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Author(s): Md. Masuduzzaman

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Supervisor(s): Dr. Md. Nazmus Sadath, Professor, Forestry and Wood Technology Discipline, Khulna University

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Regeneration status of tree species under mature stands in the Cox-bazar area of Bangladesh

Md. Masuduzzaman
Student ID : 140538

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LIFE SCIENCE SCHOOL
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Regeneration status of tree species under mature stands in the Cox-bazar area of Bangladesh

B.Sc. Thesis

By

Md. Masuduzzaman

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Supervisor

..........................28.10.18........

Dr. Md. Nazmus Sadath

Professor

Forestry and Wood Technology Discipline

Khulna University

Khulna-9208

Bangladesh

Prepared by

Md. Masuduzzaman
....28.10.18

Md. Masuduzzaman

Student no: 140538

Forestry and Wood Technology Discipline

Khulna University

Khulna-9208

Bangladesh

Declaration

I, hereby, declare that the results submitted in this thesis are entirely the authors own investigations and this work has not previously been accepted in substance for any degree and is not being concurrently submitted in candidate for any degree to any other university or institution.

Md. Masuduzzaman.

Md. Masuduzzaman

Student ID: 140538

Forestry and Wood Technology Discipline

Khulna University, Khulna-9208

Bangladesh

Dedicated to..........

My beloved parents

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ABSTRACT

The structure and natural regeneration patterns were examined in Coxbazar area of Bangladesh, at two forest sites: Teknaf and Dulahazra. A total 30 plots with an area of 12000 m^2 were sampled and evaluated for the species. Result of vegetation characteristics showed that the composition of hilly species differed significantly between the two sites. Based on the importance values, the order of dominant hilly trees in Teknaf is *D. alatus*> *S. grande*> *A. procera*> *T. grandis*> *A. malaccensis*> *S. Cumini*> *S. oloeosa*> *H. odorata*> *A. auriculiformis*> *T. arjuna*> *S. saman* > *G. arborea* and in Dulahazra *D. alatus*> *S. Cumini*> *Q. spicata*. *Dipterocarpus alatus* regeneration gives rise to high importabce value in the study area. There is no significance difference of regeneration density between the two study areas, but in case of tree density, there is a significant difference between the studied areas.

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1. Introduction

1.1 Background of the study

The total area of Bangladesh is 14,757 million hectares, of which forest lands account for almost 17.5% (2.53 million ha). For conserving biodiversity it is fundamental to arrest the loss of natural resources by adopting proper conservation strategies and protection of natural regeneration.
Forestry is an important sector in Bangladesh's economy, which contributes about 1.69% of the country's gross domestic product (GDP). The Chittagong Hill Tracts (CHT) in Bangladesh supports almost 80% of the country's total biodiversity and is inhibited by people from 12 ethnic groups who depend largely on forest commons to fulfill their basic subsistence requirements and cash income. The wide variety of plants and animals of the hill forests has supported the livelihoods of the hill people including dwelling, food, clothing, health care, and festivals (Alam 2006)
Bangladesh has a rich biological heritage containing about 5700 species of angiosperm. During last few decades, the whole natural forest structure of Bangladesh was negatively changed by both biotic and abiotic disturbances which ultimately affect the regeneration and population dynamics. Many forces are responsible for forest degradation, collectively and individually. The trend of these forces is very complex. The major causes of forest degradation in Bangladesh are agricultural expansion, over extraction of wood and non-wood resources, infrastructure development, population growth, deforestation, settlement, urbanization, and inappropriate management practices (Asadozzaman 2016). The rapid loss and degradation of forests in Bangladesh have brought about an alarming rate of forest biodiversity depletion. To develop biodiversity sustainably one must know the species present in an ecosystem (Al- Amin 2017).
Several types of disturbances like logging, landslides, gap formation, litter fall, herbivore, etc. can affect the potential regenerative status of species composing the forest stand spatially and temporally (Devi 2014).
The reforestation strategies adopted by a country depend inter alia upon the biophysical conditions and the socio-cultural environment of a particular country (Ahmed and Bhuiyan 1994). Depending on the management objectives, it is important to maintain the process of forest

renewal by appropriate natural and artificial regeneration. Under tropical conditions regeneration of forests by seeds or vegetative means is completed rapidly within a few months which results in high species diversity. Successful regeneration ensures ecosystem stability, efficiency and flexibility (Mukul, 2007; Neelo et al. 2013). In proper forest management, stands are never harvested without careful consideration on adequate regeneration rates (Islam 2003). Natural forest sites also had higher mature tree, pole, sapling and seedling densities compared with planted forests (Chauhan et al. 2008). The importance of advanced regeneration has been highlighted in forest recovery after natural and human disturbances in the tropics (Higo, 1994; Zegeye et al. 2011). Various studies have shown that plantation of native or exotic timber species can increase biodiversity by promoting woody understory regeneration (Ashton & Hall. 1992; Zegeye et al., 2011; Neelo et al. 2015).

Several studies were carried out in the recent years to investigate the plant diversity and community structure status in Sitapahar reserve forest of Chittagong Hill Tracts (South) Forest Division, Chunati Wildlife Sanctuary, Ukhiya natural forests of Cox's-Bazar Forest Division, and Ramu reserve forests of Cox's Bazar. But information on species composition in Shitalpur Forest Beat was not available previously. Moreover, information on floristic composition and their quantitative structure and diversity is vital for understanding the functioning and dynamics of forest ecosystems. Therefore, the main objective of the study was to investigate the vegetative composition and species diversity and also the status of natural regeneration on different hill area in Teknaf and Dulahazra in Cox-bazar Forest Division (Al- Amin 2007).

1.2 Problem Statement

Information on the regeneration status is important to determine the potential of an area for biodiversity conservation, though various studies on population structure and regeneration status have been carried out by many researches in different forest ecosystems but very scanty information has been generated on this aspect under the local conditions particularly in Bangladesh. The information on tropical tree diversity is needed because of its potential usefulness and implication for conservation and management across the protected area of Bangladesh. Thus, the aim of this study was to determine the current natural regeneration status of the study area with special attention to the scope of biodiversity conservation. In the study area, seed bank is very low and in some places the ground is completely covered with sun grass, creating problems for regeneration. Regeneration is occurring mainly through dispersed seeds from the nearby localities.

1.3 Objectives of the Study

Objectives of the present study were to:

- Characterize stand structure of hilly regeneration in Cox-bazar forest area.
- Estimate regeneration capacity of the existing hilly species.

2. Literature Review

2.1 Forest Stand Structure

Forest stand structure is defined as "the physical and temporal distribution of trees in a stand" and include within the description of the distribution of species, vertical and horizontal spatial patterns, size of trees or tree parts, tree age, or combinations (Oliver and Larson, 1996; Kasawani et al. 2007). Descriptions of forest stand structure are commonly based on the aggregation of individual plant measures such as density, tree diameter at breast height distribution. In addition to zonation, hill forests are also characterized by attributes such as species richness, canopy height, basal area, tree density, age or size class distribution, and understory development (Feller and Sitnik 2002).

