Analysis of regeneration and species richness along different disturbance levels in the Kassalong Reserve Forest at Chittagong Hill Tracts, Bangladesh

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Abstract

The forests of the Kassalong reserve are one of the large important and productive government managed reserve forests located in the north forest division of the Chittagong Hill Tracts of Bangladesh. Legal or illegal logging as well as shifting cultivation with short rotation periods are important causes for a decreasing forest cover in the area. Forest Fires used as a preparatory measure for shifting cultivation have a very bad impact on natural regeneration, and the nearby forest area also. The present study was conducted in three compartments (62, 66, 68) of the Massalong block of Kassalong reserve. Based on different categories of disturbances (near to natural forest type-NNF, moderately disturbed forest type-MDF and highly disturbed forest type-HDF) 45 circular sampling plots with 9.77 m radius were chosen randomly for data investigation. The chemical status (pH, OM, N, K, P, S, B, and Zn) of the topsoil was investigated with 5 replications for each category. The natural regeneration was studied in accordance with three different height classes (< 30 cm, 31-150 cm and >150 cm). In total 91 tree species (dbh of > 5 cm) belonging to 35 families were observed on the sample plots in the forest. The species richness declined with increasing disturbances. Introduction of species showed an adverse effect on forest diversity even though stand density increased. According to site conditions the chemical status of the topsoil allowed a comparison of the species richness between all three forest types. The basal area was found highest in MDF followed by NNF and HDF. The density and species composition of the natural regeneration varied along with human disturbances in the study area. Even though the regeneration in HDF had more or less the same density as in NNF the species richness was the lowest. The number of species in the regeneration was highest in the MDF. However, the species richness declined with increasing height classes as result of human interventions. The important value index for the most dominant tree species in the three different forest types varied. A discussion of the major findings of this study with comparable research studies allowed to draw conclusions on further research activities and conservation management activities in the Kassalong reserve forest.

Keywords:

Natural regeneration, Species richness, Diversity, Disturbances and Soil analysis

Zusammenfassung

Das Reservat Kassalong ist eines der wichtigsten und produktivsten Schutzgebiete der nördlichen Forstabteilung der Chittagong Hill Tracts, welches von der Regierung in Bangladesch bewirtschaftet wird. Die legale und illegale Nutzung der Wälder sowie der Wanderfeldbau im Kurzumtrieb sind wesentliche Ursachen für den Rückgang der Waldfläche. Die betriebene Brandrodung hat dabei negative Auswirkungen auf die unmittelbar betroffene Naturverjüngung und benachbarte Waldflächen. Die Feldarbeiten zu der Arbeit wurden in drei Abteilungen (62, 66, 68) des Massalong Blocks im Reservat Kassalong durchgeführt. Basierend auf unterschiedlichen Kategorien von Störungseinflüssen (naturnahe Wälder, mäßig beeinflusste Wälder, stark beeinflusste Wälder) wurden 45 Stichprobenaufnahmen mit einem Radius von 9,77 m zufällig ausgewählt und Bestandesparameter erhoben. Bodenproben mit 5 Wiederholungen wurden aus jeder Kategorie hinsichtlich ausgewählter Parameter (pH, OM, N, K, P, S, B, Zn) analysiert. Die Naturverjüngung wurde in drei Höhenklassen (<30 cm, 31-150 cm and >150 cm) analysiert. Insgesamt konnten 91 Baumarten (mit einem BHD < 5 cm) aus 35 Familien auf den Stichprobenpunkten identifiziert werden. Die Baumartenvielfalt ging mit steigendem Störungseinfluss zurück. Das künstliche Einbringen von Baumarten beeinflusste die Diversität trotz steigender Pflanzendichte. Die Analyse der Bodenproben wies auf vergleichbare Standorte zwischen den drei Kategorien hin. Die Grundfläche war in den mäßig beeinflussten Wäldern (MDF) am höchsten, gefolgt von den naturnahen Wäldern (NNF) und den stark beeinflussten Wäldern (HDF). Die Zusammensetzung und Dichte der Naturverjüngung unterschied sich zwischen den unterschiedlichen Kategorien von Störungseinflüssen. Die HDF wiesen eine ähnlich hohe Dichte wie die NNF aus, die Baumartenvielfalt war allerdings geringer, in den MDF war die Baumartenvielfalt am höchsten. Mit steigender Höhenklasse ging die Baumartenvielfalt in der Verjüngung infolge des menschlichen Störungseinflusses zurück. Die Diskussion der Ergebnisse der Arbeit in Zusammenhang mit vergleichbaren Forschungsarbeiten erlaubte die Formulierung von Schlussfolgerungen für den weiteren Forschungsbedarf und die naturschutzfachliche Bewirtschaftung der Wälder im Reservat Kassalong.

Keywords:

Naturverjüngung, Pflanzenvielfalt, Diversität, Störungen und Bodenanalyse

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1. Introduction

Bangladesh having an area of 147,570 km^2 and a large population of 150 million in the north-eastern part of South Asia lies between $20^{0}34'$ and $26^{0}38'$ north latitude and $88^{0}01'$ and $92^{0}41'$ east longitude (FAO, 2000). It shares boundary on the west and north side with India, on the south-east with Myanmar, and on the south with Bay of Bengal. The natural ecosystems of the country range from sandy beaches to mangroves flood plains, lowland forest, terraces and hills reaching far north into the eastern Himalayas- one of 25 biodiversity hot-spots globally identified (Anon, 2006). The highest peak of the area is named Keokradong with 1230 meters. The country has a sub-tropical monsoon climate characterized by rain-bearing winds, moderately warm temperatures, and high humidity. The annual temperature averages between $7^{0}C$ to $36^{0}C$. The average annual rainfall varies within the country from 1500 to 5000 mm. But during last decade, the annual average rainfall has varied between 1900 mm to 2800 mm and shows a declining trend over last ten years (FAO, 2000).

Bangladesh has a forested land of approximately 2.41 million hectare (Reza et al., 1992). Out of this, 1.37 million ha (9.5%) is managed by the Forest Department and 0.74 million ha (5%) is under the jurisdiction of the district administration. Forests (including the mangroves) provide 90 million man-days of job opportunities annually and contribute 7% to the GDP. The forests of Bangladesh are broadly classified into three categories based on the topographic conditions; a) Hill forests, b) Plain Sal forests and c) Mangrove Littoral forests. Hill forests consist of moist tropical evergreen and semi-evergreen forests extended from Teknaf, along Myanmar border to the Chittagnong Hills and Hill Tracts and the low hills in Sylhet district. The forests are generally uneven-aged and multistoried. Pure stands of single species do not occur. The majority of smaller understory trees are evergreen and most of the dominant trees are deciduous (FAO, 2000). The hill forests contain most of the productive forest areas and contribute with 508991 ha (45.4%) to the share of forest land. Milde et al. (1985) categorize these forests into seven general forest sub-types (Tropical wet evergreen, Tropical mixed evergreen, Tropical moist deciduous, Tropical open deciduous, Bamboo, Lowland fresh water swamp and Savanna).

It is estimated that there are about 5000 angiosperm species which belong to 200 families in Bangladesh, including both wild and exotic plants (Anon, 1992[a]; Islam, 2006). Of which 2260 species are reported from Chittagong region, 8 are endemic to Bangladesh and

92 species have been rated as threatened. Many others, especially medicinal plants, are facing great pressure due to loss of habitat and over harvest (Anon, 2006).

Chittagong region (including the Kassalong Reserve) is one of seven trans-boundary landscapes in Hindu Kush-Himalayas proposed for biodiversity conservation and management (Messerli, 2009). The forests of Kassalong reserve have many of the characteristics of Burmese forests and of the Eastern Himalayas (Milde et al, 1985). However, it lacks the indigenous Teak of the Burmese forests and the Sal of the Eastern Himalayan forests.

Forestal was carried out an inventory of the Kassalong Reserves of the Chittagong Hill Tracts in 1961. Twenty years later in 1983, the areas were re-inventoried under Project BGD/79/017, "Assistance to the Forestry Sector of Bangladesh". Due to the inaccessibility of the area the project concerned only on photo-interpretation, mapping and area calculation. The volumes for timber were estimated 136.6 m^3/ha for Kassalong (Milde et al., 1985). In 1961 during the inventory there were more than 100 tree species reported. From both inventories it was observed that the forests had contained an appreciable amount of timber and bamboo type resources. Later on the FMP (1992) team revised this figure to 100 m^3 /ha for purposes of the yield calculation based on the figure of past extraction (FAO, 2000) which indicate the reduction trend of forest. After inventory in 1961 there were several changes occurred in the forest ecosystem within the reserve. But comparatively very little ground level study was carried out for accumulation of data in species diversity of the forest. There were some studies carried out in other reserves located to south forest division and Cox's Bazar forest division (Nath and Alam, 1998; Nath et al., 1999; Uddin et al., 1998; Nath et al., 1997; Hossain et al., 1995 and Hossain et al., 1997). But there were very scarce study found in this reserve forest on species diversity. There were 41 tree species reported collectively from the comparative study between un-classed state forest and in marginal boundary of reserve in Khagrachari district (Anon, 2007).

During a period of ten years ending 1996, the forest cover in Bangladesh has declined to 5.4% of the total land area due to over exploitation, illegal felling, shifting cultivation, encroachment, migration of plain land people to forest land and overgrazing (ADB, 1993; FAO, 2000; Iftekhar and Hoque, 2005). From a recent study it was observed that over the period of 1981-2003, green biomass and net primary productivity decreased by an average annual rate of almost 0.2 % over 62 % of the land area of Chittagong Hill Tracts (CHT) (Bai, 2006). In the CHT the net primary production decreased by 44 kg/ha/yr in a 23-year period. There are different actors responsible for the Hill forest reduction (Salam et al., 1999). Indigenous forest dwellers are facing scarcity of cultivable land and the increasing population leading ultimately a change of land use for cultivation. Timber industry can be identified as another factor in putting pressure on timber harvesting. In this context Government (Forest Department) are not able or willing to implement suitable policies to regulate cutting trees and illegal cutting.

Habitat loss is the major factor causing the current decline in the world's biodiversity (Anon, 1992[b]). Clearing the forest through the method of slash- and- burn for the purpose of traditional shifting cultivation is a common practice. Permanent land-use change for agriculture or plantation often results in degraded grasslands or degraded fallows (Tinker et al., 1996, Gafur et al., 2002 and Milde et al., 1985). However, indigenous people were using forests in a sustainable way. In previous time the population pressure was less and the cultivation cycle was long enough. On the contrary, it was reported that the resource was not degraded until external interventions take place (Rasul, 2007). The history of external intervention in the forest in CHT (including Kassalong Reserve) is more than two centuries old. Since 1871 the hill forests are managed under clear felling followed by artificial regeneration system with valuable timber species like *Tectona grandis* (Anon, 1970). The plantation was done through 'taungya' system leaving a continuous strip of natural forest for natural regeneration. But in the long term perspective because of several management and socio-economic problems the natural regeneration was not successfully introduced. In addition, people started to clear those natural forest strips for shifting cultivation. It was observed that when the natural forest is replaced with Teak (*Tectona grandis*) plantations the nutrient content (organic matter, nitrogen, phosphorus, potassium, calcium, magnesium) of the soil (0-40 cm depth) declined significantly (Amponsah and Meyer, 2000; Anon, 2005). Moreover, the 'taungya' dramatically changes landscape, interrupts the structure of ecosystems for recovery and causes loss of species (Shankar, 2001; Shankar et al., 1998). Based on different disturbances (shifting cultivation, fire used as preparatory measure for shifting cultivation and plantation as well, legal or illegal felling) the forests might be categorized into three classes: the near to natural forest type, moderately disturbed forest type (no introduction of species) and highly disturbed forest type (introduction of species through 'taungya').

The dam at Kaptaimukh, known as Kaptai Dam on the River Karnafuli in the Chittagong Hill Tracts (CHT), the only hydro-electric power project in Bangladesh was constructed in 1962. This reservoir submerged over 400 square miles (1000 km^2) of land and flooded at least 54,000 acres (22,000 hectares) 40% of the regions arable land mostly farmed by indigenous community. Around 100,000 people lost their homes and prime agricultural lands. In consequence, about 5,600 families were resettled in the state-owned Kassalong Reserve Forest on an area of 23,000 acres, but had limited possibilities for farming (Internal displacement monitoring centre, 2006). Additionally, during the time period of 1979-1984 more than 400,000 landless Bengalis from plains were resettled in the Chittagong Hill Tracts. This newly settled population was directly or indirectly responsible for deforestation and degradation of the land for carrying their livelihood.

