GROWTH OF BIOTICALLY DISTURBED AND UNDISTURBED FOREST AT RARHA OF RANCHI EAST FOREST DIVISION

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We, the undersigned, members of the Advisory Committee of **Mr. Praveen Kumar,** a candidate for the Degree of **Master of Science in Forestry** with the major in Forest Management have gone through the manuscript of the thesis entitled **"Growth of biotically disturbed and undisturbed forest at Rarha of Ranchi East Forest Division"** may be submitted by **Mr. Praveen Kumar** in partial fulfillment of the requirements for the degree.

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THESIS

SUBMITTED TO THE

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BY

Praveen Kumar

IN PARTIAL FULFILMENT OF THE REQUIREMENT

FOR THE DEGREE OF

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Dedicated to My Parents

WHOSE EVER LASTING BLESSINGS

INSPIRED ME FOR HIGHER AMBITION IN

LIFE

Praveen Kumar

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***Place** - Kanke, Ranchi*

Date** -* ***(Praveen Kumar)

Abstract

Forests are valuable natural resource. The goods and services provided by forests are of immense importance. The population explosion in India has resulted drastic change in the environment, habitat as well as on number and variety of species. In India Present forest cover is about 21.02% (690,899 km^2) of total geographical area, whereas, in Jharkhand state which is characterized by hill, minerals and tribals, the forest cover is about 29.61% (23,605 km^2) of the geographical area of the state. However, this much percentage of the forest is not sufficient to meet the people's demand as a result the forest wealth is facing lot of problems. Ultimately the forest of the area is also affected due to intensive rate of deforestation or tree removal.

Man and his domestic animals are the most important factors affecting forest vegetation, although man has been managing forests on scientific basis principle for the past 100 years or more, yet maximum destruction is cause by man in many part of the world. The present study has been conducted to assess the effect of biotic disturbances on two forest areas of Rarha Road identified as biotically disturbed and biotically undisturbed sites, which is located in hilly region of Chotanagpur Plateau of Jharkhand at distance of 25 km from Ranchi on Ranchi-Patratu.

The data was collected by partial sampling techniques taking the randomly distributed sample plots on both the sites in 5 ha area on each type. For collection of data on trees, shrubs, herbs and climbers, separate sample plots of the size 10.00 m X 10.00 m, 5.00m X 5.00m and 1.00 m X 1.00 m are selected, respectively. All the plant species whether it is tree, shrub, herb and climber occurred in a sample plot was recorded with respect to the number and basal area. In case of tree species diameter and height was also measured.

Study on species composition of biotically disturbed and undisturbed sites indicted presence of 73 plant species distributed to different families. Out of a total of 19 tree species, 12 species was found at both the sites viz. biotically

disturbed as well as undisturbed sites, while at of 10 shrub species, 6 shrubby species were common at both sites. Total number of herbaceous species was noticed as 31, out of which, 19 were common at both the sites. Out of 13 climber species, 8 were found at both sites. While remaining 5 climber species was found only at undisturbed site.

The maximum value of density, frequency and abundance were found for Sal (*Shorea robusta*) among ten selected economically important tree species at biotically disturbed and undisturbed sites. Similarly, maximum relative dominance values were found for Sal (*Shorea robusta*) at both the sites. However, maximum variation, were noticed in case of Palash, Kendu and Semal.

Among 8 commonly occurring species at disturbed and undisturbed sites in 7 tree species (Asan, Jamun, Kendu, Mahua, Piar, Palash and Sal) more average diameter at undisturbed site was found. The top diameter at undisturbed site for Asan, Jamun, Kendu, Mahua, Palash and Sal was found greater than disturbed site, while on disturbed site Semal and Piar have shown more diameter. The average height of Sal among ten species was found more at undisturbed site (17.86m) than disturbed site (13.33m). The top height estimated to know site quality of a forest area has indicated at maximum value in case of Jamun (15.50 m), followed by Semal (15.00 m) and minimum in case of Rori (9.75 m) an disturbed site, while at undisturbed site, maximum top height was calculated for Sal (20.41 m) and minimum in case of Kendu (11.50 m). At disturbed site maximum form quotient value has of Kushum (0.99) indicated cylindrical form, while at undisturbed site, Sal bearing on value of 0.90 for form quotient showed cylindrical form.

The total volume of Sal was found maximum as compared to all most all the tree species. The total volume of Sal at undisturbed site (268.90 cu.m/ha) was found almost eight time greater than its value at disturbed site (33.17 cu.m/ha). Fair regeneration Sal (36.7%) and Palash (29.5%) at disturbed site, while moderate (59.8%) in Sal and deficient (19.5%) in Palash at undisturbed site is noticed. Other species found at both the sites showed deficient regeneration.