Tree species diversity that influences the forests are climate, stand structure, species composition, and geomorphology. Forest stand structure is a key element in understanding forest ecosystems and also an important element of stand biodiversity (Ozcelik 2009). The rapid inventory of tree species that provides information on diversity will represent an important tool to enhance our ability to maximize biodiversity conservation that results from deforestation and degradation (Baraloto et al 2013). Information from this quantitative inventory will provide a valuable reference forest assessment and improve our knowledge by the identification of ecologically, useful species as well as species of special concern, thus identifying conservation efforts for sustainability of forest biodiversity.

2.1.1 Diameter at Breast Height

One of the simplest forms of stand characterization is the measurement of tree diameter. Diameter is usually measured with a tape at 1.3m above ground level and this measurement is referred to as DBH. The diameter measurement should be taken at 30 cm above. Diameter is closely related to stand development and can easily be converted to basal area (Kasawani et al., 2007)

2.1.2 Tree height

The height is also useful criterion in forest stand classification. In hill forest, stand height can be divided into three or four classes. Stand height at 0 – 9 m considered as regeneration while stand height at 10 – 19 m considered as young stand. Lastly, when a stand height reaches at > 20 m, it considered as old stand (FAO 1994).

2.1.3 Basal area

Basal area is the space covered or area occupied by a trees stem. The basal area of a stand is the sum of the individual basal areas of all trees greater than a certain diameter per unit ground area. It is a good measure of the overall stand development and can be related to wood volume and biomass (UNESCO 1984).

2.2 Relative Density

Relative density is the ratio of the density (mass of a unit volume) of a substance to the density of a given reference material. Specific gravity usually means relative density with respect to water. The term "relative density" is often preferred in scientific usage. It is defined as a ratio of density of particular substance with that of water.

If a substance's relative density is less than one then it is less dense than the reference; if greater than 1 then it is denser than the reference. If the relative density is exactly 1 then the densities are equal; that is, equal volumes of the two substances have the same mass.

Relative density can be calculated directly by measuring the density of a sample and dividing it by the (known) density of the reference substance. The density of the sample is simply its mass divided by its volume (Schetz et al 1999)

2.4 Relative Frequency

Relative frequency is the frequency of a given species expressed as a percentage of the sum of frequency values for all species present

Relative frequency = (number of trials that are successful)/ (total number of trials)

2.5 Relative Dominance

Relative dominance is the basal area of a given species expressed as a percentage of the total basal area of all species present.

2.6 Important Value Index (IVI)

The sum of relative density, relative frequency and relative dominance is termed as Important value Index and it lies between 0 and 300.

2.7 Natural regeneration on hilly area:

Natural regeneration is the process by which woodlands are restocked by trees that develop from seeds that fall and germinate in situ. The use of natural regeneration in forest management helps to reduce logging impacts on biodiversity, since the objective is to ensure that exploited trees are replaced by juveniles of tree species characteristic of the natural forest. The diversity of natural regeneration will generally exceed the diversity of species that could be planted on a commercial scale. Natural regeneration systems exploit existing seed and seedling banks and circumvent the problem of obtaining healthy planting stock. Seed production in many important tropical tree species is erratic and poorly documented and it is often difficult or impossible to obtain a regular supply. Planting stock cannot therefore be produced on demand. Where planting stock is available it is often collected from a narrow range of sites outside the local area and is likely to be of unknown but probably rather narrow genetic composition. Planted seedlings often suffer an initial period of poor growth and high mortality, termed planting shock. Poor initial growth will often put planted trees at a significant competitive disadvantage relative to the regeneration of other plants in disturbed forest sites. In contrast, natural regeneration will often show enhanced survival and vigorous growth in response to canopy disturbance. Major disadvantage of natural regeneration systems is that the forester has only indirect control over the composition of future forest stands. Although an aim of natural tropical rainforest Silviculture is to increase the regeneration of commercially desirable species and enhance their growth, this is constrained by the species and genotypes that are present in the seed and seedling banks. Genetic improvement is unlikely to occur through natural regeneration systems and little or nothing is known about the relative performances of different provenances of climax tropical rainforest trees. Concern has often been expressed that the 'creaming' or preferential felling of the largest trees or those with the best form from an area of natural tropical rainforest will leave only trees with undesirable genotypes in the forest. Natural regeneration offers a simple method for reducing the risk of such dysgenic selection. Most climax tropical rainforest tree species have populations which are composed of large numbers of seedlings and saplings and progressively fewer larger-sized trees. The largest commercial-sized trees will therefore constitute only a small fraction of the total population (Higo 1994).

Different Regeneration approaches face this challenge in different ways. The most common method simply consists in planting single-species stands of hill in areas thought to be suitable, without consideration of whether or not they supported hill in the past. This approach usually fails over the long term because the underlying soil and hydrological requirements of the hills are not being met. More informed methods aim to bring a damaged mangrove area back into its preexisting condition, taking into account not only ecosystem factors but also social, cultural and political perspectives. Taking this into account, it becomes crucial to the success of a regeneration project to evaluate what the hydrology of a disturbed hill site should look like under normal conditions, and the ways in which it has been modified (Feller 2002).

3. Materials and Methodology

3.1 Study Area

The study was conducted at Teknaf forest area and Dulahazra forest area. It is situated at the southwestern part of Chittagong district, between 20°90′10.18″ and 21°62′10.18″N latitude and 92°27′10.18″and 92°08′15.18″E longitude.