Even though Kassalong reserve forest is facing degradation problem for more than centuries, this forest still consists the large productive government forest of the country. May be due to several management and socio-economic problems the diversity of plant community and natural regeneration were drastically hampered. In that context diversity indices provide important information about diversity of a community (Magurran, 1988). Shannon-Wiener and Simpson’s index are used widely for determination of species diversity in an ecosystem. Considering the present situation the following research questions and objectives could be formulated,

- to study the species richness of the forests of the Kassalong reserve
- to identify the human impacts on the species richness, diversity and structure of the forest
- to observe the regeneration status and the human impacts on natural regeneration

In detail the following questions will be analysed:

1. Is it possible to classify the sample plots to a certain class of disturbances?
2. Are there any significant differences of species richness, species diversity, density and basal area distribution at different disturbance levels?
3. Is there any difference between the diameter class distributions at different disturbance levels?
4. Are there any common species found in all disturbance levels? If yes, which species and how frequently?
5. How does the importance value index differ among species at different disturbance levels?

6. Is there any significant difference according to species richness, species diversity and number of individuals in the natural regeneration of different height classes (0-30 cm, 31-150 cm and > 150 cm) at different disturbance levels?
7. Are there some species regenerating in all disturbance levels? Are there any influences of logging on the regeneration?

2. Materials and Methods

2.1. Study location and site characteristics

The forests of the Kassalong reserve are situated in the Chittagong Hill Tracts bordered with Myanmer to the south and east, with Assam and Tripura in India to the east and north and to the west by the Chittagong District and extension of Hindu Kush-Himalayas region. The reserved forests cover approximately 1,645 square kilometers (Milde et al., 1985). The present study was conducted in three compartments (62, 66 and 68) of the Massalong Block in the north forest division. The latitude of the forests is between 22^0 57′ N and 23^0 45′ N and the longitude is between 91^0 55′ E and 92^0 21′ E. It comprises the entire catchment area of the upper part of the Kassalong River and its main branches. The topography is inhomogeneous and a series of ridges running more or less north to south direction. The hills are generally not very high but very uneven and facing steep slopes. The valley bottom ranges from 30 to 90 meters whereas the maximum elevation within the reserves is just over 900 meters. Soil is acidic and clay to clayey loams in the valleys and sandy to sandy loams in the hill sides. The accumulation of the humus layer varies according to the topographic condition. Annual temperatures vary according to altitude from 10^0 to 35^0 C and mean annual rainfall is between 2450 mm-3810 mm (Bai, 2006).

The vegetation of the forest comprises a mixture of tropical evergreen and deciduous trees, occurring in association with bamboo jungle as well. There are more than 100 tree species recorded (Milde et al., 1985) along with numerous number of shrubs, canes and brush-like species. No uniform or clearly defined forest type was found all over the forest except the plantation. The height of the trees varies from 30-60 meters. In the upper storey the principal species are *Dipterocarpus* spp., *Swintonia floribunda*, *Pterygota alata*, *Tetrameles nudiflora*, *Artocarpus chaplasha*, and in the middle to lower storey the common and important species are *Palaquium polyanthum*, *Artocarpus chaplasha*, *Trewia nudiflora*, *Syzygium* spp., *Duabanga grandiflora*, *Michelia champaca*, *Lagerstroemia speciosa*, *Hydnocarpus kurzii*, *Gmelina arborea*, and *Mangifera sylvatica*. In addition, plantations of Teak along with other timber species have been raised by ‘taungya’ system after clear felling. Plantations were first started in 1871. Now-a-days clear felling with afforestation is not practiced at all but artificial regeneration is practiced on degraded land.

The forest under the north forest division was declared as a reserve in late nineteenth century (1881). This division was created by splitting the Chittagong Hill Tracts Forest Division into two, Chittagong Hill Tracts North and South division. There are two compact areas of reserved forest in Chittagong Hill Tracts North division: Kassalong Reserved and Maini Head Water Reserved forest.

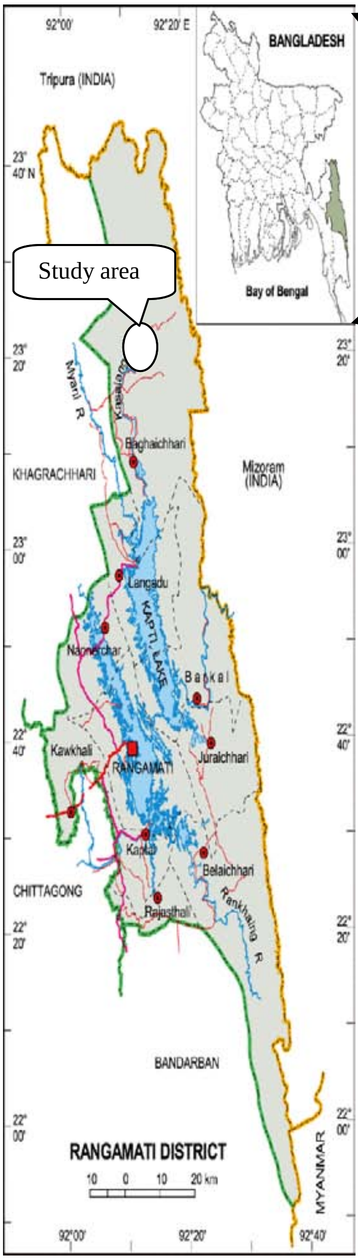
Indigenous peoples have been practicing shifting cultivation in this area before declaring the forests a reserve. So it was not possible to completely exclude the people from practicing shifting cultivation within the forest even after the declaration (Golam, 2007). In the past this cultivation was environmentally sustainable because of less population and longer cultivation circle. But now-a-days steady increase of population reduces the cultivation circle to 2-3 years which results in a degradation of forests and hampering natural regeneration (Rasul et al., 2004; Bai, 2006).

2.2. Sampling design and data collection

In total 45 circular sampling plots with 9.77 m radius were chosen randomly for data investigations (Figure 5). Within each plot diameter at breast height of all individuals having diameter of 5 cm and above were recorded. Twigs along with available flowers and fruits were collected from unidentified tree species for further investigation. Each sampling plot was divided into two subplots for the data investigation of the natural regeneration. The natural regeneration was sampled according to three different height classes (< 30 cm, 31 – 150 cm and > 150 cm but < 5 cm dbh) by means of three additional respective square plots (1 m X 1 m, 2 m X 2 m, and 4 m X 4 m). All individuals were counted according to three different height classes. Different human disturbances like logging, making fire, shifting cultivation (traditional agriculture), girdling, bamboo cutting and plantations were recorded for each sampling plot. Topsoil from 15 sampling plots was collected according to the field manual of Soil Research Development Institute (SRDI) to investigate the chemical status (pH, OM, N, K, P, S, B, and Zn) of the topsoil.

2.3. Species identification

The collected twigs from unidentified species were brought to the herbarium of the Institute of Forestry and Environmental Sciences, University of Chittagong, Bangladesh for identification. Consultation was made with Professors, from the Department of Botany, University of Chittagong, Bangladesh and the Research scientists of Bangladesh Forest Research Institute, Bangladesh for species identification.



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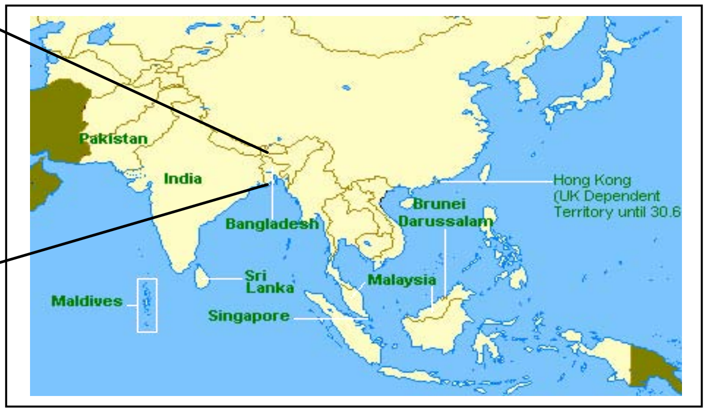

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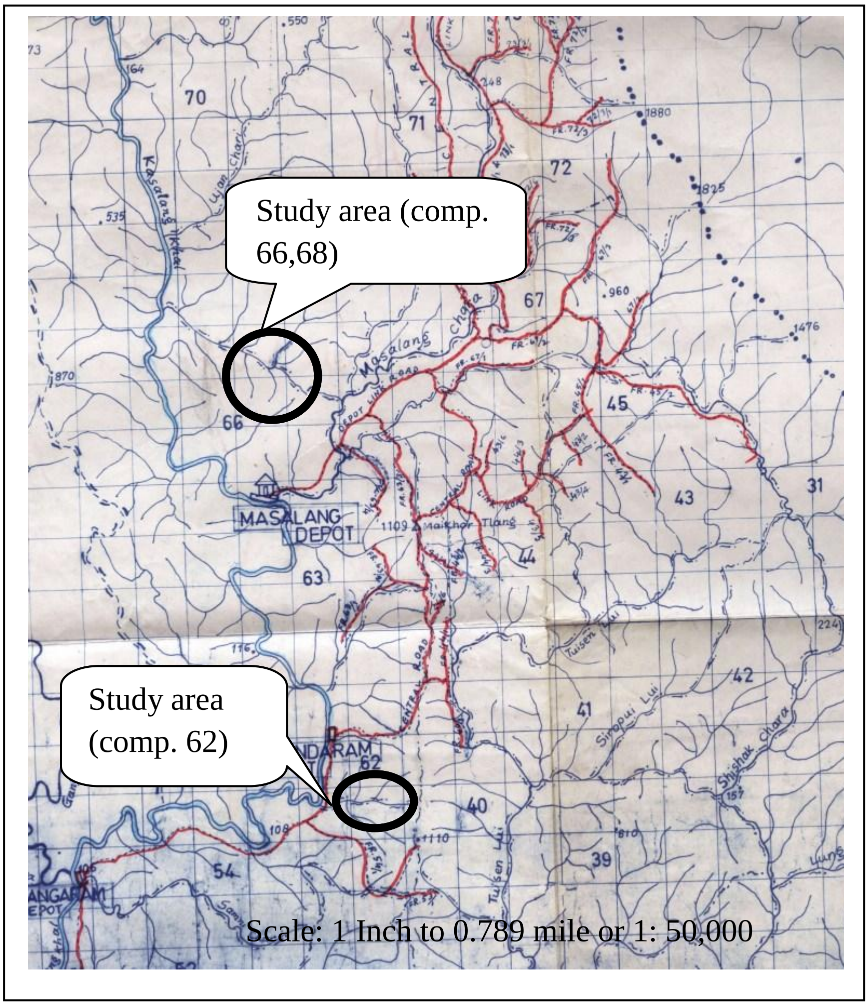

Figure 1: Location of the study area at Chittagong Hill Tracts (Rangamati district) in Bangladesh.

Figure 2: Near to natural forest type.

Figure 3: Moderately disturbed forest type.

Figure 4: Highly disturbed forest type.

2.4. Classification of sampling plots

A disturbance index was calculated after the modified disturbance index by Rahman et al. (2009). The index is a qualitative assessment based on different kinds of disturbances (Figure 6). There were 16 sample plots classified as near to natural forest type (NNF), 15 plots as moderately disturbed forest type (MDF) and 14 plots as highly disturbed forest type (HDF) according to the disturbances index. The plots of the NNF having disturbances with non-timber forest product (bamboo etc.) extraction, sometimes logging for medicinal trees but no cultivation or introduction of foreign species was observed (Figure 2). On the other hand, the plots of MDF experienced impacts from fire, logging leaving scattered trees, after clear felling or as a consequence after shifting cultivation the area is recruiting naturally, no tree species are introduced (Figure 3). On the HDF plots there was the taungya system implemented by clear felling with artificial regeneration of Teak (*Tectona grandis*), Gamar (*Gmelina arborea*), Koroi (*Albizia procera*) and allowing natural regeneration of other good quality natural tree species (*Dipterocarpus* spp, *Lagerstroemia speciosa*, *Artocarpus chaplasha*) (Figure 4).