Physico-Chemical properties of soil in biotically disturbed and undisturbed sites of Rarha forest area has indicated sandy loam soil on both the sites, while percentage of silt and sand was found more at undisturbed site. The soil pH ranged from 6.15 to 6.93 at biotically disturbed site, and 5.27 to 5.90 for undisturbed site. The value of organic carbon (%) was found more at undisturbed sites. The difference of available nitrogen between two sites (undisturbed and disturbed) was highly significant than available phosphorus and available potassium.

Chapter-I

INTRODUCTION

Man and his domestic animals are the most important factors affecting forest vegetation. Though man has been managing forests on scientific principle for the past 100 years or more, yet he continues to be the most powerful agent in destroying or otherwise damaging forests in many part of the world.

Forest are valuable natural resource. The goods and services provided by forests are of immense importance. In India, wood is a major forest produce used extensively for various purposes, i.e. for construction of houses, agricultural implement, bridges, sleeper, etc. Many species such Teak, Sal, Deodar, Sissoo, Babul, Chir, Haldu, Axlewood, Rosewood, Dipterocarps, etc. provide valuable timber.

The forests cover in India occupy 21.02 % (690,899 km^2) of land area (F.S.I, 2007), which has been greatly affected day by day by increasing human population. The impact of forest loss is seen in term of soil erosion, depletion of biological diversity, damage to watershed areas, and damage to wildlife habitat. In India, a large number of communities have been traditionally managing degraded land to promote vegetation which has provided an alternative to traditional Forest Management by State Forest Department. Millions of people living in rural parts of India directly or indirectly depend upon forest for meeting their basic requirements of food, fodder, and other forest produce. This has been a way of life for people for the past many centuries. Even after the organization of Forest Department about 140 years back, people still continued to enjoy rights and concession in near by forests. This has been the main cause for the degradation and depletion of forest area.

Presently, in Jharkhand State about 81.27% area (19,184.78 sq. km.) is protected area, while unclassed forest area is 0.14% (33.49 sq. km). If state of affairs of Bihar Forest is seen during the past ten year, it is noticed that about 2000 sq. km. forest area have been depleted, giving forest destruction rate to about 200 sq. km. per year. But after the establishment of Jharkhand increasing trend in forest cover is noticed.

Growth is the intrinsic capability of tree species tuned with the external conditions at the growing site. The magnitude of growth reflects the outcome of interactions between the genetic makeup of an individual and the prevailing environmental conditions. Various factors are known to influence growth and performance of tree through regulating various vital physiological processes.

Tree growth has been observed to be adversely affected by inadequate amount of water (Parker and Pallardy, 1988; Seiler and Cazell, 1990). Growth of different tree species varies from site to site. The growth in general and the height growth in particular is checked at any phenophase by any limiting factor. The growth in plants is not uniform throughout the year. Generally, the growth is affected directly with the prevailing climatic factors. In active growth period, i.e. in summer and in rainy season more growth is seen, while in winter season slowing of growth rate is observed in most of the plant species. As a result formation of distinct annual rings is obtained in temperate plants.

Tree growth has been shown to be adversely affected by inadequate amount of water (Kozilowski, 1985). Various environmental factors are known to affect growth and performance of tree through regulating various vital physiological processes (Dhyani and Purohit, 1984; Turnbull, 1991).

There are acute shortage of timber and other forest products in India and the resultant high cost is not only because of less productivity (0.5 cu.m.ha^{-1} yr^{-1}, while world average is 2.1 cu.m.ha^{-1} yr^{-1}, but also due to availability of small forest area on per capital basis, i.e. 0.12- 0.08 ha against the world average of 1.6 ha (Deb Roy, 1986).

Much attention is given to tropical forests in recent years due to their species richens (Whitmore, 1984), high standing biomass (Brunig, 1983) and greater productivity (Jordan, 1983). Tropical forest also act a major carbon sink (Lugo& Brown, 1992). In India, of the 86% of the tropical forest area, 54% is dry deciduous, 37% moist deciduous and the rest is wet evergreen or semi evergreen (Kaul and Sharma, 1971).

Biotic disturbances in forest ecosystem strongly affect the population structure. Indiscriminate felling, removal of forest biomass, heavy grazing and forest fire are most destructive factors, resulting into unstable climax communities and poor regeneration.

Fire wood occupies a predominant position as an energy source in rural India. As against the estimated requirements of about 157 million tones of fuel wood per annum, the supply is about 40 million tones of which recorded production is only 15 million tones (Anon, 1988b). The construction and industrial timbers which are important forest produce are also not in adequate supply. The present recorded production of timber is about 12.5 million. m^3 as against the requirements of 27.5 million m^3 (Anon, 1988b).