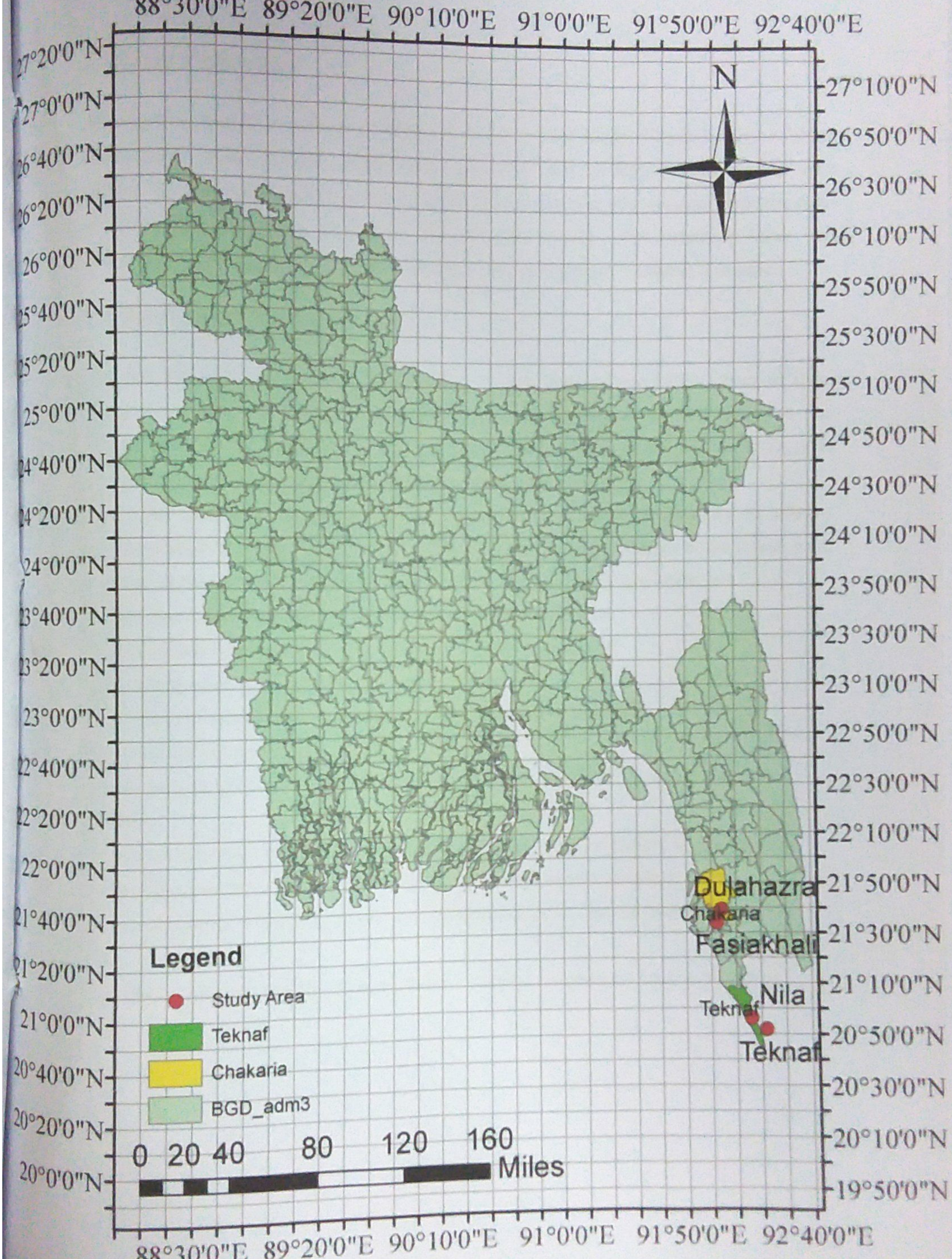
Tropical moist climate prevails in the area with distinct summer (March to May), monsoon (June to October) followed by a short, cool or dry winter (November to February). The mean annual maximum and minimum temperature are 30.9°C and 24.4°C respectively. The highest monthly rainfall occurs during the period from June to September with pre and post monsoon periods of rain during April, May and October, respectively. Average annual rainfall is to be 2687 mm. (Subhasis, 2017).

Firstly I randomly established fifteen plots in Teknaf area and fifteen plots in dulahazra area, which are located in the Cox-bazar area of Bangladesh. The number of the plots differed between the areas because of the accessibility of the stands. Within each sample plot of 20 m × 20 m, we also randomly established 2 sub-plots as pole plots with an area of 10 m × 10 m each and sapling plots with an area of 5m x 5m. The size of the plots differed between plots and sub-plots because of the differences in size and density of the mature trees, pole and sapling. All plots were established about 200 meters away from the shore of the river for avoiding potential destruction of the plots due to river erosion and damages due to storms.

3.2 Methodology

Several materials have been used along this data collection. Tape measurement for plot and transects establishment, diameter tape for DBH measurement, and compass for guide the pathway, Global Positioning System (GPS) for coordinate recorded.

Bangladesh's Map



3.3 Data Collection

All trees taller than 18 m in the study plots were numbered and height (H) and diameter at breast height (DBH) were measured. Within each regeneration plot, all the poles and saplings were marked, counted, and identified to species level. Then height and stem diameter were measured in April 2018. According to Cintron and Schaeffer-Novelli, 1984, structural index was calculated: importance value, I_v: relative density + relative frequency + relative dominance.

3.4 Analysis of the Data

The data gathered were types of species, DBH, Height. Mean of stand DBH, mean of stand height, basal area and DBH size class distribution were calculated for each mangrove tree species found in the study area. I also calculated mean seedling height and mean $D_{0\,1H}$ to calculate relative density, relative frequency and relative dominance.

The ecological importance of each species was calculated by summing its relative density, relative frequency and relative dominance. The complexity indexes of the forests were obtained as the product of a number of species, basal area, maximum tree height (m).

Density was measured species wise and total in each plot as follows:

Density of each species (no/ha) = no. x 10,000 m^2 / area of plot in m^2

Total density of all species = sum of all species densities

Basal area was measured species wise and total in each plot as follows:

Basal area (m^2) of each species = 0.005 x DBH

Total basal area of all species (m^2/ha) = sum of all species basal area / area of plot in m^2 x 10,000 m^2

Relative density = no. of individuals of a species / total no. of individuals of all species x100

Relative dominance = total basal area of a species / basal area of all species x 100.

Relative frequency = frequency of species/ total frequency of all species in different plots x 100.

Importance value of a species = relative density + relative dominance + relative frequency

4. Result and Discussion

The Hill species which are present in the study area is presented in Table 1. I found thirteen hilly mature tree species belonging to seven families. These are *A. auriculiformis*, *Albizia procera*, *Aquilaria malaccensis Dipterocarpus alatus*, *Gmelina arborea*, *Hopea odorata*, *Quercus spicata*, *Samanea saman*, *Schleichera oloeosa*, *Syzygium Cumini*, *Syzygium grande*, *Tectona grandis*, *Terminalia arjuna*. I also found ten hilly regeneration species: *Acacia mangium*, *Azadirachta indica*, *Castanopsis tribuloides*, *Dipterocarpus alatus*, *Hopea odorata*, *Phyllanthus emblica*, *Quercus spicata*, *Schleichera oloeosa*, *Syzygium Cumini*, *Syzygium grande*.

