quadrat was obtained by adding the BA of all individuals of a species. BA was expressed in % using the following formula:

$$\text{Basal Area of a species (\%)} = \frac{\text{Total Basal Area of a species}}{\text{Total Area sampled}} \times 100$$

$$\text{Relative Basal Area (\%)} = \frac{\text{Basal Area of individual species}}{\text{Total Basal Area of all species}} \times 100$$

Importance value index (IVI) gives the overall importance of each species in the community. For trees, it was calculated as the sum of relative frequency, relative density and relative Basal area.

Importance Value Index (for trees) = Relative frequency + Relative Density + Relative Basal Area

4.3.2 Species Diversity

Species diversity is the combination of species richness and species evenness. Species richness is the number of individual species per sampling area. Species evenness is the distribution of individual species among other species. Species evenness is Maximum when all the species have same or nearly equal number of individuals. For the calculation of species diversity, the Shannon-Weiner's Index 'H' (1963) with mathematical manipulation by Zobel *et al.* (1987) was used.

$$\text{Shannon-Weiner's Index (H)} = 3.3219 \frac{(N \log N - \sum n_i \log n_i)}{N}$$

Where, N = Sum of total number of individuals of all species.

n_i = Number of individuals of a species

K=Number of species

4.3.3 Beta (β) Diversity

Beta (β) diversity is a measure of species turnover across various habitat types. So it is also called as interhabitat diversitiy. It is the difference in species diversity between communities, which represents the difference in species composition. The Whittaker's β diversity (βw) was calculated using the following formula (Magurran, 2004).

$$\beta w = \frac{S}{\sim} - 1$$

Where, S = Total number of species found in both sites.

$\bar{\sim}$ = Average of total number of species found in two sites.

The value of β diversity ranges from O (complete similarity) to 1 (complete dissimilarity) for two sites.

4.3.4 Index of Similarity (IS)

Similarity Index is used to obtain the degree of similarity between any two communities. Similarity Index is a community coefficient, which depends on the quantitative phytosociological characters of species common to both communities. Higher the index value, more similar will be the communities. For calculation of similarity Index, following formulae were used.

Jaccard's Similarity Index (IS_J) = $\frac{C}{A \Gamma B Z C} | 100$

Sorensen's Similarity Index (IS_S) = $\frac{2C}{A \Gamma B} | 100$

Where, IS = Index of similarity

A = Total number of species in one community
B = Total number of species in another community
C = Number of species found in both communities

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

4.3.5 Regeneration of Sal (Size class distribution diagram)

Size class distribution diagram was used to predict the regeneration behaviour of trees. All the trees of Sal were divided into dbh classes of 5cm interval (e.g. 10-15 cm, 15-20 cm, 20-25 cm…) and density of Sal in each diameter class was calculated. Size class distribution diagram was obtained by plotting diameter class on x-axis and density on y-axis. Percentage of seedling, sapling and tree of Sal population were calculated and represented in a bar diagram.

4.4 Statistical Analysis

Spearman's correlation coefficients were determined among the vegetation attributes and soil parameters in each study site. Linear regression analysis was done to

establish relations among vegetation attributes and soil characters. The relevant and significant relations obtained by regression analysis were reported in the results. The statistical analyses were done using Statistical Package for Social Science (SPSS) version 11.5.

5. RESULTS

5.1 Vegetation Structure

5.1.1 Neware Community Forest

In Neware community forest (NCF), 15 species were recorded at tree stage. *Shorea robusta* was the dominant tree species with the highest Importance Value Index 218 (Table 1). *Terminalia alata* had the second highest Importance Value Index of 11. Out of fifteen tree species, thirteen tree species had Importance Value Index less than ten. The tree density ranged from 4 to 962 Pl/ha. The total tree density of all species was found 1116 Pl/ha (Table 1). The Basal area ranged from 0.0004% to 0.1309%. The total Basal area of all tree species was found 0.1467% (Table 1). *Dalbergia sissoo* and *Pinus roxburghii* were the planted tree species in this forest.

In shrub layer, 31 species were found including climbers and sapling of trees (Annex 1). Among them, 12 species were sapling of trees. Sapling density of *Shorea robusta* was 4484 Pl/ha (Annex 3). *Lagerstroemia parviflora, Holoptelia integrifolia, Engelhardia spicata, Bombax ceiba, Pinus roxhurghii, Psidium guajava, Ficus semicordata* and *Ficus religiosa* were found only in sapling stage. *Asparagus racemosus*, a medicinal plant was also found in this forest.

In herbaceous layer, 39 species were recorded including herbaceous climber, seedlings of woody species and pteridophytes (Annex 1). Among them 8 species were seedlings of trees. Seedlings of *Shorea robusta* were the most abundant with density 6758 Pl/ha (Annex 3). Seedling density of other woody species was much lower than that of *Shorea robusta*. Trees such as *Desmodium oojeinense, Rhus wallichi, Engelhardia spicata, Mallotus philippensis, Dalbergia sisso, Bombax ceiba, Holoptelia integrifolia, Toona ciliata, Cleistocalyx operculata* and *Pinus roxburghii* had no seedlings. *Curculigo orchioides*, a medicinal plant was also recorded in NCF.

Table: 1. Density (D), Relative Density (RD), frequency (F), Relative frequency (RF), Basal Area (BA) Relative Basal Area (RBA) and Importance Value Index (IVI) of tree species at Neware Community Forest.

S.N.	Plant species	D (Pl/ha)	RD (%)	F (%)	RF (%)	BA (%)	RBA (%)	IVI
1.	*Shorea robusta*	962	86.20	100	42.73	0.1309	89.22	218.15
2	*Terminalia alata*	24	2.15	18	7.69	0.002	1.36	11.2
3	*Lagerstroemia parviflora*	18	1.61	16	6.83	0.0016	1.09	9.53
4	*Holoptelia integrifolia*	16	1.43	14	5.98	0.0014	0.95	8.36
5	*Desmodium oojeinense*	14	1.25	14	5.98	0.0014	0.95	8.18
6	*Cleistocalyx operculata*	12	1.07	8	3.41	0.0026	1.77	6.25
7	*Toona ciliata*	14	1.25	10	4.27	0.001	0.68	6.2
8	*Syzygium cumini*	12	10.7	10	4.27	0.001	0.68	6.02
9	*Engelhardia spicata*	10	0.89	10	4.27	0.001	0.68	5.84
10	*Rhus wallichi*	10	0.89	8	4.27	0.001	0.68	5.84
11	*Mallotus philippensis*	8	0.71	8	3.41	0.0012	0.81	4.93
12	*Dalbergia sissoo*	4	0.35	4	1.7	0.0004	0.27	2.32
13	*Pinus roxburghii*	4	0.35	4	1.7	0.0004	0.27	2.32
14	*Litsea monopelata*	4	0.35	4	1.7	0.0004	0.27	2.32
15	*Bombax ceiba*	4	0.35	4	1.7	0.0004	0.27	2.32
	Total	1116	99.92	234	99.91	0.1467	99.95	299.78

5.1.2 Kankrebihar Protected Forest

In Kakrebihar protected forest, thirteen species were recorded at tree stage. Tree density ranged from 4 to 1008 Pl/ha. The total tree density was 1120 Pl/ha (Table 2). The Basal area ranged from 0.0004 to 0.2097%. The total Basal area of all trees was 0.223% (Table 2). *Shorea robusta* was the dominant tree species with the highest Importance Value Index of 232 (Table 2). The second dominant tree species was *Terminalia alata* with importance value index 10. Out of thirteen tree species, eleven species were with IVI less than ten. *Psidium guajava, Pinus roxburghii* and *Melia azederach* etc. were the planted species in this forest.

In the shrub layer, 32 species were present including climbers and sapling of trees (Annex 2). There were twelve species of trees in their sapling stage. Sapling density of *Shorea robusta* was 422 Pl/ha (Annex 3). *Cleistocalyx operculatus, Lagerstroemia parviflora, Psidium guajava, Terminalia alata, Lannea coromendelia, Engelhardia spicata* and *Pinus roxburghii* were not found in sapling stage. *Rhus wallichi, Sapindus mukorossi, Ficus semicordata* and *Toona ciliata* were found only in sapling stage. *Asparagus racemosus,* an important medicinal plant was also found in this forest.