2.5. Analysis

Stand structure and diversity was investigated according to the following measures: basal area and density (1) of the forest, frequency (2) and abundance (3) of the species, important value index (5), Shannon-Wiener diversity index (H) (9), Evenness Index (E) (10) and Simpson's dominance index (11). Kruskall-Wallis non-parametric test was carried out to find out significant differences among the three different forest types. The basic formulas (Mueller-Dombois and Ellenberg, 1974) for data analysis are as follows,

$$Density\ of\ a\ species = \frac{\text{Total No.of individuals of one species in all plots}}{\text{Total no.of plots studied}} \quad (1)$$

$$Frequency = \frac{\text{Total no.of plots in which one species occures}}{\text{Total no.of plots studied}} \text{X } 100 \quad (2)$$

$$Abundance\ of\ one\ species = \frac{\text{Total no.of individuals of one species in all the plots}}{\text{Total no.of plots in which the species occure}} \quad (3)$$

$$Relative\ Abundance\ of\ one\ species = \frac{\text{Abundance of one species}}{\text{Total abundance of all species}} \text{X } 100 \quad (4)$$

The important value index (IVI) consists of relative frequency, relative density and relative dominance (Muller-Dombois and Ellengberg, 1974).

IVI $= Relative\ density + Relative\ dominance + Relative\ frequency$………..… (5)

Where, relative density, relative dominance and relative frequency are as follows (Nath et al. (2000) :

$$Relative\ density = \frac{\text{Total number of individual of one species}}{\text{Total number of individuals of all species}} \text{X } 100 \quad (6)$$

$$Relative\ dominance = \frac{\text{Total basal area of one species in all plots}}{\text{Total basal area of all species in all plots}} \text{X } 100 \quad (7)$$

$$Relative\ Frequency = \frac{\text{Frequency of one species in a plot}}{\text{Sum of all frequencies for all species}} \text{X } 100 \quad (8)$$

The Shannon-Wiener diversity index (Nath et al., 2000) was calculated using the following formula,

$$H = -\sum_{i=1}^{S} pi \text{ In } pi \quad (9)$$

Where, ρ_i is the proportion of the *i*th species and the number of all individuals of all species (n/N).

Evenness was calculated according to the following Pielou's evenness index (Nath et al., 2000),

$$E = H/logS \quad (10)$$

Where, H is the Shannon-Wiener diversity index and S is the number of species.

Simpson index (D) was calculated by the following formula (Simpson, 1949),

$$\text{D} = \sum_{i=1}^{S} pi^2 \quad (11)$$

Where, ρ_i is the proportion of the *i* th species.

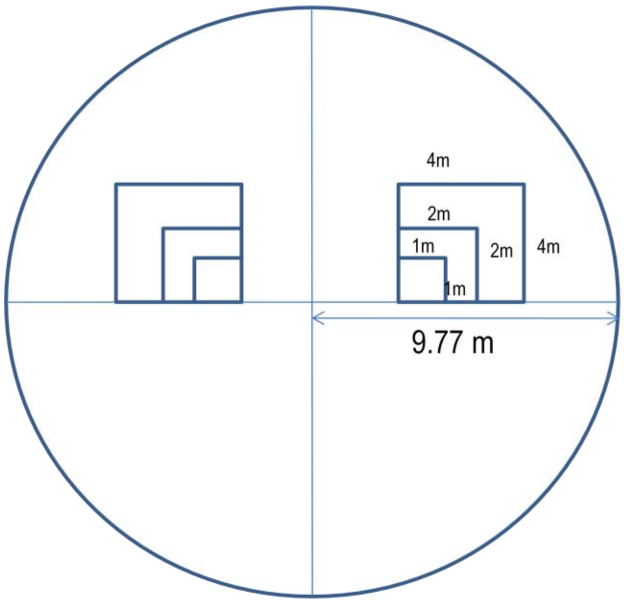

Figure 5: Circular sampling plot with 9.77 m radius and subplots for regeneration study.

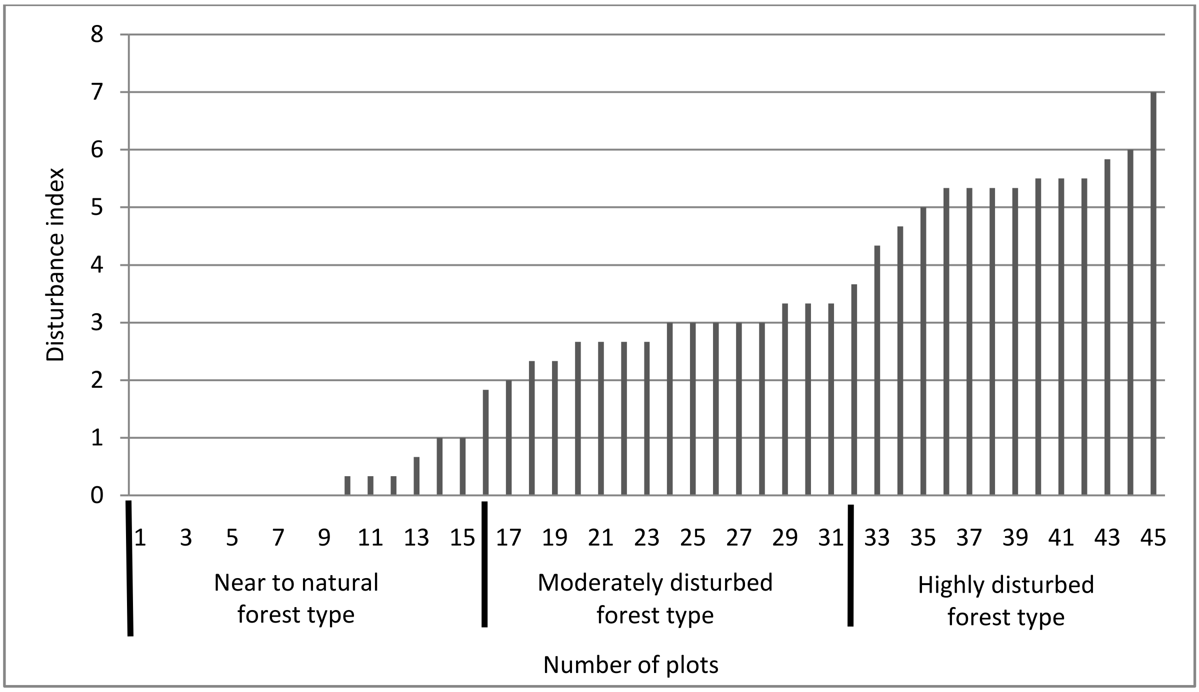

Figure 6: Classification of sample plots regarding the three classes of disturbances.

3. Results

3.1. Stand structure and diversity

3.1.1. Species richness, density and basal area

The number of stems/ha and number of species varies according to forest types (Table 1). The median value of stems/ha were 399, 233 and 533 in near to natural forest type (NNF), moderately disturbed forest type (MDF) and highly disturbed forest type (HDF) respectively. Even though the median basal area of the three different forest types was more or less same, HDF had the lowest basal area of 33.9 m^2/ha. The MDF had the highest basal area (37.2 m^2/ha) followed by NNF (35.5 m^2/ha). There were significant differences found in stem numbers/ha among three forest types but no significant difference in basal area (Table 1).

On the sample plots in the forest 91 tree species having dbh of > 5 cm have been observed in total including introduced species (Table 2). Among them 81 species belong to 35 families were identified up to genus and 7 species were identified up to the family level (Appendix 1). The highest number of species (63) was found in the NNF followed by the MDF (54) and only 14 species (including 3 introduced species) were found on the plots of the HDF (Table 1). There were some species found overlapping between the three forest types. Thirty one species found common in both NNF and MDF (Table 3). Seven species were found common in both MDF and HDF whereas only 5 species were common between NNF and HDF.

Table 1: Total number of tree species, median value of stems/ha and basal area/ha according to the forest types.

	NNF	MDF	HDF	Kruskal-Wallis test	
				Q2	ρ
Density (N/ha)	399	233	533	16.634	0.000
Basal Area(m^2 /ha)	35.5	37.2	33.9	0.294	0.864
Species present (No.)	63	54	14	-	-

Note: NNF – near to natural forest type; MDF- moderately disturbed forest type and HDF- highly disturbed forest type; ρ is asymmetric significant.

Table 2: Important Value Index (IVI) of all tree species with local name according to forest types (NNF, MDF and HDF).

Serial No.	Local name	Botanical name	IVI		
			NNF	MDF	HDF
1	Teak	*Tectona grandis*	-	-	167.9
2	Gamar	*Gmelina arboria*	-	9.07	44.19
3	Dharmara	*Steriospermum personatum*	1.56	23.8	-
4	Shimul	*Bombax ceiba*	-	5.32	-
5	Jumur	*Derris robusta*	1.11	5.59	3.45
6	Bhadi	*Garuga pinnata*	8.27	8.65	-
7	Gutguti	*Bursera serrata*	2.78	17.3	-
8	Bandorhola	*Duabanga sonneratioides*	5.95	9.43	7.28
9	Shiuri	*Anogeissus acuminata*	1.46	4.46	4.94
10	Sundul	*Tetrameles nudiflora*	30.85	2.52	6.93
11	Bahera	*Terminalia bellirica*	3.03	3.97	-
12	Mostali	*Sterculia guttata*	3.66	-	3.41
13	Sada Koroi	*Albizia procera*	-	-	37.71
14	Udal	*Sterculia villosa*	-	7.45	-
15	Jial bhadi	*Lannea coromadelica*	-	6.69	-
16	Chapalish	*Artocarpus chaplasha*	12.74	9.14	-
17	Bhuro	*Macaranga denticulata*	2.24	8.2	-
18	Dhakijam	*Syzygium grande*	12.16	-	-
19	Achar	*Grewia microcos*	-	4.62	-
20	Toon	*Cedrela toona*	-	3.21	3.38
21	Shanesil	*Adina cordifolia*	-	4.11	3.6
22	Modon mosta	*Dechasia kurzii*	1.16	-	-
23	Amra	*Spondias pinnata*	2.93	-	4.17
24	Hoza	*Callicarpa macrophylla*	-	-	4.19
25	Bongal	*Cordia dichotoma*	-	-	3.95
26	Kala koroi	*Albizia lebeck*	-	-	4.9
27	Nariche	*Maesa ramentacea*	2.4	-	-
28	Shibeng	Unknown	6.68	-	-
29	Unknown_1	Unknown_1	1.16	-	-
30	Kurohar	Unknown	8.34	4.53	-
31	Uriam	*Mengifera sylvatica*	2.49	4.07	-
32	Pitraj	*Dysoxylum* sp	17.79	15.69	-
33	Kathbadam	*Terminalia catappa*	3.57	-	-
34	Srilankan chatian	*Gardenia* sp	2.07	-	-
35	Jalpai	*Eleocarpus* sp	2.55	-	-
36	lotkon	*Baccaurea ramiflora*	2.32	1.97	-
37	Adalipun	*Meliosma pinnata*	9.02	-	-
38	Rosbharala	*Holigarna* sp	5.41	-	-
39	Moma	*Saraca* sp	4.72	2.1	-
40	Kao	*Garcinia cowa*	3.66	1.96	-
41	Felatheng	Unknown	1.32	-	-
42	Chalmogra	*Hydnocarpus kurzii*	8.24	3.97	-
43	Jarul	*Lagerstroemia speciosa*	2.15	9.51	-
44	Suche	*Litsea glutinosa*	2.47	-	-