Table 1. Hilly species and regeneration recorded in the Coxbazar area of Bangladesh

Mature Hilly Species			Regeneration Species		
Sl No	Species	Family	Sl NO	Species	Family
1	*A. auriculiformis*	Fabaceae	1	*Acacia mangium*	Fabaceae
2	*Albizia procera*	Fabaceae	2	*Azadirachta indica*	Meliaceae
3	*Aquilaria malaccensis*	Thymelaeaceae	3	*Castanopsis tribuloide*	Fagaceae
4	*Dipterocarpus alatus*	Dipterocarpaceae	4	*Dipterocarpus alatus*	Dipterocarpaceae
5	*Gmelina arborea*	Lamiaceae	5	*Hopea odorata*	Dipterocarpaceae
6	*Hopea odorata*	Dipterocarpaceae	6	*Phyllanthus emblica*	Phyllanthaceae
7	*Quercus spicata*	Fagaceae	7	*Quercus spicata*	Fagaceae
8	*Samanea saman*	Fabaceae	8	*Schleichera oloeosa*	Sapindaceae
9	*Schleichera oloeosa*	Sapindaceae	9	*Syzygium Cumini*	Myrtaceae
10	*Syzygium Cumini*	Myrtaceae	10	*Syzygium grande*	Myrtaceae
11	*Syzygium grande*	Myrtaceae			
12	*Tectona grandis*	Lamiaceae			
13	*Terminalia arjuna*	Combretaceae			

The composition of hilly species, relative dominance, density, frequency and importance values of these species are presented in Table 2. Results showed that the composition of hilly differed significantly between the study sites and species. At Teknaf site, *S, grande* had the highest density (27.32%) and the importance value is 49.19. Meanwhile, *G. arborea* had the significance lowest density with recorded values of 0.5% and the less important value of *G. arborea* 2.55. In contrary, *D, alatus* had the highest density (89.36%) and the highest important values of *D. alatus* species (273.93) in Dulahazra site whereas *Q. spicata* had the lowest density (4.25%) and importance value (12.06).

Table 2. Specific (and relative) density, basal area (and derived % dominance), and relative frequency of mature trees in hilly communities along the Teknaf and Dulahazra area of Coxbazar. Relative values are expressed as %.

Site	Species	Specific density (relative %) (ha^{-1})	Relative frequency (%)	Basal area (dominance %) (m2 ha-1)	Importance value Iv	Mean stand H (m)	Mean stand DBH (cm)
	D. alatus	1000(21.85)	26.667	17.25(47.58)	80.00		
	A. procera	575(12.56)	20.000	4.89(13.49)	53.37		
	S. grande	1250(27.32)	15.000	5.01(13.82)	49.19		
	H. odorata	225(4.91)	13.333	5.78(15.95)	40.00		
	T. grandis	425(9.28)	5.222	1.02(2.81)	22.90		
Teknaf	*S. oloeosa*	275(6.10)	5.222	0.85(2.35)	12.32		
	A. malaccensis	325(7.10)	3.556	0.24(0.66)	10.55		
	S. saman	100(2.18)	3.556	0.38(1.05)	8.77	14.83±0.97	29.21±3.13
	T. arjuna	125(2.73)	2.222	0.40(1.12)	8.69		
	A. auriculiformis	175(3.82)	2.222	0.23(0.644)	8.05		
	S. Cumini	75(1.63)	1.667	0.08(0.22)	3.62		
	G. arborea	25(0.5)	1.333	0.08(0.24)	2.55		
	D. alatus	2100(89.36)	81.111	33.90(96.80)	273.93		
Dulahazra	*S. Cumini*	150(6.38)	11.111	0.91(2.61)	14.01	18±0.83	38.28±3.28
	Q. spicata	100(4.25)	7.778	0.20(0.58)	12.06		

For the combined data of both Teknaf and Dulahazra, in term of species, the density was the order of *S. grande* > *D. alatus* > *A. procera*> *T. grandis*> *A. malaccensis*> *S. oloeosa* > *H. odorata* > *S. Cumini* > *Q. spicata*> *A. auriculiformis*> *T. arjuna*> *S. saman* > *G. arborea.*

In the regenerating pole population, Ten hilly species namely *D. alatus, A. procera, T. grandis, A. malaccensis, S. Cumini, H. odorata, A. auriculiformis, Q. spicata. M. parvifolia, L. speciosa.* The mean pole density of the study area was 840 $ha,^{-1}$ the mean height (±SE) was 6.58±0.34 m, and the mean DBH (±SE) was 7.49±0.30 cm. The preponderance of *Q.spicata* regeneration gives the highest density 3100 ha^{-1} in the study area (Table 3). The importance value index for the pole species of *D. alatus, Q. spicata, S. Cumini, M. parvifolia, A. auriculiformis, H. odorata, T. grandis, L. speciosa, A. malaccensis, A. procera* were 102.88, 61.63, 39.63, 18.88, 14.28, 14.28, 14.28, 14.28, 10.13, 9.68 respectively. Based on the specific density and importance value, *D. alatus* was the principle hilly regeneration species in the Teknaf and Dulahazra area of Coxbazar. Similarly on the basis of relative density, relative frequency and overall importance value index, *Q. spicata* and *S. Cumini* were the species that were secondary in dominance among the hilly regeneration.

Table 3. Structural composition of hilly regeneration for pole species in Teknaf and Dulahazra area of Coxbazar. Relative values are expressed as %.

Species	Specific density (ha-1)	Relative Density(%)	Relative frequency(%)	Relative dominance(%)	Importance value I_v	Mean stand H(m)	Mean stand DBH(cm)
D. alatus	1700	34.8	33.3	34.8	102.88	7.81±1.02	7.03±0.40
Q. spicata	3100	20.2	21.4	20.0	61.64	7.61±0.51	7.73±0.52
S. Cumini	1000	12.6	14.3	12.7	39.64	6.34±0.07	7.56±0.10
M. parvifolia	400	6.0	7.1	5.8	18.89	8.33±0.19	8.01±0.41
A. auriculiformis	900	4.8	4.8	4.8	14.29	8.51±0.50	6.98±0.41
H. odorata	200	4.8	4.8	4.8	14.29	4.95±0.03	7.30±0.35
T. grandis	200	4.8	4.8	4.8	14.29	6.85±0.03	7.32±0.14
L. speciosa	200	4.8	4.8	4.8	14.29	4.75±0.03	6.82±0.07
A. malaccensis	400	3.8	2.4	3.9	10.13	5.77±0.64	7.67±0.11
A. procera	300	3.6	2.4	3.7	9.68	4.91±0.16	8.53±0.44

In the regenerating sapling population, Nine hilly species namely *D. alatus, T. grandis, A. malaccensis, S. Cumini, H. odorata, A. auriculiformis, Q. spicata. S. oloeosa*. The mean sapling density of the study area was 2888.88 ha,$^{-1}$ the mean height (±SE) was 4.44±0.24 m, and the mean DBH (±SE) was 3.98±0.30 cm. The preponderance of *D. alatus* regeneration gives the highest density 8000 ha^{-1} in the study area (Table 4). The importance value index for the pole species of, *D. alatus, S. Cumini, T. grandis, A. malaccensis, A. mangium, H. odorata, A. auriculiformis, S. oloeosa* were 73.6, 59.3, 58.4, 32.0, 25.3, 16.7, 16.7, 9.4, 8.7 respectively.

Based on the importance value, *Q. spicata* was the principle hilly sapling regeneration species in the Teknaf and Dulahazra area of Coxbazar. Similarly, on the basis of relative density, relative frequency and overall importance value index *D. alatus, S. Cumini* were the species that were secondary in dominance among the hilly regeneration.

Table 4. Structural composition of hilly regeneration for sapling species in Teknaf and Dulahazra area of Coxbazar. Relative values are expressed as %.