There were 49 herb species in Kankrebihar forest including herbaceous climber, seedlings of woody plants and pteridophytes (Annex 2). Eleven species were the seedlings of trees. Seedling density of *Shorea robusta* was 4422 Pl/ha (Annex 3). *Lagerstroemia parviflora* and *Pinus roxburghii* had no seedlings. *Pyrus pashia* was found only in seedling stage. Medicinal plant named *Curculigo orchioides* was also found in this forest.

Table: 2. Density (D), Relative Density (RD), frequency (F), Relative frequency (RF), Basal Area (BA) Relative Basal Area (RBA) and Importance Value Index (IVI) of tree species at Kankrebihar Protected Forest.

S.N.	Plant species	D (Pl/ha)	RD (%)	F (%)	RF (%)	BA (%)	RBA (%)	IVI
1.	*Shorea robusta*	1008	90	100	48.54	0.2097	93.74	232.28
2	*Terminalia alata*	18	1.60	16	7.76	0.0026	1.16	10.52
3	*Syzygium cumini*	14	1.25	14	6.79	0.0018	0.80	8.84
4	*Engelhardia spicata*	14	1.25	14	6.79	0.0014	0.62	8.66
5	*Mallotus philippensis*	12	1.07	10	4.85	0.001	0.44	6.36
6	*Lagerstroemia parviflora*	12	1.07	10	4.85	0.001	0.44	6.36
7	*Desmodium oojeinense*	10	0.89	10	4.85	0.001	0.44	6.18
8	*Cleistocalyx operculata*	6	0.53	6	2.91	0.0008	0.35	3.79
9	*Psidium guajava*	6	0.53	6	2.91	0.0008	0.35	3.79
10	*Lannea caromandelia*	6	0.53	6	2.91	0.0006	0.26	3.7
11	*Melia azederach*	6	0.53	6	2.91	0.0004	0.17	3.61
12	*Pinus roxburghii*	4	0.35	4	1.94	0.002	0.89	3.18
13	*Ficus religiosa*	4	0.35	4	1.94	0.0006	0.26	2.55
	Total	1120	99.95	206	99.95	0.2237	100	299.82

5.2 Species richness and species diversity

Altogether 68 plant species were recorded in the Neware Community Forest and 80 species in the Kankrebihar forest (Annex 1 and 2). Tree species richness (|ℑ) and tree species diversity (H) was higher in Neware forest than in Kankrebihar forest (Table

3). There was no significant difference in shrub species richness and herb species richness in these forests.

Table: 3. Total number of species, Species richness (α) and Species diversity (H) in Neware Community Forest (NCF) and Kankrebihar Protected Forest (KPF)

Plant habit	Total number of species		Species richness(α)		Species diversity (H)	
	NCF	KPF	NCF	KPF	NCF	KPF
Tree	15	13	3.48	2.86	1.076	0.81
Shrub/sapling	31	33	3.9	3.3		
Herb/seedling	33	47	3.62	3.44		

5.3 Beta (β) diversity

The β diversity for trees was the highest (0.5) between the two forests while β diversity for shrubs/saplings was the lowest of value 0.28 (Table 4).

Table: 4. Beta diversity between Neware Community Forest and Kankrebihar Protected Forest

Plant habit	β-diversity
Tree	0.50
Shrub/sapling	0.28
Herb/Seedling	0.45

5.4 Index of Similarity (IS)

Jaccard's and Sorensen's similarity indices were found highest for shrubs/saplings i.e. 56.09% and 71.87% respectively. These similarity indices were least for herbs/seedlings with the value 37.28% and 54.32% respectively. Trees had the Jaccard's Similarity Index (IS_J) 38.09% and Sorensen's Similarity Index (IS_S) 57.14% (Table 5).

Table: 5. Jaccard's Similarity Index (IS_J) and Sorensen's Similarity Index (IS_S) of plant species between Neware Community Forest and Kankrebihar Protected Forest

Plant habit	IS_J (%)	IS_S (%)
Trees	38.09	57.14
Shrub/sapling	56.09	71.87
Herb/seedling	37.28	54.32

5.5 Population Structure and Regeneration of *Shorea robusta*

In Neware Community Forest, 55.37% seedlings, 36.74% saplings and 7.88% trees of Sal represented the population structure of Sal. (Figure 3).Greater numbers of plants were found in lower size classes. The size class distribution diagram resembled reverse J-shape (Figure 4). In size classes 50-55 cm, 55-60 cm and 65-70 cm, no

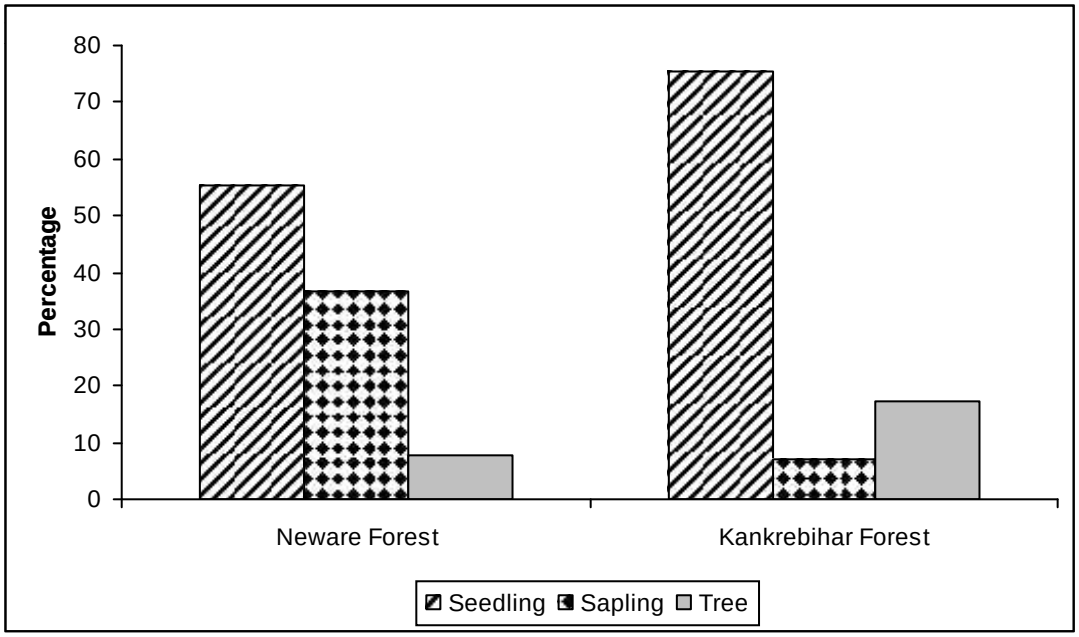

Figure: 3. Percentage of trees, saplings and seedlings of Sal population in Neware Community Forest and Kankrebihar Protected Forest

In Kankrebihar Protected Forest, the percentage of seedlings, saplings and trees in the population of Sal were 75.56%, 7.21% and 17.22% respectively (Figure 3). There were greater numbers of plants in lower size classes. The size class 35-40 cm had no population. The size class distribution diagram resembled nearly J-shape (Figure 5).

Figure: 4. Density of different diameter classes of *Shorea robusta* in Neware Community Forest

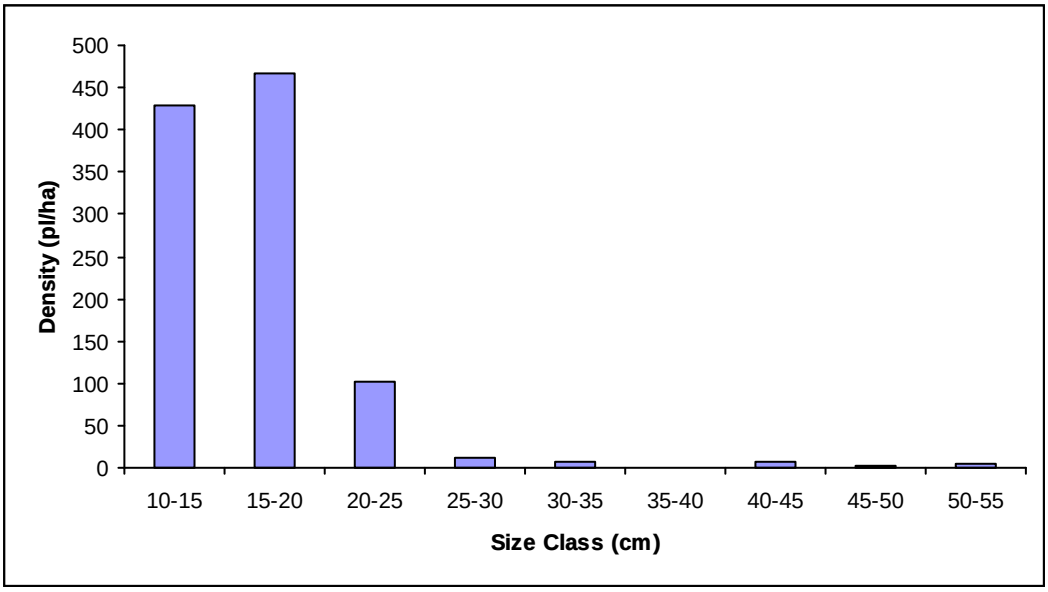

Figure: 5. Density of different diameter classes of *Shorea robusta* in Kankrebihar Protected Forest

In both forests seedling density of Sal was much higher than the total seedling density of all other tree species (figure 6).