Serial No.	Local name	Botanical name	IVI		
			NNF	MDF	HDF
45	Helpata	*Pongamia pinnata*	1.14	-	-
46	Demolgulo	*Garcinia xanthochymus*	6.99	3.15	-
47	Kali garjan	*Dipterocarpus turbinatus*	17.69	9.99	-
48	Kurukh	*Polyalthia simiarum*	5.01	-	-
49	Putijam	*Syzygium* sp	3.99	-	-
50	Nilkadam	Unknown	-	1.93	-
51	Tali	*Palaquium polyanthum*	1.25	1.99	-
52	Borta	*Artocarpus lacucha*	1.52	-	-
53	Sudogulo	Unknown_4	3.51	-	-
54	Chickrashi	*Chickrasia tabularis*	4.2	5.17	-
55	Unknown_5	Unknown_5	8.33	-	-
56	Chepuru	Unknown		7.55	-
57	Barala	*Holigarna caustica*	9.78	2.22	-
58	Rangi Garjan	*Dipterocarpus sp*	8.34	2.46	-
59	Nageswar	*Mesua ferrea*	9.01	-	-
60	Batna	*Quercus* sp	1.62	3.31	-
61	Bongori	unknown_6	4.24	2.02	-
62	tulon pagor	*Anisoptera scaphula*	4.32	-	-
63	Kanugo Bharal	*Dillenia suffruticosa*	3.33	-	-
64	Hachkuro	*Leea alata*	1.9	-	-
65	Bek gulo	Unknown	1.2	-	-
66	Sirifall	Unknown_7	2.26	2.37	-
67	Soley	*Aphania danura*	1.56	-	-
68	Mon hona	*Oroxylum* sp	5.22	1.95	-
69	Civit	*Swintonia floribanda*	1.86	-	-
70	Hedocam	Unknown_8	2.89	-	-
71	Narikeli	*Pterygota alata*	1.64	-	-
72	Horitaki	*Terminalia chebula*	1.57	9.91	-
73	Dhali garjan	*Dipterocarpus gracilis*	3.01	7.97	-
74	Burigulo	Unknown_3	1.22	2.02	-
75	Dhup	*Canarium resiniferum*	2.05	-	-
76	Bharatta	*Diospyros stricta*	1.23	-	-
77	Telsur	*Hopea odorata*	1.86	-	-
78	Ashoth	*Ficus religiosa*	-	7.96	-
79	Jogona	*Mitragyna parviflora*	-	5.67	-
80	Monbhuro	*Mallotus* sp	-	3.89	-
81	Dumur	*Ficus hispida*	-	1.93	-
82	Ramkola	Unknown	-	2.12	-
83	Joggo dumur	*Ficus* sp	-	1.94	-
84	Kadam	*Anthocephalus chinensis*	-	2.32	-
85	Hona	*Oroxylum lucidum*	-	1.94	-
86	Arsol	*Vitex pinnata*	-	10.97	-
87	Unknown_9	Unknown_9	-	7.53	-
88	Songori	Unknown_2	-	2.27	-
89	Borpada	*Haplophragma adenophyllum*	-	2.3	-
90	Unknown_10	Unknown_10	-	4.56	-
91	Monada	*Mellotus philippensis*	-	3.26	-

Table 3: Number of species similar to all forest types in mature trees according to natural regeneration.

	Species overlapping		
	NNF - MDF	MDF - HDF	NNF - HDF
Mature trees	31	7	5
<30cm ht Seedling	5	10	2
31-150cm ht Seedling	8	8	6
>150cm ht Seedling	8	9	9

Note: NNF – near to natural forest type; MDF- moderately disturbed forest type and HDF- highly disturbed forest type.

3.1.2. Species diversity

The Shannon Diversity Index for the near to natural forest type (NNF), moderately disturbed forest type (MDF) and highly disturbed forest type (HDF) were found 4.08, 3.93 and 2.18 respectively (Table 4). From this index it was found that NNF and MDF had almost same and very high species diversity and in contrary HDF had lower species diversity. The same trend was seen for Simpson Index (Table 4), too. In this index NNF and MDF appeared with 0.02 which indicate that both ecosystem types were highly diverse or have heterogeneous ecosystem. In other side, HDF (0.16) was not as diverse as NNF and MDF. Evenness index was 0.98 for both of NNF and MDF and 0.83 for HDF (Table 4). From the evenness index it was observed that the species in three of the forest types were almost evenly distributed. Disturbance index showed a continuous increasing trend from NNF to MDF and HDF (Table 4). The Shannon diversity index was shown a very diverse view of species diversity among the sample plots (Figure 7). Among 45 sample plots the Shannon index varies with a great range from 0 to 2.78. The NNF comprising the 1st until the 16th sample plot had the index value of 1.47- 2.78 showing a heterogeneous ecosystem. The highest index value (2.78) were found in the 11th sample plot followed by 13th (2.57) and 16th (2.36) and the lowest index value (1.47) was found in the 4th and in the 10th number of plots. From the 17th to the 31st sample plot representing the MDF type had an index value within the range of 1.27 – 2.24. The same trend of heterogeneity like NNF was found in this type of forest as well. The highest value (2.24) was observed in the 28th sample plot followed by 23rd (2.15) and 30th (2.0) and the lowest value (1.27) was found in 17th plot. The HDF represented the sample plots from the 32nd to the 45th where it was observed that 5 plots (34th, 35th, 36th, 43rd and 45th) having no species diversity at all. The highest index value (1.79) was found on the 32nd plot (1.38) followed by the 37th plot (1.08). Seven plots (33rd, 38th, 39th, 40th, 41st, 42nd and 44th) were not having so high diversity compared to the other two plots (32nd and 37th).

Table 4: Indices according to forest types of mature trees.

Indices	NNF	MDF	HDF
Shannon Index	4.08	3.93	2.18
Simpson Index	0.02	0.02	0.16
Evenness Index	0.98	0.98	0.83
Disturbance Index	0.34	2.82	5.31

Note: NNF – near to natural forest type; MDF- moderately disturbed forest type and HDF- highly disturbed forest type.

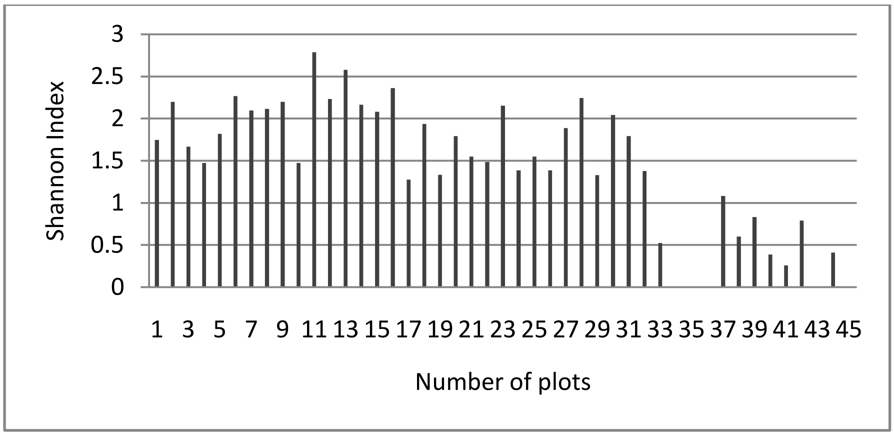

Figure 7: Shannon index in accordance with sample plots with an order of increasing disturbance.

3.1.3. Common species

There were four species namely *Derris robusta*, *Duabanga sonneratioides*, *Anogeissus acuminate* and *Tetrameles nudiflora* found common in all three forest types (Table 5). The same species were found in different forest types with different frequencies even though the frequency of occurrence was very low. For instance, *Derris robusta* was found almost with same frequency 0.06 and 0.07 in the NNF and HDF but in the MDF the frequency was higher (0.13). The frequency of occurrence for *Duabanga sonneratioides* was found more or less similar in the NNF (0.19) and MDF (0.13).

Table 5: Frequencies of common species among mature trees according to the forest types.

Botanical name	Frequency		
	NNF	MDF	HDF
Derris robusta	0.06	0.13	0.07
Duabanga sonneratioides	0.19	0.13	0.07
Anogeissus acuminata	0.06	0.07	0.07
Tetrameles nudiflora	0.31	0.07	0.07

Note: NNF- near to natural forest type; MDF- moderately disturbed forest type; HDF- highly disturbed forest type.

In the HDF this species had less frequency of occurrence (0.07) compared to other forest types. *Tetrameles nudiflora* had quite high frequency (0.31) in NNF whereas very low frequency in other the forest types (0.07). *Anogeissus acuminate* was found with almost same frequency in all three forest types.

3.1.4. Important value index

The important value index (IVI) of all species in accordance with the forest types is shown in Table 2. It was observed that the IVI varies for same species at different forest type substantially. The highest IVI (30.85) was found in NNF for *Tetrameles nudiflora*, followed by *Dysoxylum* sp (17.79) and *Dipterocarpus turbinatus* (17.69). However, *Dysoxylum* sp and *D. turbinatus* and also *Artocarpus chaplasha* (12.74) and *Syzygium grande* (12.16) had more or less similar IVI. Around 14 species have a IVI within the range of 5-10 and the rest of 44 species have the value of IVI lower than 5. Among 54 species the highest IVI (23.80) in MDF was found in the *Steriospermum personatum* followed by *Bursera serrata* (17.30) and *Dysoxylum* sp (15.69). The IVI for 18 species were observed under the range of 5-10. The rest of the 33 species were having an IVI below 5. In HDF there were very few species (14) found. Among them the introduced species (*Tectona grandis*, *Gmelina arboria* and *Albizia procera*) have higher IVI: 167.90, 44.19, and 37.71 respectively. Only two species (*Duabanga sonneratioides* and *Tetrameles nudiflora*) were found having the IVI between the range of 5-10 and the rest of 9 species have the IVI below 5. In the HDF the share of *Tectona grandis* consists 77 % among species having an IVI of 10 (Figure 8). The others namely *Gmelina arborea* (13%) and *Albizia procera* (10%) have more or less similar percentage. Quite different view observed in MDF with 6 different species (Figure 9). The highest (31%) sharing was found in *Steriospermum personatum* followed by *Bursera serrata* and *Dysoxylum* sp where both species had the same percentage (24%). *Terminalia chebula* and *Dipterocarpus turbinatus* both were having the same share of percentage (6%) and 9% share found for *Vitex pinnata*. There were five species having an IVI of 10 in NNF (Figure 10). The highest share (32%) was observed for *Dysoxylum* sp. The other four species namely *Syzygium grandi*, *Artocarpus chaplasha*, *Tetrameles nudiflora*, and *Dipterocarpus turbinatus* had a share of 19%, 16%, 12% and 21% respectively.

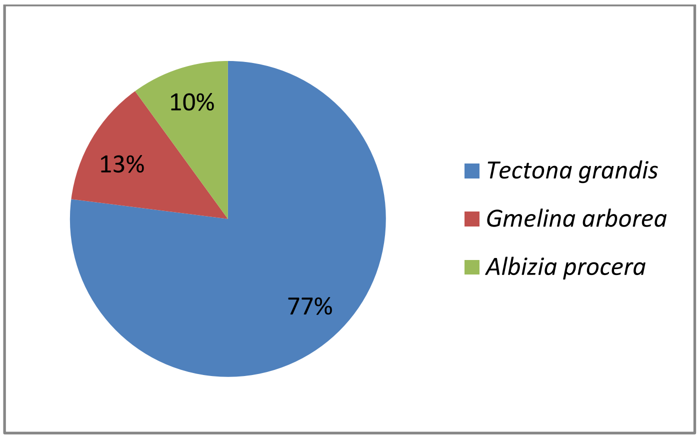

Figure 8: Share of individual tree species having an IVI ≥ 10 in highly disturbed forest type.

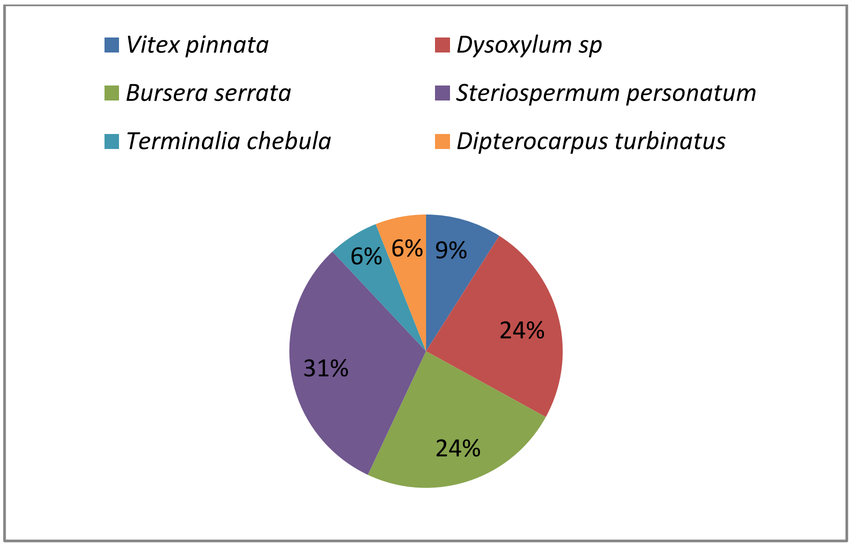

Figure 9: Share of individual tree species having an IVI ≥ 10 in moderately disturbed forest type.