Species	Specific density (ha^{-1})	Relative Density(%)	Relative frequency (%)	Relative dominance(%)	Importance value I_v	Mean stand H(m)	Mean stand DBH(cm)
Q. spicata	6800	23.33	26.85	23.4	73.6	4.92±0.38	3.57±0.42
D. alatus	8000	20.86	18.52	19.9	59.3	5.20±0.22	3.52±0.25
S. Cumini	5200	20.09	18.52	19.8	58.4	4.99±0.23	3.39±0.33
T. grandis	800	10.71	11.11	10.2	32.0	3.76±0.13	3.76±0.17
A. malaccensis	1200	8.33	8.33	8.6	25.3	4.71±0.12	3.05±0.08
A. mangium	1600	5.56	5.56	5.6	16.7	3.8±0.24	2.95±0.33
H. odorata	1600	5.56	5.56	5.6	16.7	3.35±0.19	4.12±0.22
A. auriculiformis	400	2.78	2.78	3.8	9.4	6.13±0.24	5.83±0.76
S. oloeosa	400	2.78	2.78	3.2	8.7	3.1±0.40	4.43±0.19

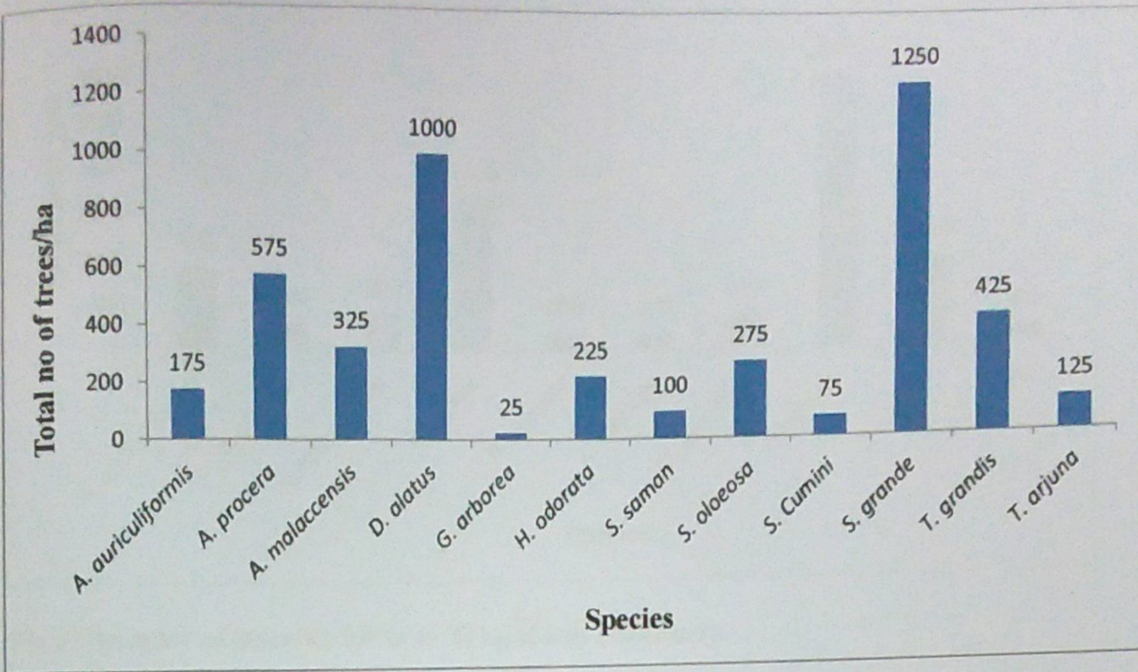


Fig1: Number of trees/ha in Teknaf

This figure showed that *S.grande* was the most abundant tree with 1250 trees/ha and *G. arborea* was the less abundant tree with 25 trees/ha in Teknaf area. For encroachment, illegal cutting of *G. arborea* stand reduce its abundance.