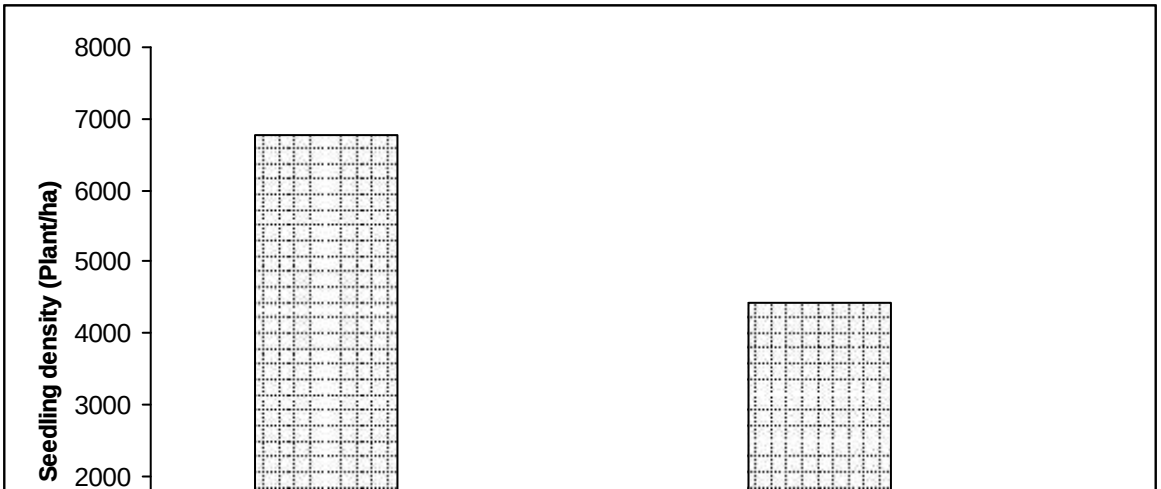

Figure: 6. Seedling density (Pl/ha) of Sal and other trees in Neware Community Forest and Kankrebihar Protected Forest

5.6 Soil Characters

Soil was acidic in both forests and the average soil pH was significantly higher in Neware community forest than in Kankrebihar protected forest (p Φ0.05). Soil pH of the Neware forest ranged from 5.16 to 6.49 and in Kankrebihar forest, it ranged from 5.16 to 6.90 % (Table 6). The soil nitrogen (N) of Neware forest was 0.029±0.016 and that of Kankrebihar forest was 0.024±0.010 %. The average organic carbon in Neware forest was found 0.72±0.42% and in Kankrebihar forest was found 0.74±0.35% (Table 6).

Table: 6. Mean (ïSD) values of soil attributes of two forests. Values in the parentheses indicate the range.

Soil attributes	Forests		Statistics*	
	Neware CF	Kankrebihar PF	F value	P value
Soil pH	5.83ï 0.44 (5.16-6.90)	5.66ï 0.36 (5.12-6.62)	4.77	0.031
Soil OC (%)	0.72±0.42 (0.07-1.78)	0.74ï 0.35 (0.13-1.6)	0.085	0.772
Soil N (%)	0.029±0.016 (0.014-0.056)	0.024ï 0.010 (0.014-0.042)	2.64	0.107

*Based on comparison of mean values of two forests using one way ANOVA

Table: 7. Mean (ïSD) values of vegetation attributes of two forests. Values in the parentheses indicate the range.

Community attributes	Forests		Statistics*	
	Neware CF	Kankrebihar PF	F value	P value
Herb species richness (Species/100m^2)	3.62±1.15 (1-7)	3.32±1.74 (1-8)	1.027	0.313
Shrub species richness (Species/100m^2)	3.94±1.70 (1-9)	3.26±2.13 (1-9)	3.092	0.082
Tree species richness (Species/100m^2)	2.96±1.30 (1-6)	1.82±0.74 (1-3)	28.6	0.000
Total plant species richness (Species/100m^2)	10.52±2.66 (4-16)	8.4±3.16 (3-17)	13.10	0.000
Total tree basal area (%)	0.13±0.11 (0.03-0.67)	0.21±0.12 (0.02-0.58)	9.16	0.003
Total tree density (Pl/ha)	1056±459.44 (400-2600)	1072±501.03 (100-2400)	0.027	0.86
Sal sapling density (Pl/ha)	9470±3894.01 (3200-21200)	728±756.74 (0-3600)	242.82	2.84
Sal seedling density(Pl/ha)	13120±7660.12 (1200-33600)	9696±10374.48 (400-50400)	3.52	0.063

* Based on comparison of mean values of two forests using one way ANOVA

5.7 Comparision of two forests

Analysis of Variance (ANOVA) test indicated that tree species richness and total plant species richness were significantly higher in Neware CF than in Kankrebihar PF

(p Φ0.01). There was no significant difference between the other vegetation attributes measured in these forests.

5.8 Relations among the vegetation attributes and soil characters

In case of Neware community forest (NCF), linear regression analysis showed that shrub species richness decreased on increase in canopy (Figure 7) and seedling density of Sal decreased on increase in density of Sal trees (Figure 8). In Kankrebihar forest, Seedling density of Sal decreased on increase in canopy coverage (Figure 9) and Sal sapling density decreased on increase in total tree Basal area (Figure 10). The significant correlations among the vegetation attributes and soil characters are shown in the following table.

Table: 8. Correlation Coefficients between various vegetation attributes and soil characters in Neware Community Forest

Attributes		Correlation coefficients	Significance level (P)
Total tree density	Sal tree density	0.70**	0.000
	Total BA	0.73**	0.000
	Sal BA	0.62**	0.000
Sal tree density	Total BA	0.67**	0.000
	Sal BA	0.76**	0.000
	Sal seedling density	-0.42**	0.002
	Total seedling density	-0.43**	0.002
Total BA	Sal BA	0.95**	0.000
Sapling density	Sal sapling density	0.94**	0.000
	Sal seedling density	0.33*	0.017
	Seedling density	0.34*	0.015
Sal sapling density	Sal seedling density	0.30*	0.032
Seedling density	Sal seedling density	0.97**	0.000
Herb species richness	Total species richness	0.39**	0.005
Shrub species richness	Total species richness	0.73**	0.000
	Canopy	-0.35*	0.011
Tree species richness	Total species richness	0.64**	0.000

* Correlation significant at $P < 0.05$ ** Correlation significant at $P \leq 0.01$

Table: 9. Correlation Coefficients between various vegetation attributes and soil characters in Kankrebihar Protected Forest

Attributes		Correlation coefficients	Significance level (P)
Total tree density	Sal tree density	0.82**	0.000

	Total BA	0.767**	0.000
	Sal BA	0.74**	0.000
	Sal sapling density	-0.36**	0.009
	Canopy	0.32**	0.023
Sal tree density	Total BA	0.68**	0.000
	Sal BA	0.765**	0.00
	Total seedling density	-0.37**	0.008
Total BA	Sal BA	0.96**	0.000
	Sal sapling density	-0.29*	0.039
	Canopy	0.313*	0.027
Total sapling density	Sal sapling density	0.64**	0.000
	Total seedling density	0.30*	0.031
Total seedling density	Sal seedling density	0.97**	0.000
Sal seedling density	Herb species richness	-0.29*	0.037
	Tree species richness	-0.3*	0.034
	Canopy	-0.285*	0.045
Herb species richness	Total species richness	0.63**	0.005
	Nitrogen	-0.33*	0.019
Shrub species richness	Total species richness	0.79**	0.000
Tree species richness	Total species richness	0.30**	0.029
	Nitrogen	0.29*	0.037
Canopy	Litter thickness	0.46**	0.001