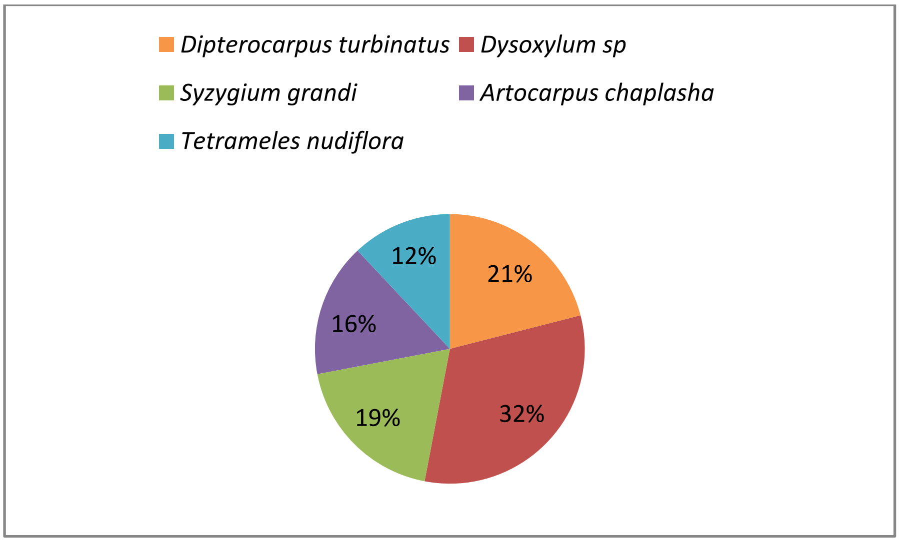

Figure 10: Share of individual tree species having an IVI ≥ 10 in near to natural forest type.

3.1.5. Diameter class distribution

Number of individuals (%) at different diameter classes (dbh) according to forest types is shown in the Figure 11. In all three forest types number of individuals declined with increasing diameter classes. But the HDF had a very low range (< 10 cm to 60-70 cm) of diameter class distribution. The highest number of individuals (42%) for the HDF was found in 20-30 cm dbh class whereas for NNF the highest number of individuals (34%) was found in 10-20 cm diameter class. Two sharp declines of individuals were observed for HDF from the diameter class of 20-30 cm to 30-40 cm and 30-40 cm to 40-50 cm. In the NNF there was observed a continuous decline of individuals from 10-20 cm diameter class with increasing diameter class. There were no individuals found under the dbh class of 90-100 cm. In the MDF almost all diameter classes had some representative individuals. But there was no continuous declining trend of individuals (%) observed. The highest number of individuals (22 %) was observed in the 10-20 cm diameter class.

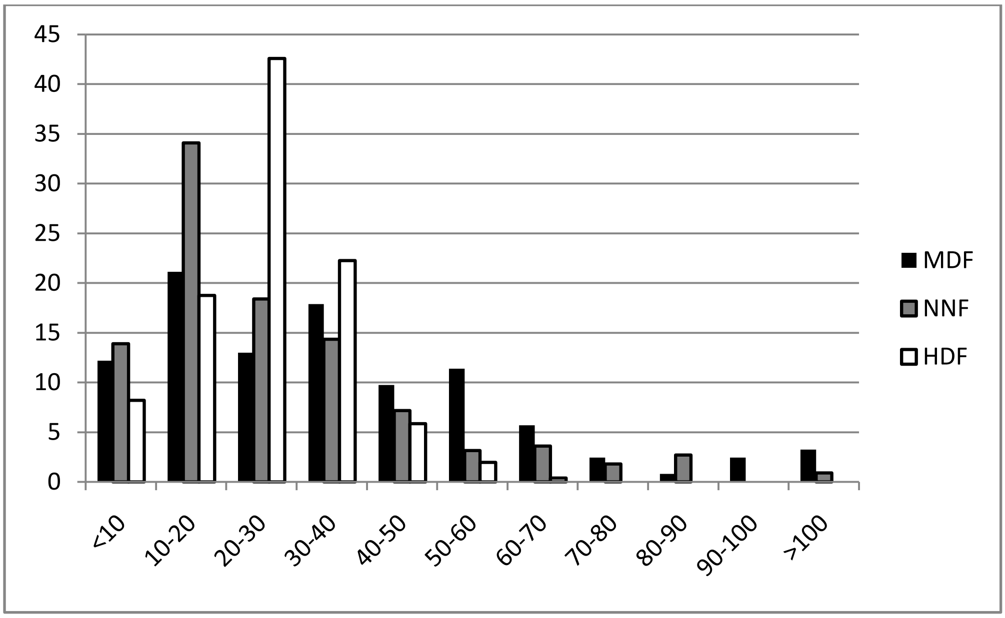

Figure 11: Number of individuals (%) according to diameter classes and the three forest types.

3.1.6. Rarity

Mature trees categorized as very rare (individual = 1 among the sample plots), rare (individuals = 2 to 9), frequent (individuals = 10 to 20) and very frequent (individuals > 20) (Table 6). In NNF among 63 species 59 species found as rare and very rare based on the number of individuals found during sampling which collectively comprising around 80% of total individuals. Only four species found frequently with 23% of total individuals whereas only one species (8%) found frequently in MDF. Most of the species found under the category of rare and very rare species comprise a total share of more than 90%. Except the introduced species there were 6 and 5 species found under very rare and rare species categories respectively.

Table 6: Number of species (%) according to rarity and different forest types.

Species category	NNF	MDF	HDF*
Very rare	22(10%)	23 (19%)	6 (38%)
Rare	37(67%)	30 (73%)	5 (62%)
Frequent	4(23%)	1 (8%)	-
Very Frequent	-	-	-
Total	63 (100%)	54 (100%)	11(100%)

Note: Very rare = 1 individual, Rare = 2 - 9 individuals, Frequent =10 - 20 individuals and Very frequent = > 20 individuals;* introduced species are excluded.

3.1.7. Correlation

The correlation between the number of species, stem number/ha, basal area and Shannon index with disturbance index are given in Table 7. There were negative correlation found between species number and disturbance index and also between Shannon index and disturbance index using the Spearman correlation index (SPSS, 2008). There were no correlation found between stems/ha and disturbance index and also between the basal area and disturbance index.

Table 7: Correlation of species richness, stems/ha and basal area with disturbance index.

	Correlation Co-efficient
Species number Disturbance Index	-0.776**
Stems/ha Disturbance Index	0.167
Basal area Disturbance Index	-0.094
Shannon Index Disturbance Index	-0.763**

**. Correlation is significant at the 0.01 level (2-tailed).

3.1.8. Chemical status of top soil

The chemical status (pH, OM, N, K, P, S, B and Zn) of the top soil was examined and it was observed that the average pH value and organic matter (%) is little bit higher in NNF than MDF and HDF (Table 8). Percentages for N were highest in NNF whereas K and P content were found highest in MDF followed by HDF and the lowest average values were found in NNF. S and B were higher in NNF compared to other forest types. But Zn was the highest in HDF followed by MDF and NNF.

Table 8: Chemical status (pH, OM, N, K, P, S, B, and Zn) of the top soil according to forest types.

Forest types	pH	OM (%)	N (%)	K (meq/100g)	P (µg/g)	S (µg/g)	B (µg/g)	Zn (µg/g)
NNF	5.42	2.756	0.16	0.328	1.2	7.6	0.326	0.604
MDF	5.32	2.626	0.152	0.59	4.4	5	0.268	0.706
HDF	5.32	2.498	0.142	0.432	1.6	6	0.254	0.71

Note: NNF- near to natural forest type; MDF- moderately disturbed forest type; HDF- highly disturbed forest type.

3.2. Natural regeneration

3.2.1. Density, species recruitment and common species

The number of individuals (N/ha) in natural regeneration according to different height classes and three different forest types are given in Figure 12. With increasing height classes the number of individuals decline in all forest types. The highest number of individuals (66666) was found regenerating at < 30 cm height class in MDF followed by NNF (49375) and lowest was in HDF (26785). Even though the highest number of regeneration was found in MDF at < 30 cm height class, regeneration was lowest at the other two height classes (31-150 cm ht and > 150 cm ht). In the height class of 31-150 cm and > 150 cm the number of individuals in the regeneration were found almost similar in NNF and HDF.

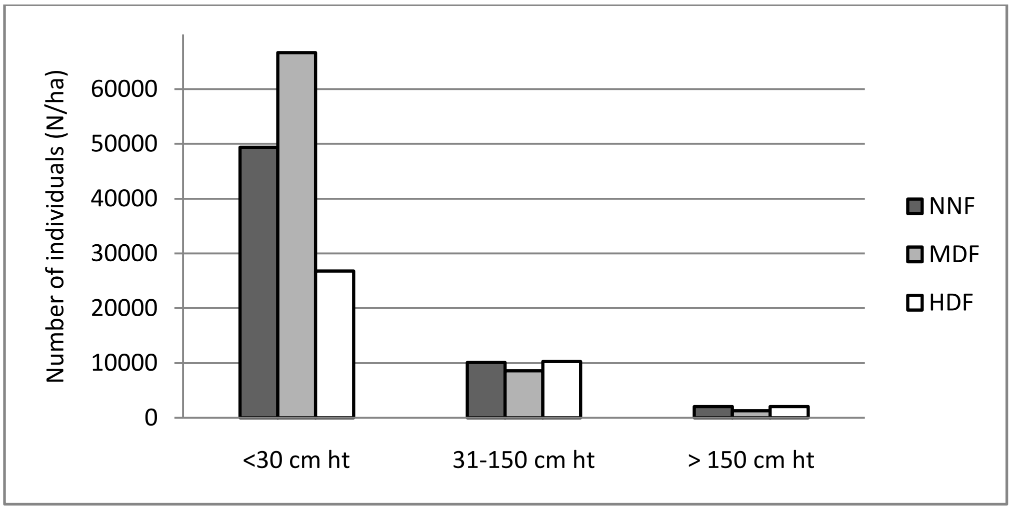

Figure 12: Number of individuals (N/ha) in the natural regeneration according to height classes and forest types.

Even though there were some differences in number of individuals among three forest types and in accordance with height classes, there were no significant differences found among them (Table 9). The number of species regenerating in the three forest types at different height classes is presented in Figure 13. The number of species increases with increasing height classes. At the height class of < 30 cm MDF had the highest number of species (19) and in contrary NNF and HDF have similar number of species (13). But in the NNF the number of species at height class of 31-150 cm and > 150 cm were found higher than other two forest types and same view was also in mature stand. On the other hand, HDF had low number of species throughout all height classes.

Table 9: The median value of individuals (N/ha) according to height classes and forest types in natural regeneration.

	Seedling	NNF	MDF	HDF	Kruskal-Wallis test	
					Q2	ρ
Density (N/ha)	< 30cm ht	20000	45000	22500	1.408	0.495
	31-150cm ht	11875	87500	81250	0.278	0.759
	>150 cm ht	21875	31250	15625	4.084	0.130

Note: NNF - near to natural forest type; MDF - moderately disturbed forest type and HDF – highly disturbed forest type; ρ is asymmetric significant.

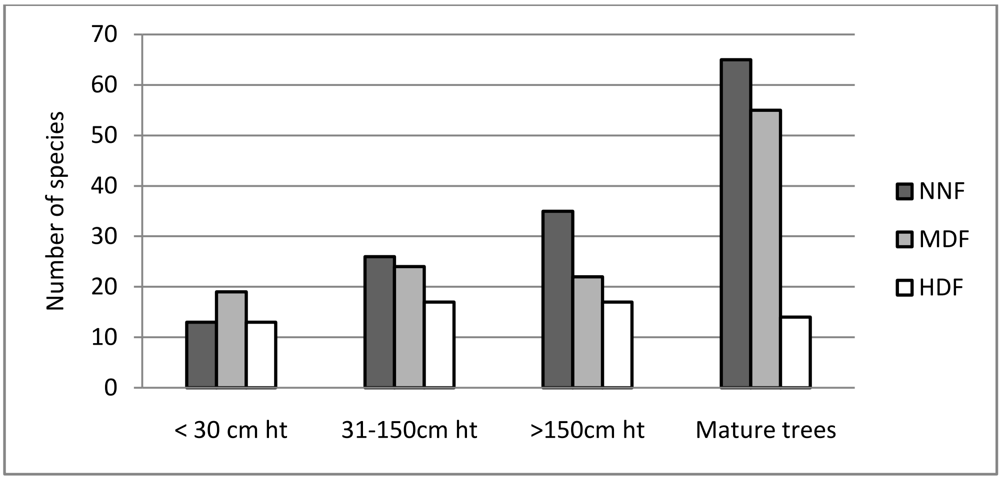

Figure 13: Number of species in the natural regeneration and mature stand according to forest types.