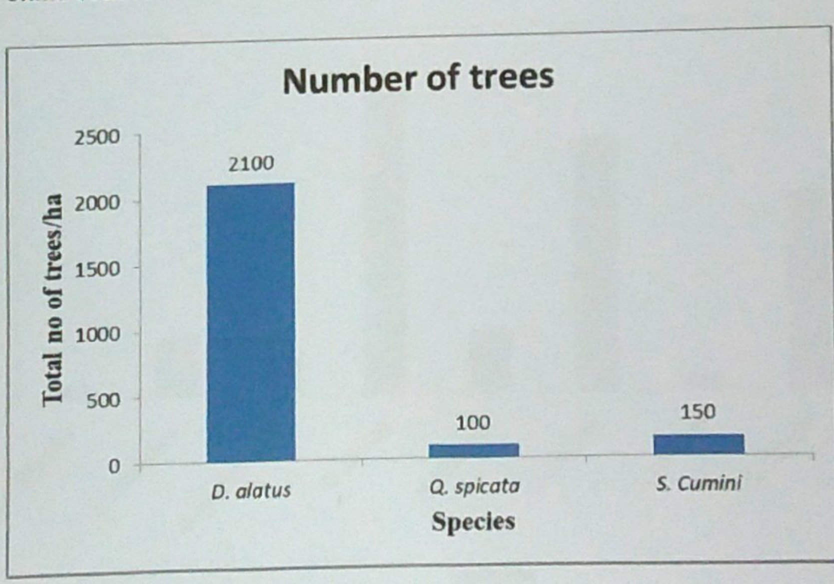


Fig 2: Number of trees/ha in Dulahazra

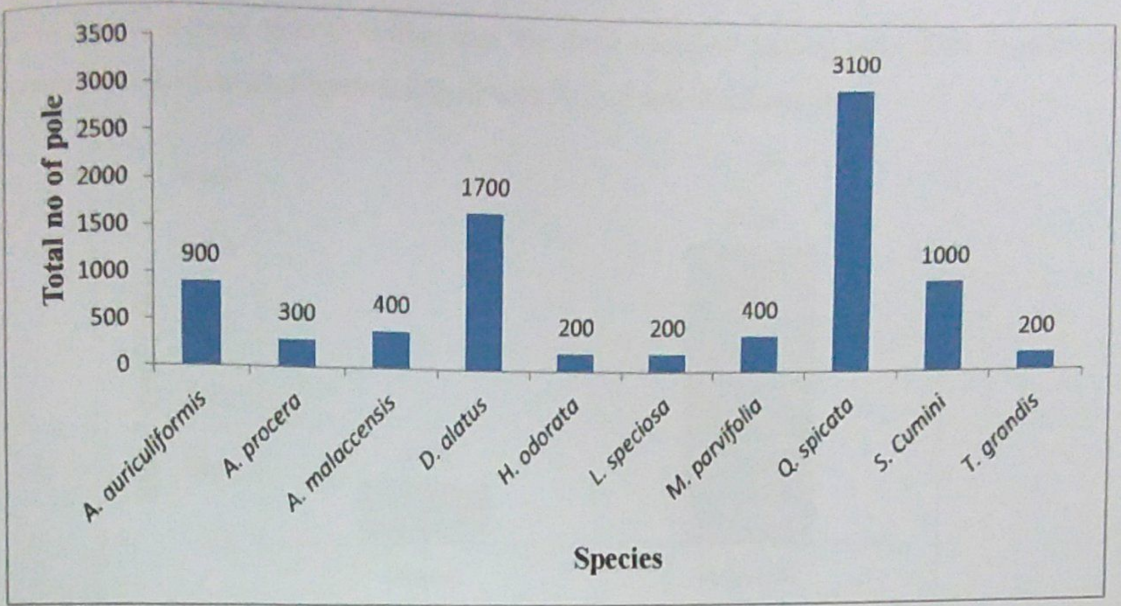


Fig 3: Number of poles/ha for both Teknaf and Dulahazra

This figure showed that *Q. spicata* was the most abundant pole with 3100 trees/ha and *H. odorata* , *L. speciosa, T. grandis* was the less abundant poles in both Teknaf and Dulahazra area. For encroachment, illegal cutting of *H. odorata, L. speciosa* stand reduce its abundance.

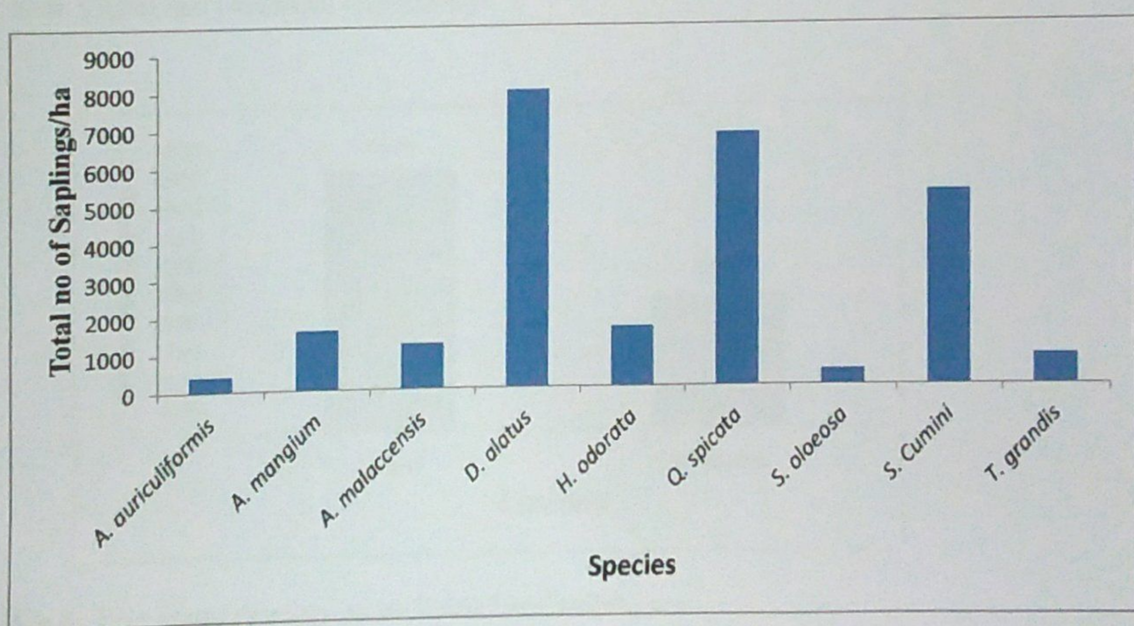


Fig 4: Number of sapling/ha for both Teknaf and Dulahazra

This figure showed that *D. alatus* was the most abundant sapling with 8000 trees/ha and *S. oleosa* was the less abundant sapling in both Teknaf and Dulahazra area.

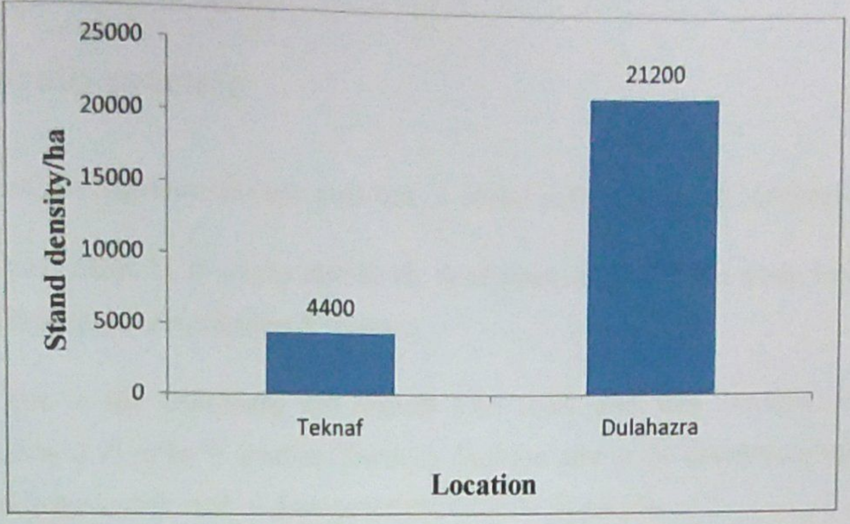


Fig 5: Sapling stand density/ha in Teknaf and Dulahazra

The density of hilly sapling were 4400 saplings/ha and 21200 sapling/ha for both Teknaf and Dulahazra respectively. The density of hilly sapling were 4575 trees/ha and 2350 trees/ha for both Teknaf and Dulahazra respectively.

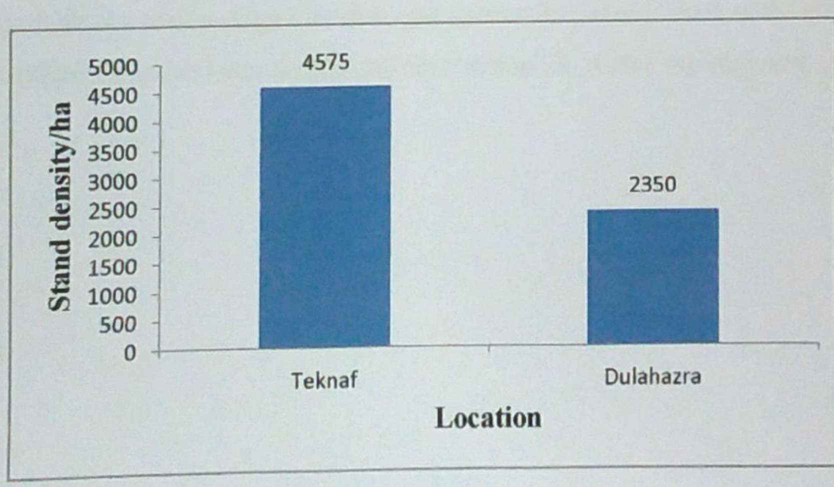


Fig 6: Tree stand density/ ha in Teknaf and Dulahazra

From the figure 5 and 6, we have found that tree density is higher in Teknaf. On the other hand sapling density is higher in Dulahazra. So it can be said that, higher number of mature trees reduces the number of sapling.