The other cause of forest destruction has been by domestic animals. Voracious browsers like goat nibble the growing buds and young seedling resulting loss to regeneration. A part from grazing and browsing, trampling of soil by the animals has also adversely affected growth of the seedlings. The hooves of cows, bulls, buffaloes, etc, besides trampling the Forest floor harden it, which becomes in hospitable habitat to receive the seeds and natural regeneration of forest species.

Planning for development of natural resources without endangering the environment is a prominent issue that world is facing today (Khorram and John, 1991). Now a days, more emphasis is given on adverse effect of deforestation and very little attention has been on the widening gap between demand and supply. Total rate of deforestation in tropical regions is in the order of 13.6 million ha per years and the forest loss is responsible for depletion of global biodiversity at a rate of 2 - 5% per decade.

Dry peninsular Sal forests are highly supported by the sub-tropical climate of Chotanagpur plateau of Jharkhand. Through-out the plateau, Sal grows naturally with sporadic associates like *Terminalia spp*, *Acacia catechu*, and *Butea monosperma*, etc. These forests are regarded as a climax formation on drier and more shallow soil by Champion and Seth (1968). The Tribal population in this region is largely dependent on neighbouring forest for its livelihood and daily requirement of fuel, fodder and other non-timber forest produces. The forest cause of the than Bihar (87.7%) for total Sal forest (Joshi, 1980). Now these forests have been reduced considerably due to heavy biotic interference during last decades.

The dominant tree species of dry peninsular Sal forest (*Shorea robusta*) face many problems viz, “die-back”, grazing and browsing and forest fires. Osmaston (1928) reported severe forest damage in Palamau Sal forest during 1904-1905 and Sinha (1967) noticed damage in these forests due to cold waves in 1961 for seventeen species including *Shorea robusta, Diospyros malanoxylon, Emblica officinalis*, *Butea monosperma* and *Terminalia species*.

Heavy mortality of Sal in forests of Bihar was also observed by Sahay (1958). Large scale die back of Sal seedling in Bhaber and Tarai Sal Forests were reported due to gnawing by rodents (Rajkhowa, 1964)

The plant wealth of India is about 45,000 species, which roughly constitutes 12% of the world plant diversity (Tiwari, 1993), and out of this flowering plants account for about 15,000 species, e.g. 16% of the world flora, of which roughly one third are endemic. Biodiversity loses its character when managed by monocyclic management system or by over exploitation. In the developing world, however, loss of landraces and semi-natural habitats is occurring at an alarming rate (Williams, 1988). Raven (1988) reported that vascular plant species are being lost at an average rate of about five species per day and this will raise to ten species per day in the early decades of the 21st century. Of the world's 250,000 plant species only 3000 are being used directly for human consumption and just two hundred species have been domesticated.

India Forest Policy 1988 endorses for at least 33% of forest cover for sustainable and stable environment in the country. But due to excessive anthropogenic pressure only 19% forest area is left. Moreover, merely 12% of this having close canopy and rest are categorized as open degraded forest. Forest degradation and deforestation are mainly because of increasing population and their encroachment in forest land for grasses, fuel, timber and NTFPs. Now under these circumstances the survival of forests and their continuous contribution to environment and human welfare cannot be assured on sustainable basis.

Although the forests contain a great number of tree species, they have become threatened to loss of tree species diversity in recent years (Biswas, 2001). There has been a government ban on felling of trees form natural forests for more than a decade, which illicit felling by encroacher has not stopped, This not only causes removal of large-bold trees and sapling, but also damage of seedling that come through natural regeneration (Das, 1980; Biswas, 2001).

In India, where almost 75% of the total population lives in rural areas, dependency on natural resources is common since varied biomass needs are met from surrounding vegetation (Singh, 1979; Bowonder *et al.*, 1987; Kothari *et al.*, 1989). Moreover, due to ever increasing human population, commercial demand on wood resources also has increased manifold. A substantial part of this demand is from urban centers, leading to the rapid destruction of country wide forest resources (Leach, 1987; Rangnathan *et al.*, 1993).

In India, population explosion has resulted a drastic change in environmental condition and habitat throughout the country. Many human activities such as deforestation, selective removal of trees, urbanization, dam construction, mining activities etc, have further aggravated the environment conditions resulting depletion of biodiversity.

Environment security has become a serious concern across the globe. Recent meteorological records have shown significant increase in environmental temperature commonly referred to as "Global Warming." Increasing levels of carbon dioxide in the atmosphere due to industrial emissions, deforestation to meet the growing needs of wood, land degradation and change in land use pattern are causing serious threat to forests and environment (Schopfhauser, 1998; Burgin *et al.*, 2000). The average levels of CO_2 are increasing at an alarming rate of 0.3% per year since the 1850s, reaching 350 ppm in recent time (Houghton, 1991).