Common species in natural regeneration are listed in accordance with three forest types and height classes in Table 10. There were only two species namely *Garuga pinnata* and *Bursera serrata* found common with different frequencies at < 30 cm height class. The highest frequency (0.33) for both species was found in the MDF followed by NNF (0.25 and 0.13 respectively) and the lowest frequency (0.14 and 0.07) was found in HDF. There were four species (*Derris robusta*, *Garuga pinnata*, *Bursera serrata*, *Artocarpus chaplasha*) common at 31-150 cm height class with different frequencies. *Derris robusta*

(0.71) and *Bursera serrata* (0.36) were found with the highest frequency in HDF followed by MDF and NNF. On the other hand, the highest frequency (0.31) of *Garuga pinnata* was found in the NNF. In MDF and HDF this species was found with the frequency of 0.27 and 0.21 respectively. Even though *Artocarpus chaplasha* had more or less same frequency in NNF (0.25) and MDF (0.27), the highest frequency was observed in MDF. This species had very low frequency (0.07) in HDF. *Derris robusta* had the same trend of frequency at > 150 cm height class as 31-150 cm ht class. In HDF this species regenerated with the highest frequency (0.29), a very low frequency (0.06) was observed in the NNF. But *Artocarpus chaplasha* was found in the NNF with the highest frequency of 0.44 and in MDF and HDF was found with the same frequency (0.07). *Bursera serrata* had almost same frequency in the NNF (0.13) and in the HDF (0.14), the highest frequency (0.2) was observed in the MDF. The same frequency (0.13) was found for *Garuga pinnata* in NNF and MDF. *Anogeissus acuminate* have the highest frequency (0.29) in HDF whereas very low frequency found in NNF and HDF. It was clearly observed that as the height class of regeneration increases the number of common species is also increased.

Table 10: Common species in natural regeneration with their frequencies according to different height classes.

Height class	Botanical name	NNF	MDF	HDF
<30cm ht	*Garuga pinnata*	0.25	0.33	0.14
	Bursera serrata	0.13	0.33	0.07
31-150cm ht	*Derris robusta*	0.13	0.2	0.71
	Garuga pinnata	0.31	0.27	0.21
	Bursera serrata	0.19	0.27	0.36
	Artocarpus chaplasha	0.25	0.27	0.07
>150cm ht	*Derris robusta*	0.06	0.13	0.29
	Garuga pinnata	0.13	0.13	0.07
	Bursera serrata	0.13	0.2	0.14
	Anogeissus acuminata	0.06	0.07	0.29
	Artocarpus chaplasha	0.44	0.07	0.07

Note: NNF - near to natural forest type; MDF - moderately disturbed forest type and HDF – highly disturbed forest type.

3.2.2. Species diversity

Shannon index, Simpson index and evenness index for each height class in accordance with different forest types are given in Table 9. The Shannon index varied with different height classes and according to the different forest types also. The NNF had less species diversity in < 30 cm height class of regeneration compared to the other two forest types. The highest index value (2.40) was found in HDF followed by the MDF (2.00). However, in the other two height classes (31-150 cm ht and >150 cm ht) the highest index value (3.14 and 3.50 respectively) was found in the NNF which represent high species diversity in this type of forest. The MDF had high species diversity in both regeneration classes (31-150 cm ht and > 150 cm ht) with the value of 3.05 and 2.76 respectively. Even though the HDF had not have a high diversity as the other two types, it had quite a diverse regeneration with a more or less even distribution of individuals for each species. More or less the same trend was observed for the Simpson index among the three different forest types at three different height classes of regeneration (Table 9). The same table presents the evenness of each species at different height classes and different forest types. The individuals among the three forest types were distributed evenly at the height class of 31-150 cm (Table 9). But in the NNF and the MDF at the height class of < 30 cm the individuals were not distributed evenly. In the >150 cm height class the evenness index value for the NNF and the HDF were found near to 1 which indicates evenness of individuals. The MDF had the evenness value of 0.89 at > 150 cm height class of regeneration was lower than in the HDF (0.95).

Table 11: Shannon index, Simpson index and Evenness index according to height classes and forest types.

Indices	Seedlings	NNF	MDF	HDF
Shannon Index	< 30cm ht	1.89	2.00	2.40
	31-150cm ht	3.14	3.05	2.69
	>150 cm ht	3.50	2.76	2.70
Simpson Index	< 30cm ht	0.26	0.23	0.10
	31-150cm ht	0.05	0.05	0.08
	>150 cm ht	0.03	0.10	0.08
Evenness Index	< 30cm ht	0.74	0.68	0.94
	31-150cm ht	0.96	0.96	0.95
	>150 cm ht	0.99	0.89	0.95

Note: NNF - near to natural forest type; MDF - moderately disturbed forest type and HDF – highly disturbed forest type

Shannon diversity index in natural regeneration of < 30 cm height according to each sample plot is presented in Figure 14. The Shannon index value for each plot varied from 0 to 1.5 which indicates that the species diversity and also evenness of the species within the regeneration were not as high as in mature stand. On the plots of the NNF (1st to 16th plot) there was no species diversity or absence of regeneration in 9 sampling plots. But three sampling plots (3rd, 7thand 13th) had relatively higher diversity than others. The MDF is represented with 17th to 31th sampling plot. Among them 5 sample plots had relatively higher diversity than others having index value of > 1 and above. In the HDF only 3 sample plots had index value of > 1 and rest of 11 plots had the less index value ranged from 0-1. The species diversity changed with increasing height classes (Figure 15 and Figure 16).

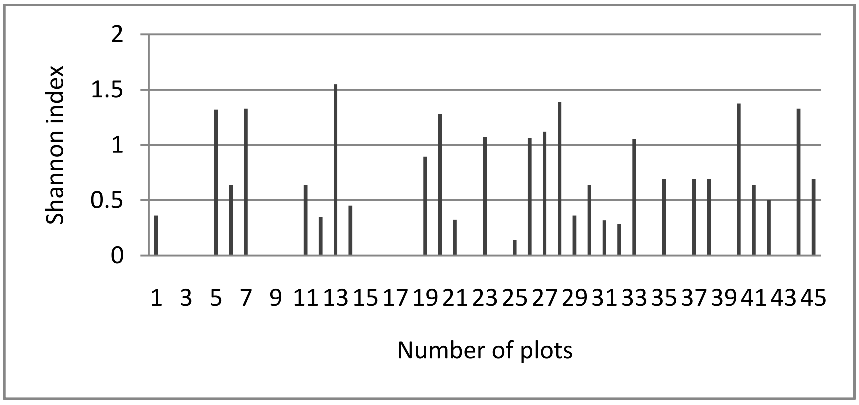

Figure 14: Shannon index in natural regeneration at < 30 cm ht class according to sample plots.

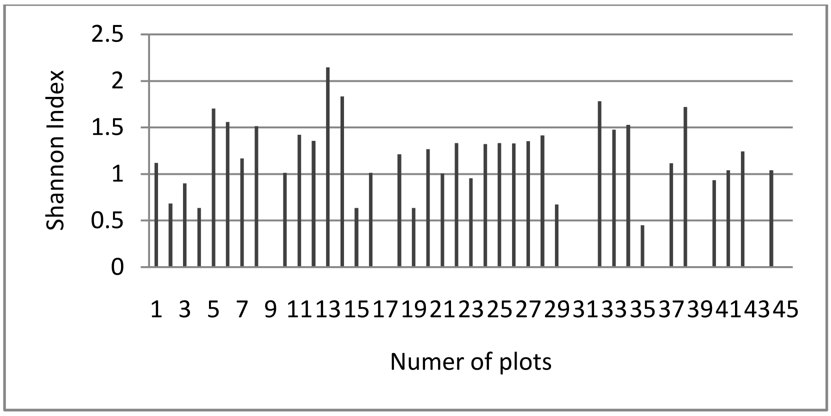

Figure 15: Shannon index in natural regeneration at 31-150 cm ht classes according to sample plots.

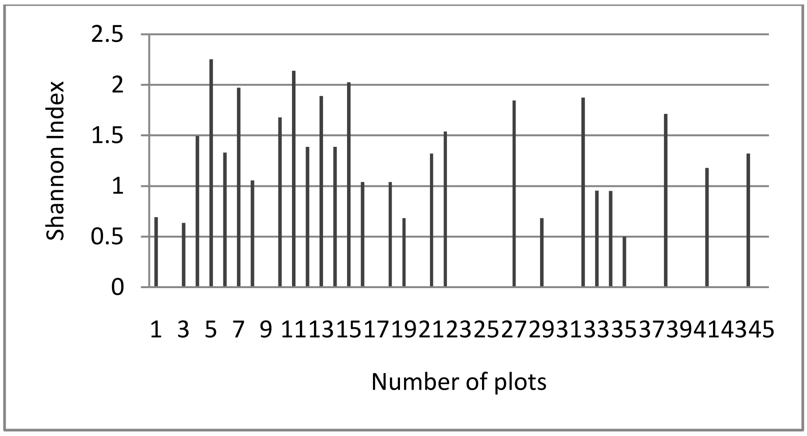

Figure 16: Shannon Index in natural regeneration at > 150 cm ht class according to sample plots.

At the height class of 31-150cm more or less high diversity was observed in the NNF and the MDF compared to the HDF. But as height class increased to > 150 cm the highest species diversity was observed in NNF (Figure 16). At 31-150 cm height class 11 sample plots in the NNF had the index value of > 1. In the MDF and the HDF index value of > 1 were observed in 9 and 8 sample plots respectively. At > 150 cm height class 12 sample plots in the NNF had the index value of > 1 whereas the MDF and the HDF had only 4 sample plots with the index value of > 1.

3.2.3. Rarity

Rare species based on occurrence along with their composition in natural regeneration at the height class of < 30 cm were given in Table 12 according to the forest types. There were 13 species found regenerating in both NNF and HDF whereas 19 species in the MDF. There were 10 species found rare among 13 species with 19% of composition in NNF and only one species was found very frequently. Among three forest types there were 5 species found frequently within a share of 67%. Of them 2 species found in both NNF and HDF and only one species found in MDF. Only one species was found very frequently in NNF and 3 species in MDF. In total 26 species were found rare and very rare in MDF and HDF. Among them 6 very rare species belong to MDF and 2 found in HDF. As height class of regeneration increased the rarity of species based on the occurrence changes remarkably (Table 13). There were in total 26 species in NNF, 24 species in MDF and 17 species in HDF were found regenerating. Rarity increased in NNF and MDF. Collectively 22 species were found as rare and very rare in NNF, 20 species for MDF and 14 species for HDF. Only one species was found frequently and 2 species very frequently in HDF in natural regeneration whereas 4 species were found frequently for both forest of NNF and MDF. There were 35 species under NNF, 22 species under MDF and 17 species under HDF were found in natural regeneration at > 150 cm ht class (Table 14). There was only one species found very frequently in HDF with 52 % of composition. All together 33 species were found in category of rare and very rare in NNF whereas 20 species in MDF and 16 species in HDF. There were only 2 species found frequently in both NNF and MDF.

Table 12: Number of species (%) according to rarity and different forest types in natural regeneration (< 30 cm ht).

	NNF	MDF	HDF
Very rare	-	6 (3%)	2 (3%)
Rare	10(19%)	9 (19%)	9 (53%)
Frequent	2 (14%)	1(9%)	2 (44%)
Very frequent	1 (67%)	3(69%)	-
Total	13(100%)	19(100%)	13 (100%)

Note: Very rare = 1 individual, Rare = 2 - 9 individuals, Frequent =10 - 20 individuals and Very frequent = > 20 individuals

Table 13: Number of species (%) according to rarity and different forest types in natural regeneration (31-150 cm ht).