* Correlation significant at $P < 0.05$ ** Correlation significant at $P < 0.01$

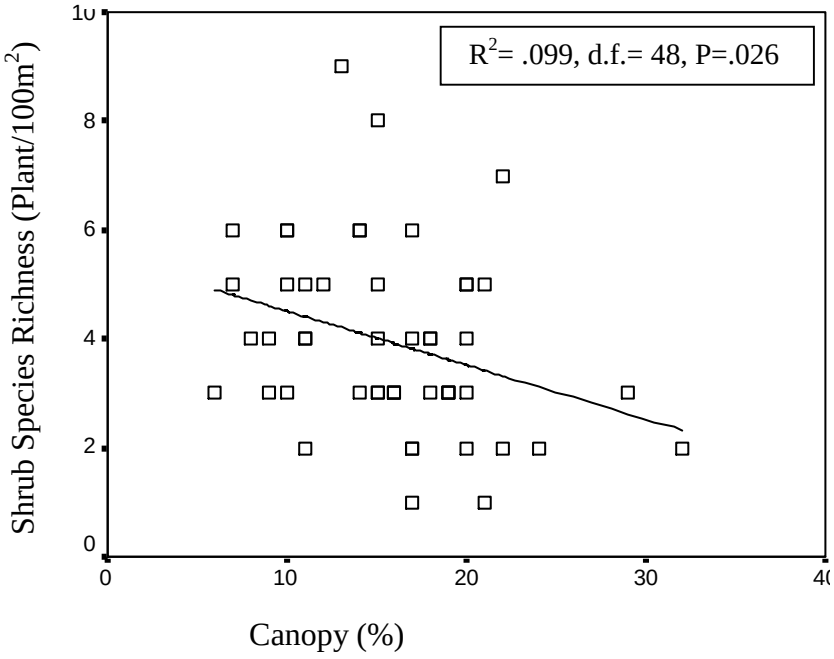

Figure: 7. Relationship between shrub species richness and canopy coverage in Neware CF

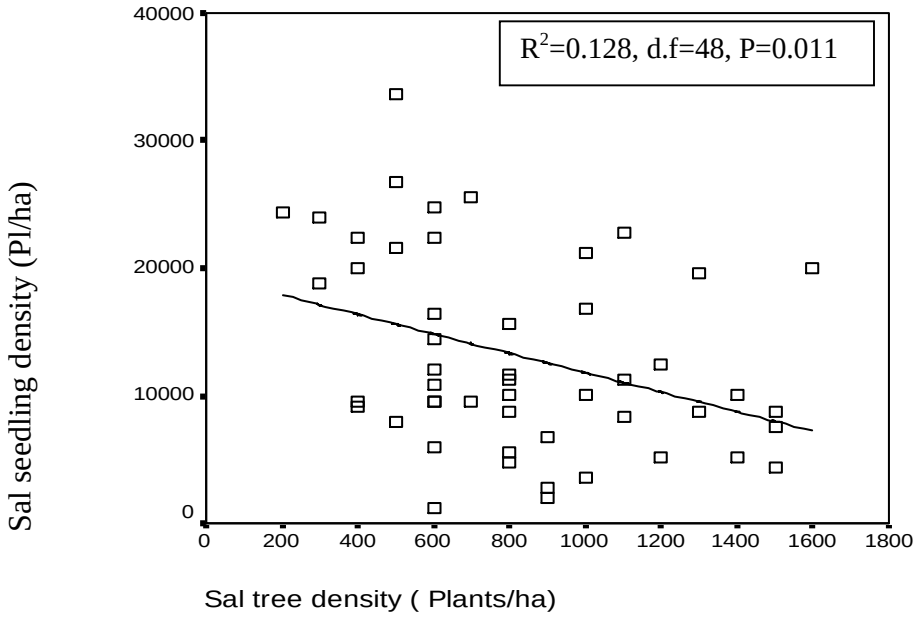

Figure: 8. Relationship between sal seedling density and sal tree density in Neware CF

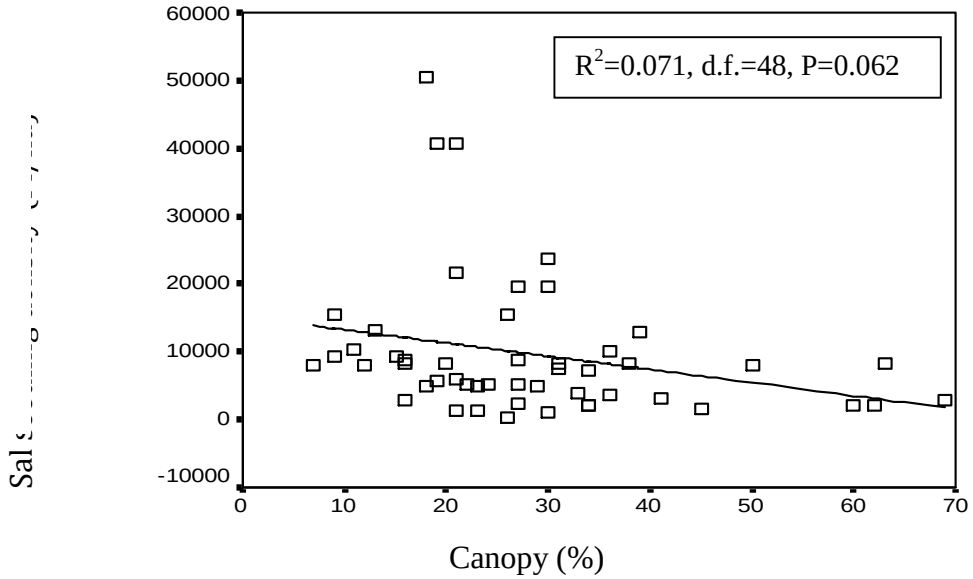

Figure: 9. Relationship between sal seedling density and canopy coverage in Kankrebihar PF

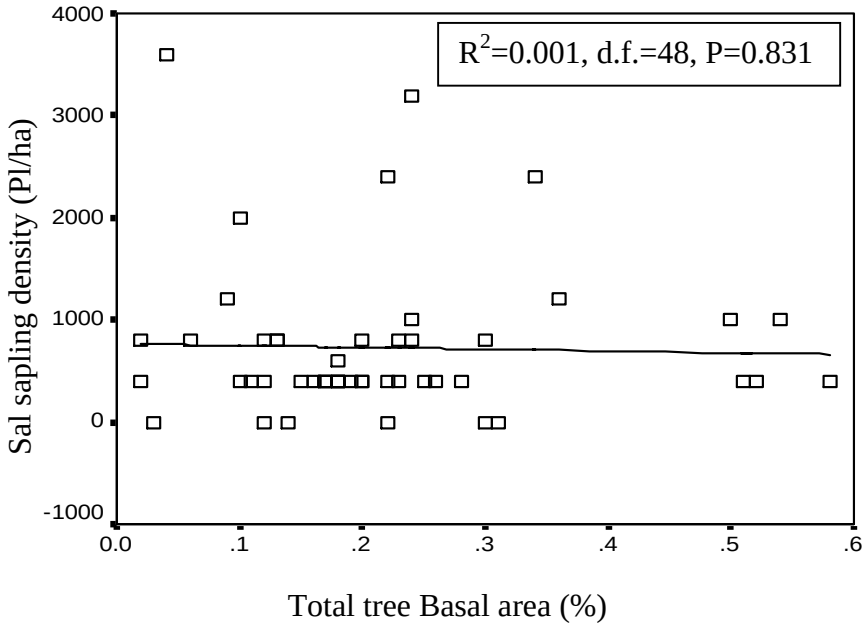

Figure: 10. Relationship between sal sapling density and total tree Basal area in Kankrebihar PF

5.9 Forest Management

5.9.1 Neware Community Forest

In this forest only fallen trees of Sal have been used for timber. The use of Sal for fuelwood and fodder has been banned in this forest. Thinning has been done at interval of 3 years to increase the regeneration of valuable tree species. Importance has been given for the conservation of trees such as *Shorea robusta, Terminalia alata, Syzygium cumini* etc. during thinning process. However *Shorea robusta* has been given the first priority for the conservation. Free grazing of domestic animals has been prohibited. The forest has been opened for 5/6 days in a year. For collection of fuelwood, each person should pay Rs. 10 per day. People can cut dead trees and fallen branches for fuelwood. The Forest User Groups (FUGs) had kept two forest-guards to safeguard the forest on payment basis. The main resources extracted from the forest are timber, fuel wood and fodder. Timber and fuelwood come from dead and fallen logs. Generally grasses, *Woodfordia fruticosa*, *Flemingia strobilifera* etc. were found to be used for fodder by the villagers. The FUG committee used to sell 1 cubic feet wood in Rs. 370. Sometime illegal activities can take place for the collection of forest resources. Members of committee punish those people who collect the forest resources illegally. Medicinal plants like *Asparagus racemosus, Curculigo orchioides, Xanthoxylum armatum* etc. are found in this forest. Commercial collection of these medicinal plants from this forest was not reported. Re establishment of Forest user group committee was found in each two years.