Community structure:

In Teknaf, the highest total basal area was *D. alatus* with 17.25 m^2ha^{-1} followed by 5.78m^2ha^{-1}

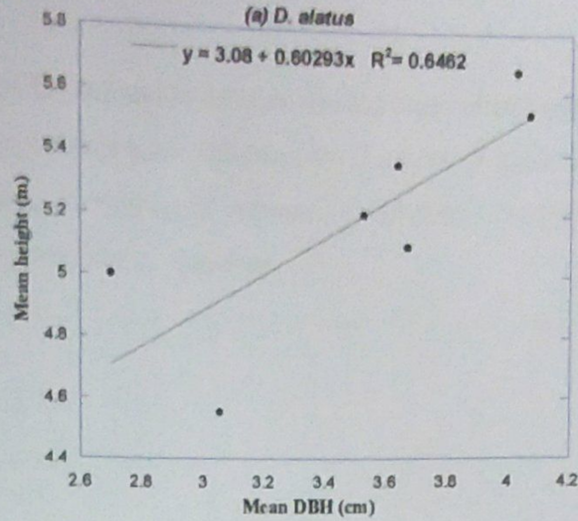
H. odorata (Table 2). *D. alatus* also be the dominance species in this study area while the lowest total of dominance recorded by *S. cumini.*

But in the Dulahazra, the highest total basal area was *D.alatus* with 33.90 m^2ha^{-1} followed by 0.91 m^2ha^{-1}*S. cumini* (Table 2). *D.alatus* also is the dominance species in this study area while the lowest total of dominance recorded by *Q.spicata.*

Total specific density for Teknaf study area was 4575 ha^{-1}. Meanwhile, total importance value for this study area was 80 with *D.alatus* be the highest total of importance value.

In case of Dulahazra study area, we found that total specific density was 2350 ha^{-1} whereas total importance value for this study area was 273.93 with *D. alatus* be the highest total of importance value.

Figure 6 shows scatter diagrams of height against diameter (*DBH*) of the hilly sapling. There was clear relationship between height and diameter of *D. alatus* saplings and *Q. spicata*(Fig. 6a and 6b).



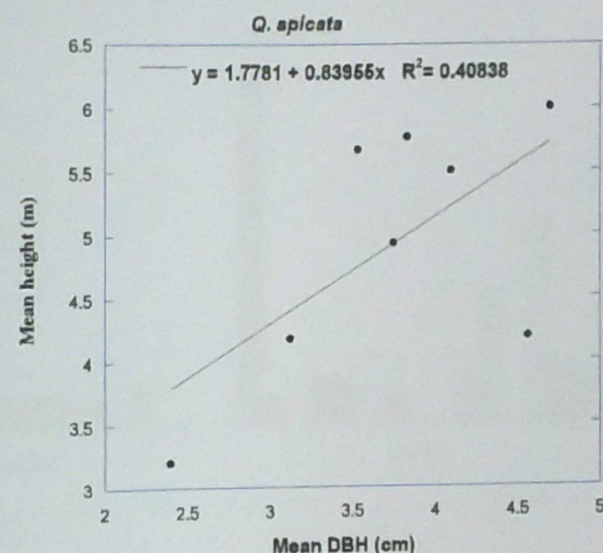


Fig. 7: Relationship between mean stem diameter and mean height of (a) *D. alatus* and (b) *Q. spicata*, the dominant hilly regeneration in the study area.

Figure 7 (a) shows that significant relationship between heights and DBH on the other hand figure 7 (b) shows that no significant relationship between heights and DBH.

For the combined data of Teknaf and Dulahazra, for the cases of tree and poles, it is seen that D. alatus had the highest importance value followed by *D. alatus, S. grande, A. procera, T. grandis A. malaccensis, S. Cumini, S. oloeosa, H. odorata, Q. spicata, A. auriculiformis, T. arjuna, S. saman , G. arborea. M. parvifolia, L. speciosa.*

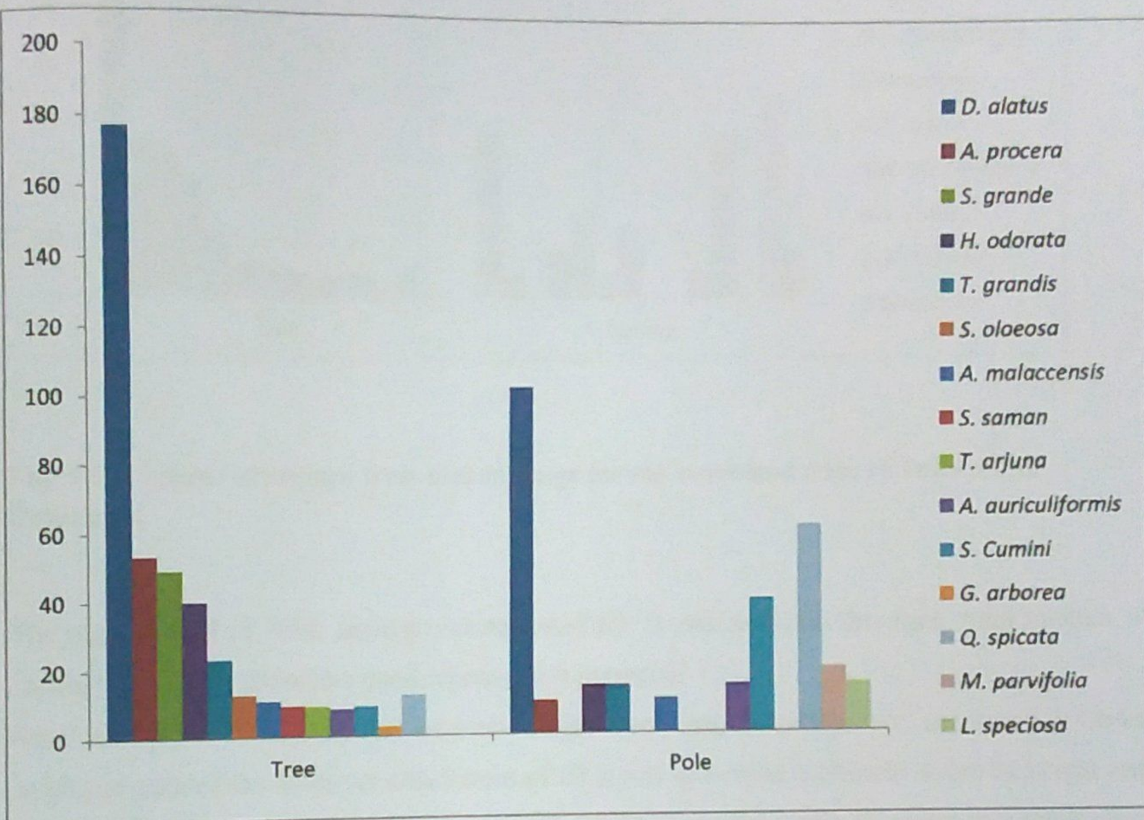


Fig: 8 IVI values of mature trees and poles for the combined data of Teknaf and Dulahazra