	NNF	MDF	HDF
Very rare	6(5%)	5 (5%)	4 (3%)
Rare	16 (53%)	15 (49%)	10 (35%)
Frequent	4 (42%)	4 (47%)	1 (13%)
Very frequent	-	-	2 (49%)
Total	26 (100%)	24 (100%)	17 (100%)

Table 14: Number of species (%) according to rarity and different forest types in regeneration (> 150 cm ht).

	NNF	MDF	HDF
Very rare	18 (17%)	12 (20%)	6 (6%)
Rare	15 (59%)	8 (44%)	10 (42%)
Frequent	2 (24%)	2 (36%)	
Very frequent	-	-	1 (52%)
Total	35 (100%)	22 (100%)	17 (100%)

Note: NNF - near to natural forest type; MDF - moderately disturbed forest type and HDF – highly disturbed forest type

4. Discussion

In the present study 91 species were recorded of which 81 species belong to 35 families in Kassalong reserve forest (North Forest Division). However, from a previous inventory in 1961 it was reported that more than 100 species were found (Anon, 1970). In comparison, 41 tree species were recorded from the reserve forest of Khagrachari district on a sample area with around 600 m^2 (Anon, 2007). However, it is crucial to have an appropriate sample size for an accurate representation of species richness in the tropics. There are different arguments for an appropriate size of the sample area in tropical forests (Ashton, 1965; Riswan, 1987; Richard, 1996; Wilkie et al., 2004; Rahman et al., 2009). According to Ashton (1965) 2-5 ha sample area is sufficient for species richness but Wilkie et al. (2004) proved that 15 ha might be not enough for measuring of species richness. On the contrary, it was reported that species richness is almost steady within the area of 1.2 to 1.8 ha in moist deciduous forest of Bangladesh (Rahman et al. 2009). In the present study the sample area was 1.35 ha. The Kassalong reserve forest had a high species numbers compared to other reserve forests of the country. In the Sitapahar and Bamu reserve forest 85 tree species have been observed (Nath et al., 2000 and Hossain et al., 1997). As Kassalong reserve forest has similarity (except the absence of *Shorea robusta*) with the forest of Eastern Himalayas the species richness could be comparable with wet-evergreen forest of Arunachal Pradesh, Darjeeling, Eastern and Western Ghats of India. In Arunachal Pradesh Nath et al. (2005) reported 94; in Darjeeling Shankar (2001) recorded 87 tree species, whereas Kadavul (1999) and Parthasarathy (1999) estimated 80 species in Eastern Ghats and 122 in Western Ghats. However, tree species richness declines with the increase of disturbances where in NNF have been found 63 species, 54 species in MDF and only 14 species in HDF. The same species declining trend with disturbances were observed in different studies of Eastern Himalayas and moist deciduous forest of Bangladesh (Bhuyan et al., 2003; Rao et al., 1990 and Rahman et al., 2009). Especially botanical diversity along with species richness decreases in management system using the 'taungya' system (Webb and Sah, 2003). In the present study only 14 species were observed in HDF created by 'taungya' system as well.

In the present study the highest median stand density was found in the HDF (533 stems/ha), followed by NNF (399) and lowest was recorded in MDF (233) of having dbh ≥ 5 cm. But well stocked tropical forest have a density of 283 to 382 stems/ha of dbh ≥ 10cm (Howard and Valerio, 1992; Nath et al., 2000). On the other hand from the study of

Bhuyan et al., (2003) in Arunachal Pradesh the stand density was in between 338 to 5452 stems/ ha of dbh ≥ 6.36 cm where density of the stand decrease by disturbance intensity. The same declining trend of density with disturbances was also observed in the study of Nath et al. (2005) and Parthasarathy (1999). However, stand density varies according to human interference. In the present study it was observed lower stems/ha in the MDF than the NNF. But the HDF had the highest stems/ha compared to the other forests because of artificial regeneration.

The reverse J shaped diameter distribution was observed in the NNF. From the study of Kadavul (1999) and Hossain et al. (1997) the same diameter distribution observed in natural forest. MDF had no regular declining trend of individuals with increased diameter classes compared to NNF but trees with high diameter classes. The same relation was also found from the study of Nath et al. (2005). On the contrary, the HDF had limited diameter class range (< 10 cm – 60 cm) compared to others.

The value of basal area in Sitapahar reserve forest was reported 55.23 m^2/ha (Nath et al., 2000) which is quite higher than Kassalong reserve forest where the MDF had the highest median value of basal area (37.2). But this value is near to other tropical forests ranges from 10.73 to 39.62 m^2/ha (Saxena and Singh, 1982; Dawkins, 1959). But the value of density and basal area of the present study only represents the existing coverage of the forest. Because data were collected only from the forest where some vegetation was exist. Some plots from HDF and MDF were ignored where most of all trees were felled for cultivation or temporary or permanent settlement purposes.

According to chemical status it was observed that natural decomposition was higher in NNF followed by MDF and HDF showed the lowest decomposition. Interestingly, the amount of potassium and phosphorus was higher in MDF which could be explained by the cultivation with different crops or for using chemical fertilizer. However, the site conditions were comparable in order to draw conclusion on species richness.

It is observed that diverse communities are more stable then ecosystem with less diversity (Ralhan et al., 1982; Elton, 1958; Odum, 1971). In the present study Shannon –wiener index of the mature trees shows a value ranging from 2.18 to 4.08. Among them the highest species diversity were found in NNF (4.08) which was quite higher than the Shannon index value (2.98) found in Sitapahar reserve forest in Bangladesh (Nath et al.,2000). In addition, species diversity of the forest decreases with increasing disturbances. The same trend was found from other tropical forests (Bhuyan et al., 2003;

Rao et al., 1990) as well. However, the present study had higher species diversity than wet evergreen forest of Arunachal Pradesh where the Shannon index value recorded 2.02 in undisturbed forest (Bhuyan et al., 2003). In the HDF a comparatively higher dominance and less even distribution was found among the species compared to the other two forest types. Rao et al. (1990) observed high dominance and low equitability in disturbed forest and vice-versa in undisturbed forest. The NNF and the MDF had higher species diversity having the index value of 1.27- 2.78. On the contrary, the HDF had only two sampling plots with an index value of 1 and 5 plots having index value of 0 indicate zero diversity. So, this could explain that the species diversity declined in the HDF more than in the MDF and the NNF. The result is in line with the study of Webb and Sah (2003) where they reported the natural tree species gradually decline from the forest and subsequently dominated by introduced species in forests managed by the 'taungya' system.

The highest IVI (30.85) was found for *Tetrameles nudiflora* in NNF whereas Nath et al. (2000) found the highest IVI (53.15) for *Dipterocarpus turbinatus* in Sitapahar reserve forest. But in Bamu reserved forest of Bangladesh *Bursera serrata* recorded the highest IVI of 18.91 (Hossain et al., 1997). *Dipterocarpus turbinatus* in Kassalong reserve had the 3rd highest IVI of 17.69 and in Sitapahar reserve forest *Tetrameles nudifora* had very low IVI (2.04). *Artocarpus chaplasha* had the second highest IVI in both of the forest of Sitapahar and Kassalong reserve with different value of 29.51 and 12.74. Hence, from above discussion it was observed that the dominancy of species varies among different reserve hill forest of Bangladesh. Dominancy of species varies depending on stress based on past damages including human impacts, water drainage or bad site conditions (Keel and Prance, 1979; Jacobs, 1987; Richards, 1996 and Kadavul, 1999). The important value index for each species in the three different forest types varied. Among four species found common in three forest types, *Tetrameles nudiflora* had very high IVI in NNF compared to other two forest types. *Anogeissus acuminata* was found with the highest IVI in HDF and the other two species namely *Derris robusta* and *Duabanga sonneratioides* had the highest IVI in MDF.

In the present study about 59 tree species were recorded as rare and very rare species based on the occurrence in NNF that are much higher than the species (41) recorded by Nath et al. (2005) from undisturbed forest of Arunachal Pradesh. According to disturbance the number of rare and very rare species decreased where 54 species recorded in MDF and 11 species recorded in HDF. The same decreasing trend according to occurrence of rare and very rare species with disturbances was also found from the study of Nath et al.

(2005). Rare species constitute 67% of all individuals in the NNF of the present study and were very randomly distributed in the community. So, it is observed that rarity of the species in Kassalong reserve forest was higher than wet evergreen forest of Arunachal Pradesh and Darjeeling district (Nath et al, 2005; Shankar, 2001). The densities of tree seedlings at lower height class (< 30 cm ht) were higher in the MDF than in the NNF and the HDF. In MDF the density of mature trees is low which provides larger gaps suitable for natural regeneration. But quite opposite results were observed from the study of Nath et al. (2005) where density of seedlings found low in disturbed forest compared to the undisturbed forest. Interestingly at higher height classes (31-150 cm and >150 cm ht) density of seedlings were similar in NNF and HDF. It could be possible that logging activities supported the sprouting from Teak stumps which increased the total regeneration.

It was found that species richness is linked to human disturbances independently from different development stages. The number of species was higher in < 30 cm and 31 – 150 cm height class than > 150 cm height class at moderately disturbed forest type (MDF). This may result because of human interventions and a reduction of the cultivation cycle. In near to natural forest type (NNF) species richness increases with increasing height class of regeneration. However, in highly disturbed forest type (HDF) number of species was comparatively less than other forest types throughout the development stages. Similarly, from the study of Webb and Sah (2003) in Eucalyptus plantation, the species richness was found also very low. From different studies it was observed that for the recovery of species richness a range of 20-40 years is necessary for the tree community to return to pre-cut diversity levels (Webb and Sah, 2003; Webb and Fa'aumu, 1999). However, regeneration potential is related to human activities (Bhuyan et al., 2003; Kadavul, 1999). Specially, during shifting cultivation all regeneration is uprooted to allow the growth of cultivated species. According to the species richness in the MDF it could be hypothesized that if succession is allowed without human interventions species richness at MDF could reach the state of the NNF throughout the natural development of the forest. So, according to conservation of species diversity human impacts should be minimized to a certain level in order to allow an undisturbed development.

5. Conclusions

From historical point of view forest conservation activities in India and Nepal transferring forests under reserves and excluding people living near to the forest area always resulted in a decline of the forest cover along with species richness. There is a strong need to involve local people in the management of forests in order to increase the level of acceptance. Moreover, Teak plantations with a poor botanical diversity will not provide the necessary non-timber forest products to local people. So, to protect forests from destruction and to conserve its diversity some parts of the Kassalong forest could be managed in a participatory way. The demands of the local community should be considered to allow the conservation of these forests. Some parts which contain still some natural forests could be managed as protection forest and other parts could be managed as commercial forest with mixed timber species (leguminous and indigenous timber quality species) instead of monocultures with Teak only. Further studies are necessary to observe the forest ecosystems structures at spatial level, to quantify the socio-economic conditions of the forests and describe the long term effects of the human interventions. The following research questions might serve as a baseline for further research activities:

Does the intensity and severity of the disturbances in Kassalong reserve change over time?

Does a systematic sampling design instead of a random sampling provide different results?

How is it possible to describe the structure of the forests at spatial level?

What are the long term impacts of human interventions on the growing stock?

What is the role of decay and dead standing trees in the forest ecosystem?

What is the percentage and diversity of the underground vegetation and are there any impacts of human interventions on the underground vegetation?

What is the socio-economic condition of the community living within and nearby the study area and what is the role of the stakeholders for the conservation of the forests?