5.9.2 Kankrebihar Protected Forest

In this forest, use of *Shorea robusta* as well as other trees for any use has been strictly prohibited. The military guards and the forest rangers were found safeguarding the forest. Some forest protection units such as 'Kankrebihar protection and conservation centre', 'Kankrebihar women forest protection major committee' 'Sustainable Development Facility centre' have been established for the better protection of Kankrebihar forest. The aim of conservation is to conserve the cultural heritage, ecosystem and environment found there and to promote ecotourism in this area. Although there are some means of protection, the people living around the forest used to collect the forest resources illegally.

6. DISCUSSIONS

6.1 Vegetation Composition

Density of Sal trees was higher in protected forest with value 1008 Pl/ha (Table 2) than that in community forest with value 962 Pl/ha (Table 1).This might be due to the better protection in protected forest. The value found in the community forest was higher than the values reported by Kandel (2007) in community forest of Chitwan (202 Pl/ha), Shrestha (2005) in community forest of Gorkha (909 Pl/ha) and Bashyal (2005) in Sal forest of Palpa district (209 Pl/ha).

There was no significant difference between Total tree density in the studied forests. Total tree density of Neware forest was 1116 Pl/ha (Table 1) and that of Kankrebihar forest was 1120 Pl/ha (Table 2). These values were higher than the values reported for Sal forest by Bashyal (2005) in tropical forest of Palpa district (654 Pl/ha), Acharya (2007) in community forest of Rupandehi district (452 Pl/ha), Sahu *et al.* (2007) in tropical forest of India (591 Pl/ha). The total tree density obtained was lower than the values obtained by Marasini (2003) in Churia forest of Rupandehi district (1153 Pl/ha), Duwadee *et al.* (2006) in Arun River Basin (1125 Pl/ha). Shrestha *et al*. (2000) in Chitrepani (Siwalik region) of Makawanpur district (1326 Pl/ha). The low value of total tree density in the present study area than in the reported tropical forests might be due to over exploitation of the studied forests in the past.

The Basal area is an important criterion for evaluating the timber production in forest ecosystem (Agrawal, 1992). Total tree Basal area was found significantly higher ($p \Phi 0.01$) at Kankrebihar PF (0.22%) than in Neware forest (0.14%). This was due to presence of larger and greater number of trees at KPF. These values were higher than the value obtained by Timilsina *et al.*

, *(*2007) in Sal forest of western terai (0.13%) Webb and Shah (2003) in natural forest of terai (0.11%). Total Basal area of trees in both forests was lower as compared to other parts of Nepal (Giri *et al.*, 1999), Duwadee *et al.*, (2006), Marasini (2003), Bashyal (2005) and India (Sahu *et al.*, 2007, Bauduni and Sharma, 2001). Total tree Basal area of KPF was higher than the value found in Barandabhar forest (Kandel, 2007) but the value obtained in the community forest (NCF) was lower than the value obtained in the same forest (Kandel, 2007). The low Basal area in the studied forest might be due to absence of Sal plants in some size classes and disturbances in these forests in the past.

The IVI of *Shorea robusta* was found highest in both forests (218 in NCF and 232 in KPF) among all the tree species (Table 1 and 2). This indicates that *Shorea robusta* is the most important and dominant species in both forests. Importance value index (IVI) in neware community forest was higher (Table 1) than IVI of Sal in a forest of inner terai (127) reported by Acharya (2007). In the Neware community forest and Kankrebihar protected forest, Sal contributed more than 70% of IVI. So these forests can be said as monodominant Sal forests (Negi *et al*., 2002). Monodminant condition has been also reported in some community managed Sal forests in mid hill (Shrestha, 2005), Inner terai (Acharya *et al.*, 2006; Kandel, 2007). Monodominancy of Sal species might be due to conservation of Sal at the expense of other low quality timber yielding plants.

Total plant species richness, tree species richness and tree species diversity were found higher in Neware community forest than in Kakrebihar protected forest (Table 7). This might be due to the planted species like *Dalbergia sisso, Pinus roxburghii, Eucalyptus species* etc. in NCF. Past disturbances might help in low tree species richness and tree species diversity in KPF.

Beta diversity between NCF and KPF was highest for the trees and lowest for the shrubs/saplings (Table 4).This indicates that these sites are more heterogeneous for the trees than for the herbs/seedlings and shrubs/saplings.

The highest similarity index for shrub/sapling between two sites (Table 5) might be due to similar climatic and environmental conditions. The similarity index for herb/seedling was low. It might be due to differences in management activities such as cutting of grass, animal grazing etc. These activities were allowed in community forest but it was banned in protected forest.

6.2. Forest Regeneration and Management

The seedling and sapling densities of Sal were found higher in Neware community forest (NCF) than in Kankrebihar forest (KPF). Total Basal area of trees was lower in NCF than in KPF. So, it can be assumed that the tree canopy of NCF was more open than in KPF. The high seedling and sapling densities of Sal might be due to the open canopy.The open canopy allowed sufficient light and temperature which is favourable for the abundant growth of seedlings and saplings of light demanding species like Sal (Gautam *et al.* 2006).

Smallest size class (10-15cm) of Sal had the highest density in NCF, which showed that there is continuous regeneration in present time. But in KPF highest density was found in second size class (15-20cm). Population of Sal tree was absent in some size classes in both the forest. Such situation was also obtained by Shrestha (2005) in two community forests of Nepal. It might be due to the disturbance in the studied forests in the past. Litter thickness was found more in KPF, which might restrict the germination and growth of seedlings of Sal properly. This might be the cause for less regeneration of Sal in KPF. However, reverse J shaped structure showed that the regeneration status of both forest was found good.

Seedlings and saplings together constituted about 90% in NCF and 80% in KPF (Figure 3).Thus regeneration potential of Sal was high in both forests. Rautiainen (1996) and Webb and Shah (2003) also reported good regeneration of Sal in the terai of Nepal However regeneration potential of other trees was very low since the combined density of seedlings of all other trees was very low (Figure 6). Timilsina *et*

al. (2007) also reported low mean seedling density (0.861 pl/m^2) of all other tree species in comparison to Sal (7.0462 pl/m^2) in Sal forest of western terai.

People's attitude towards both forests has changed. They think that the forest is their property and conservation of the forest should be done. But in the community forest the people were not aware for the conservation of all plant species.

6.3 Soil Characters

The soil pH of Neware CF was significantly higher than in Kakrebihar PF (p Φ0.05). More litter was found in KPF resulting more humus content. So the acidity of KPF might have increased. Soil of both the forests was acidic. (5.66 in KPF and 5.82 in NCF). Soil pH range of 5.5 to 6.5 is the most suitable acidic condition for most plants (Brady and Well, 2002). Soil pH obtained was higher than the soil pH obtained by Paudel and Shah (2003) in tropical Sal forest of Udayapur district (4.33) and Shrestha (2003) in Barandabhar forest, Chitwan, Nepal (5.0).

The soil Nitrogen in Neware CF and Kankrebihar PF were 0.029% and 0.024% respectively, but difference was not significant. These values were lower than the value reported by Acharya (2007) in community forest of terai of Nepal (0.13%), Kandel (2007) in community forest of inner terai of Nepal (0.18%).

Soil organic carbon obtained in KPF was 0.72% and in NCF was 0.74%. No significance difference was obtained for soil OC. These values were lower than the values obtained by Kandel (2007) in Sal forest of inner terai (1.52%) and Acharya (2007) in Sal forest of terai (2.14%).