For the combined data of Teknaf and Dulahazra, for the cases of tree and sapling, it is seen that *D. alatus* had the highest importance value followed by *D. alatus, S. grande, A. procera, T. grandis A. malaccensis, S. Cumini, S. oloeosa, H. odorata, Q. spicata, A. auriculiformis, T. arjuna, S. saman , G. arborea. M. parvifolia, L. speciosa.*

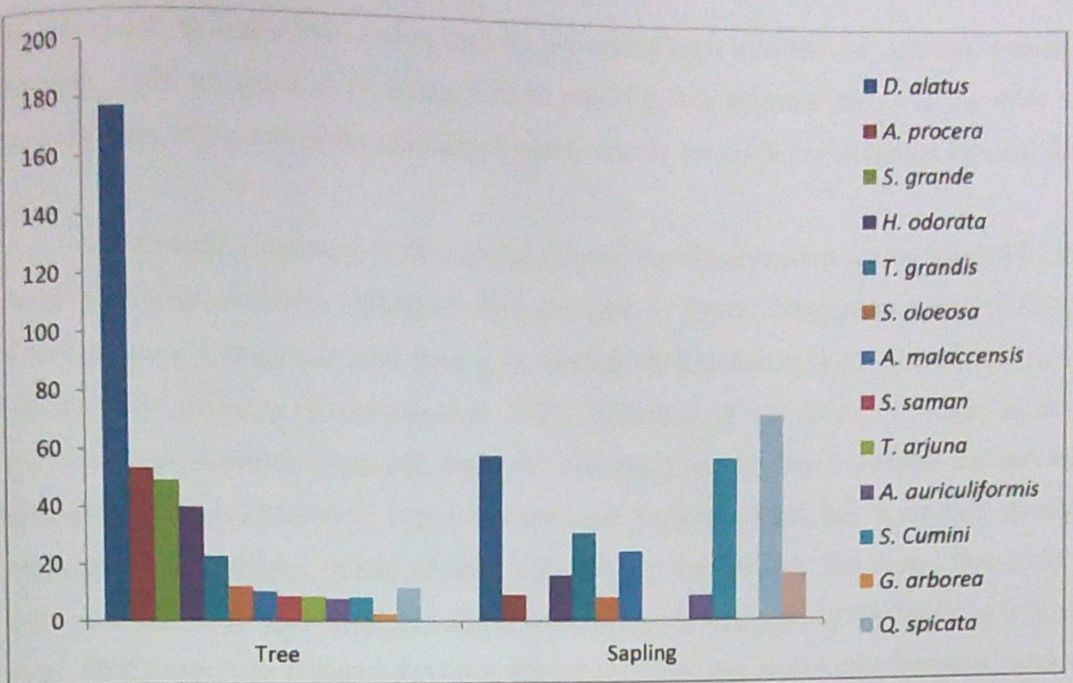


Fig: 9 IVI values of mature trees and saplings for the combined data of Teknaf and Dulahazra

The highest total of 8000 sapling was recorded for *D. alatus*. From this data, total number of sapling per hectare showed a good regeneration potential.

Basal area is the cross-sectional area of a single tree stem, including bark, measured at breast height, or sum of the cross-sectional areas of all stems in a stand measured at breast height and expressed per unit of land area (Kasawaniet.al. 2007). From the result, *D. alatus* was the highest total basal area in Teknaf and *D. alatus* was the highest total basal area in Dulahazra. The total basal area for the Teknaf study site is 36.24 m^2 ha-1 and Dulahazra site is 35.02 m^2 ha-1. Highest total basal area showed the species has wide range of diameter. If the diameter of tree wider, total basal area also will increase. The lowest total basal area was recorded by *S. cumini* in Teknaf which species was only founded in one plot and low of distribution. In Dulahazra, the lowest total basal area was recorded by *Q. spicata*.

Density is defined as the number of plants or specific plant parts per unit area of ground surface. The counting plant on sample plots of a known area is a simple means of deriving density estimates (Kasawani et.al. 2007). For the combined study area of Teknaf and Dulahazra, *D. alatus* will be dominance sapling species because of high total number saplings estimation per hectares. 8000 estimates of *D. alatus* will be grown in one hectares area. Density does not give an indication of the size of the individuals unless counts are made and recorded by size classes.

Meanwhile, frequency is the number of plots on which species occurs divided by the total number of plots sampled. Frequency data are used to detect changes in plant abundance and distribution on a range site over time or to identify differences in species responses to varying management practices (Kasawani et.al. 2007). Selection of the proper plot size is extremely important for estimating frequency, and more than one plot size may be needed for varying plant species and plant distribution. Frequency data are easily obtained, but numerous sample plots must often be evaluated before reliable estimates can be derived. We found that most of the species in hill forest give frequency above 0.05, which is supported by the findings of Kasawani et.al., (2007) who was reported that Most species in Mixed hill Forest give frequency above 0.05. This indicates that all plot samples found hilly species. Most of the plot will dominate with *D. alatus* poles and saplings, because this species showed the highest total of frequency .

In Teknaf and Dulahazra we found that *D. alatus* indicates the highest total of the important values.

In case of poles for a combined data of Teknaf and Dulahazra, *D. alatus indicates* the highest total of the important values compared to other hilly poles which was derived from the total relative density, relative dominance and relative frequency. If the species showed a higher important value indicated that species was abundance and can be found diversely in the study area.

For the combined data of Teknaf and Dulahazra, we found that the dominance tree species is *D.alatus* as well as the dominance poles species is also *D. alatus* whereas *Q. spicata* is the second dominance tree species in my study area. But in case of sapling regeneration, we found that *Q. spicata* is the second dominance sapling species in my study area.

D. alatus was the dominant mature hilly species at Teknaf and Dulahazra area and the most abundant regeneration layer was also *D.alatus*.

5. Conclusion

Hilly area natural regeneration depends on different condition of forest. Regeneration status may differ among different species due to various factors such as seed, seed buoyancy and other physic- chemical properties of the substrate. I tried to provide new and updated information about the regeneration capacity of mangrove species and the species diversity of the mature stands. This study showed that *Dipterocarpus alatus* , *Syzygium grande, Quercus spicata* and *Gmelina arborea* are dominant tree species, better suited for forest renewal in the southern part of Bangladesh. Among the common dominant species *Dipterocarpus alatus* is the best for natural regeneration. At the early stage of regeneration profuse numbers of seedlings are found and gradually it became less in the higher height classes. Disturbance like extraction of litters, regenerations, leaves for fuel purposes by local people had brought a decline in species regeneration status in plantations. Public awareness and special priority must be given to conserve the regeneration of tree species in plantations.

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