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7. Appendices

Appendix 1: Total tree species along with their botanical name, species code and family

Species code	Local name	Botanical name	Family
1	Teak	*Tectona grandis*	Verbenaceae
2	Gamar	*Gmelina arboria*	Verbenaceae
3	Dharmara	*Steriospermum personatum*	Bignoniaceae
4	Shimul	*Bombax ceiba*	Bombacaceae
5	Jumur	*Derris robusta*	Fabaceae
6	Bhadi	*Garuga pinnata*	Burseraceae
7	Gutguti	*Bursera serrata*	Burseraceae
8	Bandorhola	*Duabanga sonneratioides*	Lythraceae
9	Shiuri	*Anogeissus acuminata*	Combretaceae
10	Sundul	*Tetrameles nudiflora*	Datiscaceae
11	Bahera	*Terminalia bellirica*	Combretaceae
12	Mostali	*Sterculia guttata*	Sterculiaceae
13	Sada Koroi	*Albizia procera*	Leguminoceae
14	Udal	*Sterculia villosa*	Sterculiaceae
15	Jial bhadi	*Lannea coromadelica*	Anacardiaceae
16	Chapalish	*Artocarpus chaplasha*	Moraceae
17	Bhuro	*Macaranga denticulata*	Euphorbiaceae
18	Dhakijam	*Syzygium grande*	Myrtaceae
19	Achar	*Grewia microcos*	Tiliaceae
21	Toon	*Cedrela toona*	Meliaceae
22	Shanesil	*Adina cordifolia*	Rubiaceae
24	Modon mosta	*Dechasia kurzii*	Lauraceae
25	Amra	*Spondias pinnata*	Anacardiaceae
26	Hoza	*Callicarpa macrophylla*	Verbenaceae
27	Bongal	*Cordia dichotoma*	Boraginaceae
28	Kala koroi	*Albizia lebeck*	Leguminoceae
30	Nariche	*Maesa ramentacea*	Myrsineae
31	Shibeng	Unknown	Araliaceae
32	Unknown_1	Unknown_1	Unknown_1
33	Kurohar	Unknown	Bignoniaceae
35	Uriam	*Mengifera sylvatica*	Anacardiaceae
36	Pitraj	*Dysoxylum* sp	Meliaceae
37	Kathbadam	*Terminalia catappa*	Combretaceae
38	Srilankan chatian	*Gardenia* sp	Rubiaceae
39	Jalpai	*Eleocarpus* sp	Elaeocarpaceae
40	lotkon	*Baccaurea ramiflora*	Euphorbiaceae
41	Adalipun	*Meliosma pinnata*	Saviaceae

42	Rosbharala	*Holigarna* sp	Anacardiaceae
43	Moma	*Saraca* sp	Caesalpiniaceae
44	Kao	*Garcinia cowa*	Guttiferae
45	Felatheng	Unknown	Euphorbiaceae
46	Chalmogra	*Hydnocarpus kurzii*	Flacourtiacea
47	Jarul	*Lagerstroemia speciosa*	Lythraceae
48	Suche	*Litsea glutinosa*	Lauraceae
49	Helpata	*Pongamia pinnata*	Papilionaceae
50	Demolgulo	*Garcinia xanthochymus*	Guttiferae
51	Kali garjan	*Dipterocarpus turbinatus*	Dipterocarpaceae
52	Kurukh	*Polyalthia simiarum*	Annonaceae
53	Putijam	*Syzygium* sp	Myrtaceae
54	Nilkadam	Unknown	Rubiaceae
55	Tali	*Palaquium polyanthum*	Sapotaceae
56	Borta	*Artocarpus lacucha*	Moraceae
57	Sudogulo	Unknown_4	Unknown_4
58	Chickrashi	*Chickrasia tabularis*	Meliaceae
59	Unknown_5	Unknown_5	Unknown_5
60	Chepuru	Unknown	Euphorbiaceae
61	Barala	*Holigarna caustica*	Anacardiaceae
62	Rangi Garjan	*Dipterocarpus sp*	Dipterocarpaceae
63	Nageswar	*Mesua ferrea*	Clusiaceae
65	Batna	*Quercus* sp	Fagaceae
66	Bongori	unknown_6	Unknown_6
67	tulon pagor	*Anisoptera scaphula*	Dipterocarpaceae
68	Kanugo Bharal	*Dillenia suffruticosa*	Dilleniaceae
70	Hachkuro	*Leea alata*	Leeaceae
71	Bek gulo	Unknown	Ebenaceae
72	Sirifall	Unknown_7	Unknown_7
73	Soley	*Aphania danura*	Anacardiaceae
74	Mon hona	*Oroxylum* sp	Bignoniaceae
75	Civit	*Swintonia floribanda*	Anacardiaceae
76	Hedocam	Unknown_8	Unknown_8
77	Narikeli	*Pterygota alata*	Sterculiaceae
78	Horitaki	*Terminalia chebula*	Combretaceae
79	Dhali garjan	*Dipterocarpus gracilis*	Dipterocarpaceae
80	Burigulo	Unknown_3	Unknown_3
81	Dhup	*Canarium resiniferum*	Burseraceae
82	Bharatta	*Diospyros stricta*	Ebenaceae
83	Telsur	*Hopea odorata*	Dipterocarpaceae
85	Ashoth	*Ficus religiosa*	Moraceae
86	Jogona	*Mitragyna parviflora*	Rubiaceae
87	Monbhuro	*Mallotus* sp	Euphorbiaceae

88	Dumur	*Ficus hispida*	Moraceae
89	Ramkola	Unknown	Annonaceae
90	Joggo dumur	*Ficus* sp	Moraceae
91	Kadam	*Anthocephalus chinensis*	Rubiaceae
92	Hona	*Oroxylum lucidum*	Bignoniaceae
93	Arsol	*Vitex pinnata*	Verbenaceae
94	Unknown_9	Unknown_9	Unknown_9
95	Songori	Unknown_2	Unknown_2
96	Borpada	*Haplophragma adenophyllum*	Bignoniaceae
97	Unknown_10	Unknown_10	Unknown_10
98	Monada	*Mellotus philippensis*	Euphorbiaceae

Appendix 2: Relative density, Relative frequency and Relative dominance of all species according to different forest types.

		Relative density			Relative Frequency			Relative Dominance		
Species code	Botanical Name	NNF	MDF	HDF	NNF	MDF	HDF	NNF	MDF	HDF
1	*Tectona grandis*			72.26			41.17			54.46
2	*Gmelina arboria*		1.62	11.71		2.19	17.64		5.24	14.82
3	*Steriospermum personatum*	0.44	8.13		0.65	6.59		0.45	9.08	
4	*Bombax ceiba*		0.81			1.09			3.40	
5	*Derris robusta*	0.44	2.43	0.39	0.65	2.19	2.94	0.01	0.95	0.11
6	*Garuga pinnata*	2.24	2.43		3.26	3.29		2.76	2.91	
7	*Bursera serrata*	0.89	6.50		1.30	5.49		0.57	5.30	
8	*Duabanga sonneratioides*	2.24	3.25	0.78	1.96	2.19	2.94	1.75	3.98	3.55
9	*Anogeissus acuminata*	0.44	1.62	0.78	0.65	1.09	2.94	0.35	1.73	1.21
10	*Tetrameles nudiflora*	3.13	0.81	0.78	3.26	1.09	2.94	24.44	0.60	3.21
11	*Terminalia bellirica*	0.89	0.81		1.30	1.09		0.82	2.05	
12	*Sterculia guttata*	1.34		0.39	1.30		2.94	1.00		0.08
13	*Albizia procera*			9.76			8.82			19.12
14	*Sterculia villosa*		2.43			3.29			1.71	
15	*Lannea coromadelica*		2.43			2.19			2.05	
16	*Artocarpus chaplasha*	4.03	1.62		3.26	1.09		5.43	6.41	
17	*Macaranga denticulata*	0.89	5.69		1.30	2.19		0.03	0.30	
18	*Syzygium grande*	4.93			4.57			2.65		
19	*Grewia microcos*		1.62			2.19			0.79	
21	*Cedrela toona*		1.62	0.39		1.09	2.94		0.48	0.04
22	*Adina cordifolia*		0.81	0.39		1.09	2.94		2.20	0.26
24	*Dechasia kurzii*	0.44			0.65			0.05		
25	*Spondias pinnata*	0.44		0.39	0.65		2.94	1.82		0.83

26	*Callicarpa macrophylla*			0.78			2.94			0.46
27	*Cordia dichotoma*			0.39			2.94			0.61
28	*Albizia lebeck*			0.78			2.94			1.17
30	*Maesa ramentacea*	0.89			1.30			0.19		
31	Unknown	3.13			2.61			0.92		
32	Unknown_1	0.44			0.65			0.05		
33	Unknown	4.03	1.62		3.26	2.19		1.03	0.70	
35	*Mengifera sylvatica*	0.89	1.62		1.30	2.19		0.28	0.24	
36	*Dysoxylum* sp	8.07	6.50		3.26	4.39		6.44	4.79	
37	*Terminalia catappa*	0.89			1.30			1.36		
38	*Gardenia* sp	0.44			0.65			0.97		
39	*Eleocarpus* sp	0.89			1.30			0.34		
40	*Baccaurea ramiflora*	0.89	0.81		1.30	1.09		0.11	0.06	
41	*Meliosma pinnata*	4.03			3.26			1.71		
42	*Holigarna* sp	2.24			2.61			0.55		
43	*Saraca* sp	1.79	0.81		2.61	1.09		0.31	0.19	
44	*Garcinia cowa*	1.34	0.81		1.96	1.09		0.34	0.05	
45	Unknown	0.44			0.65			0.21		
46	*Hydnocarpus kurzii*	2.69	1.62		2.61	2.19		2.93	0.14	
47	*Lagerstroemia speciosa*	0.44	2.43		0.65	3.29		1.04	3.78	
48	*Litsea glutinosa*	0.89			1.30			0.26		
49	*Pongamia pinnata*	0.44			0.65			0.03		
50	*Garcinia xanthochymus*	2.24	1.62		2.61	1.09		2.13	0.42	
51	*Dipterocarpus turbinatus*	5.38	1.62		3.92	2.19		8.38	6.16	
52	*Polyalthia simiarum*	1.79			2.61			0.59		
53	*Syzygium* sp	1.34			1.30			1.33		
54	Unknown		0.81			1.09			0.02	
55	*Palaquium polyanthum*	0.44	0.81		0.65	1.09		0.14	0.07	
56	*Artocarpus lacucha*	0.44			0.65			0.41		
57	Unknown_4	1.34			1.96			0.20		
58	*Chickrasia tabularis*	1.34	1.62		1.30	2.19		1.54	1.34	

59	Unknown_5	3.58			1.96			2.78		
60	Unknown		2.43			2.19			2.90	
61	*Holigarna caustica*	4.48	0.81		3.26	1.09		2.03	0.30	
62	*Dipterocarpus sp*	1.79	0.81		1.96	1.09		4.59	0.54	
63	*Mesua ferrea*	3.58			3.92			1.50		
65	*Quercus* sp	0.44	1.62		0.65	1.09		0.51	0.58	
66	unknown_6	1.34	0.81		1.96	1.09		0.93	0.10	
67	*Anisoptera scaphula*	1.79			1.96			0.56		
68	*Dillenia suffruticosa*	1.34			1.30			0.67		
70	*Leea alata*	0.44			0.65			0.79		
71	Unknown	0.44			0.65			0.09		
72	Unknown_7	0.89	0.81		0.65	1.09		0.70	0.45	
73	*Aphania danura*	0.44			0.65			0.45		
74	*Oroxylum* sp	1.34	0.81		1.30	1.09		2.56	0.03	
75	*Swintonia floribanda*	0.44			0.65			0.75		
76	Unknown_8	0.89			0.65			1.33		
77	*Pterygota alata*	0.44			0.65			0.53		
78	*Terminalia chebula*	0.44	1.62		0.65	1.09		0.47	7.18	
79	*Dipterocarpus gracilis*	1.34	2.43		0.65	1.09		1.01	4.43	
80	Unknown_3	0.44	0.81		0.65	1.09		0.12	0.10	
81	*Canarium resiniferum*	0.89			0.65			0.50		
82	*Diospyros stricta*	0.44			0.65			0.12		
83	*Hopea odorata*	0.44			0.65			0.75		
85	*Ficus religiosa*		0.81			1.09			6.04	
86	*Mitragyna parviflora*		3.25			2.19			0.22	
87	*Mallotus* sp		1.62			2.19			0.07	
88	*Ficus hispida*		0.81			1.09			0.01	
89	Unknown		0.81			1.09			0.20	
90	*Ficus* sp		0.81			1.09			0.02	
91	*Anthocephalus chinensis*		0.81			1.09			0.40	
92	*Oroxylum lucidum*		0.81			1.09			0.02	

93	*Vitex pinnata*		2.43			3.29			5.23	
94	Unknown_9		2.43			3.29			1.78	
95	Unknown_2		0.81			1.09			0.35	
96	*Haplophragma adenophyllum*		0.81			1.09			0.38	
97	Unknown_10		1.62			2.19			0.73	
98	*Mellotus philippensis*		1.62			1.09			0.53	