6.4 Relations among vegetation characters and soil characters

Linear regression analysis showed that there was decrease in shrub species richness on increase in canopy in Neware Community Forest (Figure 7). Canopy might have restricted the germination and growth of shrub species. In this forest, Sal seedling

density decreased on increase in Sal tree density (Figure 8). The canopy formed by Sal trees might be the cause for this response.

In KPF, Sal seedling density decreased on increase in canopy (Figure 9). High canopy coverage is not suitable for the growth of light demanding species like Sal (Gautam *et al.* 2006). So Sal seedlings might have decreased. Sapling density of Sal decreased on increase in total tree Basal area (Figure 10). Because of more Basal area, there might be less area for establishment of Sal saplings. This result is similar to the result of Kandel (2007).

7. CONCLUSIONS

- Density of Sal was found good in Neware community forest (NCF) and Kankrebihar protected forest (KPF). Density of other tree species was low.
- Regeneration of *Shorea robusta* was found good in studied forests.
- Both the forests were found to be monodominant Sal forests.
- After declaration of Kankrebihar forest as protected forest, conservation activities by some protection groups have been increased.
- Some medicinal plants were found in both forests but they were not commercially extracted or cultivated.

8. RECOMMENDATIONS

On the basis of present study, following recommendations have been suggested: -

- Proper attention should be given for the conservation of low quality timber yielding and other commercially less importance plant species. During thinning process, these species should be protected because they are importance for balanced ecosystem. If it is done biodiversity is protected.
- Medicinal plants such as *Asparagus racemosus, Curculigo orchioides, Xanthoxylum armatum* were present at Neware community forest. Similarly, these medicinal plants along with other medicinal plants such as *Piper cubeba, Cinnamomum camphora, Justicia adhatoda* were present in Kankrebihar protected forest. These plants can be extracted and planted commercially.
- Further studies**:** studies related to following subjects can be done:

- ✓ Study about identification and management of non timber forest products can be conducted.
- ✓ Impact of conservation in KPF can be studied.

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ANNEXES

Annex – 1

List of Plants Found in Neware Community Forest

Herb species			
S.N.	Name of Herb plants	Local name	Family
1	*Ageratum conyzoides* L.	Gandhe jhar	Compositae
2	*Ariopsis* species	Karkalo	Araceae
3	*Arisaema tortuosum* (Wall.) Scholt	Banko	Araceae
4	*Bidens biternata* (Lour.) Merr. and Sherff.	Kuro	Compositae
5	*Borreria* species	Goyali	Rubiaceae
6	*Centella siatica* (L.) Urban.	Ghodtapre	Umbelliferae
7	*Cheilanthes albomarginata* C.B. Clarke	Rani sinka	Pteridaceae
8	*Cissampelos pareira* L.	Batule lahara	Menispermaceae
9	*Clematis montann* Buch.-	Angur jhar	Ranunculaceae

	Ham.-ex DC.		
10	*Curculigo orchioides* Gaertn.	Kalo musali	Liliaceae
11	*Cymbopogon citratus* (DC). Stap. f.	Pirhe ghans	Graminae
12	*Cyperus rotundus* L.	Mothe	Cyperaceae
13	*Diascorea sagittata* Royle	Tarul	Diascoreaceae
14	*Dryopteris cochleata* (D. Don) C.Chr.	Unue	Aspidiaceae
15	*Dryopteris* species	Neuro	Aspidiaceae
16	*Dumasia villosa* DC.	Mase jhar	Leguminosae
17	*Eulaliopsis binata* (Retz.) C.E.	Babiyo	Graminae
18	*Evolvulus nummularis* (L.)	Badame jhar	Convulvulaceae
19	*Fimbristylis* species	Jwane jhar	Cyperaceae
20	*Globba* species	Ban haledo	Zingiberaceae
21	*Imperata cylindrica* (L.) P. Beauv.	Siru	Graminae
22	*Inula cappa* (Buch.-Ham. ex D.Don)	Gaitihare	Compositae

23	*Jasminum* species	Chameli phul	Oleaceae
24	*Marsdenia roylei* Wight	Dudhe lahara	Asclepiadaceae
25	*Paspalum scrobiculatum* L.	Kodi	Graminae
26	*Persicaria barbata* (L.) Hara	Pire	Polygonaceae
27	*Thysanolaena maxima* (Roxb.) O. Kuntze	Amliso	Graminae
28	*Tinospora cordiofolia* (Willd.) Miers	Gurjo	Menispermaceae
29	Unidentified A.	Pritipalo	
30	*Urena lobata* L.	Dalle Kuro	Malvaceae
31	*Vigna* species	Mas lahari	Leguminosae
Shrubs species			
S.N.	Name of Shrub plants	Local name	Family
1	*Asparagus racemosus* Willd.	Kurilo	Liliaceae
2	*Bauhania vahlii* Wight and Am.	Bhorla	Leguminosae
3	*Cryptomeria japonica* (L.F.). D.Don.	Dhupi	Taxodiaceae

4	*Desmodium heterophyllum* (Willd.) DC.	Syakhuna	Leguminosae
5	*Fcus hispida* L.F.	Tote	Moraceae
6	*Flemingia macrophylla* (Willd). Merr.	Bhatte	Leguminosae
7	*Flemingia strobilifera* L.	Bhatte	Leguminosae
8	*Leea crispa* Royen ex L.	Galeni	Leeaceae
9	*Mimosa pudica* L.	Lajjawati	Leguminosae
10	Nepeta species	Kankarne	Labiatae
11	*Osbeckia stellata* Buch. Ham. ex. D.Don.	Aasare	Melastomaceae
12	*Phoenix humulis* Royle ex Becc and Hook	Thakal	Plamae
13	*Phyllanthus emblica*	Amala	Euphorbiaceae
14	*Shuteria* species	Kure jhar	Leguminosae
15	*Tespesia lampas* (Cav.) Dalzell and Gibson	Ban kapas	Malvaceae
16	*Woodfordia fruticosa* (L.) Kurz.	Dhairo	Lythraceae
17	*Xeromorphis spinosa*	Mainfal	Rubiaceae

	(Thunb.) keay		
18	*Zizyphus mauritiana* bam.	Bayar	Rhamnaceae
19	*Zyzyphus* species	Dumrai	Rhamnaceae

Tree Species

S.N.	Name of Trees	Local name	Family
1	*Bombax ceiba* L.	Simal	Bombacaceae
2	*Cleistocalyx operculatus* (Roxb.) Merr	Kyamuna	Myrtaceae
3	*Dalbergia sisso* Roxb.	Sisau	Leguminosae
4	*Desmodium oojeinense* (Roxb.) Ohashi	Sadhan	Leguminosae
5	*Engelhardia spicata* Lsch. ex. Bl.	Mauwa	Juglandaceae
6	*Ficus religiosa* L.	Pipal	Moraceae
7	*Ficus semicordata* Buch.-Ham ex. Sm.	Khaniyo	Moraceae
8	*Holoptelia integrifolia* (Roxb.) Planch	Papari	Ulmaceae
9	*Lagerstroemia parviflora* Roxb.	Botdhairo	Lythraceae

10	*Listea monopelata* (Roxb.) Pers.	Kutmiro	Lauraceae
11	*Mallotus philippensis* (Lam.) Muell.-Arg.	Rohini	Euphorbiaceae
12	*Pinus roxburghii* Sargent	Salla	Pinaceae
13	*Psidium guajava* L.	Belauti	Myrtaceae
14	*Rhus wallichi* Hook. F.	Bhalayo	Anacardiaceae
15	*Shorea robusta* Gaertn.	Sal	Dipterocarpaceae
16	*Syzygium cumini* (L.) Skeels	Jamun	Myrtaceae
17	*Terminalia alata* Heyne ex. Roth	Saj	Combretaceae
18	*Toona ciliata* M. Roem.	Tuni	Meliaceae
Total Plant species (Herbs+Shrubs+Trees) = 68			

Annex – 2

List of Plants Found in Kankrebihar Protected Forest

Herb Species			
S.N.	Name of Herbs	Local Name	Family
1	*Achyranthes aspara* L.	Datiwan	Amaranthaceae
2	*Ageratum conyzoides* (L.)	Gandhe jhar	Compositae
3	*Allium* species	Lasun phul	Liliaceae
4	*Ariopsis* species	Karkalo	Araceae
5	*Arisaema tortuosum* (Wall.) Schott.	Banko	Araceae
6	*Centella asiatica* (L) Urban	Ghod tapre	Ummbelliferae
7	*Cheilanthes albomarginata* C.B. Clarke	Rani sinka	Pteridaceae
8	*Clematis montann* Buch.-Ham.-ex. DC.	Angur jhar	Ranunculaceae

9	*Crotalaria* species	Chhinchhine	Leguminosae
10	*Curculigo orchioides* Gaertn.	Kalo musali	Liliaceae
11	*Cyanotis cristata* (L.) D. Don.	Kane	Commelinaceae
12	*Cyperus rotundus* L.	Mothe	Cyperaceae
13	*Desmodium microphyllum* (Thunb.) DC	Bakhre ghans	Leguminosae
14	*Diascorea bulbifera* L.	Githa	Diascoreaceae
15	*Digitaria ciliaris* (Retz.) koeler	Banso	Graminae
16	*Dryopteris cochleata* (D. Don) C. Chr.	Unue	Aspidiaceae
17	*Dumasia villosa* DC.	Mase jhar	Leguminosae
18	*Elephantopus scaber* L.	Bhede kuro	Compositae
19	*Eulaliopsis binata* (Retz.) (E. Hubbard)	Babiyo	Graminae
20	*Euphorbia hirta* L.	Dudhe	Euphorbiaceae
21	*Evolvulus nummularis* (L.) L.	Badame jhar	Convulvulaceae
22	*Ficus neriifolia* Sm.	Dudhilo	Moraceae

23	*Gaultheria hookeri* C.B. Clarke	Patpate	Ericaceae
24	*Globba* species	Ban haledo	Zingiberaceae
25	*Hymenopogon parasiticus* Wall.	Biri	Rubiaceae
26	*Imperata cylindrica* (L.) P. Beauv.	Siru	Graminae
27	*Jasminum* species	Chameli phul	Oleaceae
28	*Mariscus sumatrensis* (Retz.) Koyama	Karaunte	Cyperaceae
29	*Marsdenia roylei* Wight	Dhudhe lahara	Asclepiadaceae
30	*Mentha piperita* L.	Babari	Labiatae
31	*Ophioglossum vulgatum* L.	Jibre jag	Caryophyllaceae
32	*Parthenocissus semicordata* (Wall.) Planch	Charchare	Vitaceae
33	*Paspalum scrobiculatum* L.	Kodi	Graminae
34	*Themeda triandra* Forssk	Khar	Graminae
35	*Tinospora cordifolia* (Willd.)	Gurjo	Menispermace

	Miers.		ae
36	*Urena lobata* L.	Dalle Kuro	Malvaceae
37	*Urtica dioica* L.	Sisno	Urticaceae
38	*Vernonia* species	Buki/Gaitihare	Compositae

Shrub Species

S. N.	Name of Shrubs	Local name	Family
1	Asparagus racemosus *Willd.*	Kurilo	Liliaceae
2	*Bauhinia purpurea* L.	Koiralo	Leguminosae
3	*Bauhinia vahlii* Wight An.	Bhorla	Leguminosae
4	*Cissampelos pariera* L.	Batulpate	Menispermaceae
5	*Cryptomeria japonica* (L.F.) D.Don	Dhupi	Taxodiaceae
6	*Desmodium heterophyllum* (Willd.) DC.	Syakhuna	Leguminosae
7	*Ficus lispida* L.F.	Tote	Moraceae
8	*Flemingia macrophylla* (Willd.) Merr.	Bhatte	Leguminosae

9	*Flemingia strobilifera* L.	Bhatte	Leguminosae
10	*Leea crispa* Royen ex L.	Galeni	Leeaceae
11	*Millettia extensa* (Benth.) Baker	Gaujo	Leguminosae
12	*Osbeckia stellata* Buch.-Ham. ex D.Don	Aasare	Melastomaceae
13	*Phoenix humulis* Royle ex Becc. R Hook	Thakal	Palmae
14	*Ribes takare* D. Don	Dhurseli	Grossulariaceae
15	*Smilax aspata* L.	Kukurdino	Liliaceae
16	*Stereospermum personatum* (Hassk.) Chatterjee	Padari	Bignoniaceae
17	*Tespesia lampas* (Cav.) Dalzell and Gibson	Ban kapas	Malvaceae
18	*Woodfordia fruticosa* (L.) Kurz.	Dhiro	Lythraceae
19	*Xeromorphis spinosa* (thunb.) Keay	Mainfal	Rubiaceae
20	*Zyzyphus* species	Dumrai	Rhamnaceae
Tree Species			
S. N.	Name of Trees	Local name	Family

1	*Toona ciliata* M. Roem.	Tuni	Meliaceae
2	*Cleistocalyx operculatus* (Roxb.) Merr	Kyamuna	Myrtaceae
3	*Desmodium oojeinense* (Roxb.) Ohashi	Sadhan	Leguminosae
4	*Engelhardia spicata* Lsch. ex. Bl.	Mauwa	Juglandaceae
5	*Ficus benghalensis* L.	Bar	Moraceae
6	*Ficus religiosa* L.	Pipal	Moraceae
7	*Ficus semicordata* Buch.-Ham ex. Sm.	Khaniyo	Moraceae
8	*Grevillea robusta* A. Cunn. ex R. Br.	Kangiyo rukh	Porteaceae
9	*Grewia optiva* J.R. Drumn. ex Burret	Pharsa	Tiliaceae
10	*Lagerstroemia parviflora* Roxb.	Botdhairo	Lythraceae
11	*Lannea coromandelica* (Houtt.) Merr.	Dabdabe	Aracardiaceae
12	*Mallutus philippensis* (Lam.) Muell. Arg.	Rohini	Euphorbiaceae
13	*Melia azederach* L.	Bakenu	Meliaceae

14	*Pinus roxburghii* Sargent	Rani salla	Pinaceae
15	*Psidium guajava* L.	Amba	Myrtaceae
16	*Pyrus pashia* Buch.-Ham. ex D.Don	Mayal	Rosaceae
17	*Rhus wallichii* Hook. f.	Bhalayo	Anacardiaceae
18	*Salix* species	Bainsh	Salicaceae
19	*Sapindus mukorossi* Gaerth.	Rittha	Sapindaceae
20	*Shorea robusta* Gaertn.	Sal	Dipterocarpaceae
21	*Syzigium cumini* (L.) Skeels	Jamun	Myrtaceae
22	*Terminalia alata* Heyne ex. Roth	Saj	Combretaceae
Total Plant species (Herbs+Shrubs+Trees) =80			

Annex - 3

Size Class Distribution of Sal Tree species at Neware Community Forest (NCF) and Kankrebihar Protected Forest (KPF)

NCF		KPF	
Size Class (cm)	Density (Pl/ha)	Size class (cm)	Density (Pl/ha)
Seedlings	6758	Seedlings	4422
Saplings	4484	Saplings	422
10-15	694	10-15	430
15-20	112	15-20	466
20-25	42	20-25	102
25-30	30	25-30	12
30-35	22	30-35	6
35-40	14	35-40	0
40-45	10	40-45	6
45-50	12	45-50	2
50-55	0	50-55	4
55-60	0		
60-65	8		
65-70	0		
70-75	8		

Annex - 4

Average Climatic Data of Birendranagar Station, Surkhet from 2003 to 2007 A.D.

Months	Average maximum temperature (◦C)	Average minimum temperature (◦C)	Average rain fall (mm)
January	20.56	4.64	38.64
Feb.	23.58	8.88	66.2
Mar.	28.06	12.08	45.24
Apr.	33.34	16.92	23.94
May	34.22	20.18	84.7
Jun.	33.68	22.8	203.32
Jul.	30.54	23.4	577.54
Aug.	30.94	23.34	401.7
Sept.	30.5	21.98	210.8
Oct.	29.18	16.18	24.16
Nov.	24.94	10.16	0
Dec.	21.48	5.98	10.42

Annex – 5

Soil and Vegetation Characters in Neware Community Forest

.	Soil pH	Soil C (%)	Soil N (%)	Herb spp. Richness (Spp./100m^2)	Shrub spp. Richness (Spp./100m^2)	Tree spp. Richness (Spp./100m^2)	Total spp. Richness (Spp./100m$^{2)}$	Sal tree density (Pl/ha)	Sal sapling density (Pl/ha)	Sal seedling density (Pl/ha)	Total tree densit (Pl/ha
	6.47	0.36	0.014	3	8	4	15	800	11200	5600	190
	6.1	0.36	0.014	3	6	3	12	700	11200	9600	150
	5.69	0.21	0.014	4	6	6	16	200	4800	24400	260
	5.4	0.44	0.014	6	3	4	13	600	8800	22400	180
	6.08	0.36	0.014	3	3	5	11	700	9600	25600	220
	5.63	0.31	0.014	6	5	4	15	300	9200	24000	600
	6.03	0.52	0.028	3	7	5	15	400	16000	9600	600
	5.97	0.52	0.056	5	4	4	13	1000	7100	3600	400
	5.59	0.89	0.042	4	5	5	14	600	11200	1200	800
	5.39	0.39	0.014	4	5	4	13	600	7600	10800	800
	6.3	0.5	0.014	3	6	4	13	1100	9600	22800	110
	5.52	0.47	0.028	4	3	3	10	800	21200	4800	800
	5.7	0.57	0.028	3	4	3	10	1400	20000	10000	140
	5.83	1.07	0.028	3	3	5	11	1000	8800	16800	120
	5.49	0.92	0.028	3	4	4	11	1200	8800	12400	120
	5.52	0.34	0.056	3	5	4	12	1500	6800	7600	150
	6.19	0.15	0.056	3	4	1	8	1100	13200	8400	110
	6.31	1	0.014	3	6	2	11	800	6800	11200	800
	5.66	0.97	0.042	4	9	2	15	1200	13200	5200	120
	5.88	1.78	0.028	4	6	1	11	600	7600	6000	800
	5.91	1.34	0.028	4	6	2	12	1100	4800	11200	110
	5.72	1.26	0.056	2	5	2	9	1300	6000	19600	130
	5.92	0.63	0.042	6	4	1	11	900	3200	6800	900

	5.16	0.21	0.014	3	4	1	8	900	5600	2000	900
	5.3	0.07	0.042	4	4	4	12	1400	6400	5200	150
	5.57	1.31	0.056	4	3	2	9	1500	17600	8800	150
	5.18	0.65	0.028	7	3	2	12	500	16000	33600	130
	5.2	1.34	0.028	3	4	3	10	400	8000	20000	130
	5.41	0.39	0.014	3	2	1	6	1300	10400	8800	130
	5.17	1.15	0.014	4	1	2	7	400	6000	9200	100
	5.89	1.1	0.014	2	1	2	5	1000	7600	10000	150
	5.9	1.28	0.042	1	3	3	7	1500	6400	4400	160
	5.51	0.26	0.014	4	3	2	9	1600	4000	20000	800
	5.61	0.63	0.028	5	2	2	9	800	15200	8800	900
	5.57	0.34	0.014	3	3	4	10	900	7200	2800	800
	5.92	0.6	0.014	4	3	4	11	800	8800	10000	500
	5.77	0.21	0.056	3	5	3	11	500	11200	21600	700
	5.6	0.78	0.056	3	5	3	11	300	8000	18800	800
	5.6	0.6	0.014	4	3	3	10	800	9200	15600	800
	5.56	1.71	0.028	3	4	2	9	800	9200	11600	700
	6.02	0.86	0.014	5	2	4	11	600	11600	12000	700
	6.7	0.47	0.056	4	3	3	10	600	9200	9600	130
	6.8	0.86	0.056	4	2	1	7	500	12400	26800	600
	6.9	1.18	0.014	3	2	2	7	600	8800	9600	500
	5.19	0.42	0.056	4	3	1	8	500	5600	8000	600
	6.49	1.21	0.014	4	3	4	11	600	8800	14400	800
	6.22	0.31	0.028	1	2	1	4	400	8800	22400	600
	6.31	1.21	0.014	2	2	4	8	600	10800	16400	600
	6.32	0.6	0.014	4	5	4	13	600	9600	24800	600
	6.5	1.21	0.042	4	3	3	10	1000	4400	21200	100

Annex - 6

Soil and Vegetation Characters in Kankarebihar Protected Forest

N.	Soil pH	Soil C (%)	Soil N (%)	Herb spp. Richness (Spp./100m^2)	Shrub spp. Richness (Spp./100m^2)	Tree spp. Richness (Spp./100m^2)	Total spp. Richness (Spp./100m$^{2)}$	Sal tree density (Pl/ha)	Sal sapling density (Pl/ha)	Sal seedling density (Pl/ha)	Total tree density (Pl/ha)
	5.77	0.28	0.014	7	6	3	16	900	400	1600	180
	6.02	0.23	0.028	2	6	2	10	600	400	8000	150
	6.44	1.23	0.014	6	7	2	15	600	400	8400	130
	5.88	1.6	0.042	1	1	1	3	800	0	12800	110
	5.99	0.86	0.028	5	5	2	12	700	400	9200	110
	5.98	0.84	0.014	4	4	1	9	400	800	40800	10
	5.62	0.57	0.014	5	5	2	12	700	400	40800	130
	6.52	0.28	0.028	4	7	1	12	900	400	2200	80
	6.62	0.5	0.028	3	5	3	11	700	400	15600	100
0	5.8	1.5	0.014	2	4	1	7	1000	400	50400	60
1	5.95	1.1	0.014	1	1	2	4	1100	400	8000	20
2	5.51	0.28	0.028	2	5	2	9	200	800	8400	60

3	5.61	1.31	0.014	3	5	2	10	600	3600	5200	180
4	5.37	0.44	0.014	4	4	1	9	800	400	2000	130
5	5.42	1.02	0.028	7	8	2	17	1300	400	5600	140
6	6.02	1.52	0.042	1	1	1	3	1400	3200	5200	90
7	5.99	0.13	0.014	8	1	1	10	900	2400	21600	60
8	5.58	0.68	0.014	4	1	3	8	600	400	5200	60
9	5.13	0.31	0.028	3	4	1	8	600	400	8800	130
0	6.12	0.31	0.014	2	2	1	5	1300	400	4800	80
1	5.56	0.92	0.028	4	1	2	7	800	400	2000	100
2	5.4	0.78	0.028	4	1	3	8	1000	400	2000	110
3	5.44	0.31	0.014	3	4	1	8	1300	0	2800	80
4	5.26	0.97	0.042	1	2	3	6	800	2400	8400	160
5	5.18	0.73	0.014	6	3	2	11	1600	800	7600	50
6	5.67	0.65	0.028	1	2	2	5	500	400	19600	70
7	6.29	0.86	0.014	4	3	1	8	700	0	15600	70
8	5.31	0.86	0.028	3	3	2	8	700	2000	8800	20
9	5.41	0.81	0.014	4	3	1	8	100	1200	9200	110
0	5.72	0.55	0.028	6	3	3	12	1100	800	2800	110
1	5.69	0.89	0.014	5	1	1	7	1300	800	8000	70
2	5.22	1	0.028	1	4	2	7	700	800	10400	140
3	5.12	0.71	0.014	3	1	1	5	1400	800	4800	130
4	5.14	0.44	0.014	4	1	2	7	1300	400	1200	130
5	5.44	0.86	0.028	4	2	2	8	1300	400	8400	160
6	5.53	0.97	0.028	3	2	2	7	1600	800	8400	120
7	5.71	0.78	0.014	1	2	1	4	1100	800	7200	170
8	5.7	0.55	0.042	3	1	2	6	1700	1000	4000	210
9	6.01	0.63	0.028	2	5	2	9	2100	1000	3200	180
0	5.5	0.78	0.028	2	1	1	4	1800	1000	10000	100

1	5.31	1.31	0.042	2	4	3	9	1000	1200	13200	170
2	5.29	0.68	0.014	1	1	1	3	1700	600	23600	240
3	5.58	0.55	0.028	2	9	1	12	2400	0	19600	60
4	5.44	1.13	0.028	3	1	2	6	600	400	6000	110
5	5.45	0.78	0.042	2	7	2	11	1100	400	4800	80
6	5.48	0.89	0.042	3	1	3	7	800	400	3600	100
7	5.5	0.47	0.028	4	4	2	10	1000	400	2400	140
8	5.61	0.31	0.014	4	4	3	11	1400	400	1200	20
9	6	0.86	0.042	5	2	1	8	100	0	400	70
0	5.6	0.44	0.042	2	3	3	8	1500	0	1000	70

PHOTO PLATES

Photo 1: Neware Community Forest

Photo 2: Kankrebihar Protected Forest