Several studies have been conducted on response of many organisms to the clear felling system of management (Bruce and Boyce, 1984). With the Shannon's Index, it was found that clear felling has reduced the genus diversity, however species within-genus diversity invariably increased. Harvesting is not only the Forest Management operation that affects the diversity, but several other factors are also responsible (Hunter, 1990).

Forest degradation is one of the most serious problems currently faced by tropical forest managers and silviculturists. The area of degraded tropical lands has now increased to the tune of forest cover (Grainger, 1988 and FAO, 1993). Zeven and de wet (1982) have listed nearly 167 economic plants of the world whose centers of original/ diversity lie in India along with their relatives and land races.

Inappropriate forest harvesting operations is leading loss of ecosystem integrity. Siddiqui (2001) has presented detailed account of plant Biodiversity of Jharkhand state and suggested many conservation strategies. The Jharkhand state is characterized by forests and tribals and presently holds about 29.61% forests with respect to total geographical area of 23,605 sq. km. However, existing forest cover is not sufficient to meet the local demands, as a result forest wealth is facing lot of problems and ultimately plant biodiversity of the area is also affected due to intensive rate of plant remove. Therefore, under the prevailing circumstances it is urgently required to know the plant growth status of biotically disturbed as well as undisturbed forest of Jharkhand state so that production potential of both the areas may be assessed for further planning and development of the area. In this way, present study is designed to know growth of some importance timber tree species at

Rarha Forest Area (Ranchi East Forest Division) with the following objectives-

(1) To find out different types of species existing in both biotically disturbed and undisturbed forest areas.

(2) To compare the growth parameters of economically important species in both the area.

(3) To find out relative dominance of economically important species in both the areas.

(4) To study the natural regeneration status of economically important tree species in both the areas.

REVIEW OF LITERATURE

Extensive literature survey has been conducted pertaining to present work and are being presented in following paragraph -

2.1 Status of Forests in India and Jharkhand

The forest cover of the country according to the assessment of FSI (SFR, 2007) is shown in three density classes, viz; Very Dense Forest (VDF), Moderately Dense Forest (MDF), Open Forest (OF) and Scrub areas. The total forest cover of the country is 21.02% (690,899 km^2) of the geographical area of country. Very dense forest constitutes 83,510 km^2 (2.54%), the Moderately dense forest 319,012 km^2 (9.71%) and Open forest constitutes 288,377 km^2 (8.77%) of the geographical area. The scrub accounts for 41,525 km^2 (1.26%). The Madhya Pradesh has got largest forest cover (77,700 km^2) in the country followed by Arunachal Pradesh (67,353 km^2), Chhattisgarh (55,870 km2), Maharashtra (50,650 km^2) and Orissa (48,855 km^2). In terms of percentage of forest cover with respect to total geographical area, Mizoram with (91.27%) leads, followed by Lakshadweep (82.75%) and Nagaland (81.21%). The change in the assessment of 2007 as compared to revised assessment of 2005 has showed significant net increase in forest cover of Mizoram (640km^2), Manipur (328km^2), Jharkhand (172km^2), Meghalaya (116km^2) and Orissa (100km^2). The increased forest cover was due to re-growth, protection by villagers and afforestation. On the other hand, a significant net decrease in forest cover is seen in states like Nagaland (201km^2), Andhra Pradesh (129km^2), Arunachal Pradesh (119km^2), Tripura (100km^2), Assam

(66km^2) and Chhattisgarh (59km^2). This decrease is due to shifting cultivation, departmental felling, mining, encroachment, etc.

Jharkhand rich in minerals and forests has an area of 79,714 km^2 which constitutes 2.42% of the geographical area of India. As per Champion & Seth classification (SFR, 2009), the state has 6 forest types which belong to two forest group viz; 2.66% Tropical Moist Deciduous Forest under group 3 and 93.3% Tropical Dry Deciduous Forests under group 5. The recorded forest area of the state is 23,605 km^2 which is 29.61% of the geographical area of the state. Out of this Reserved forest constitute 18.58%, Protected forests 81.28%, and Unclassed forests 0.14% of the total forest area. The Chhotanagpur plateau is rich in forest resources. As compared to previous assessment a gain of 172 km^2 of forest cover is noticed in 2007 assessment. The increase in forest cover is in Moderately dense forest (7 km^2), and in Open forest (170 km^2), which a decrease of 5 km^2 in Very dense forest is observed. The increase in the forest cover in the districts of Palamu, Gumla, Hazaribag, Chatra, Lohardaga and Giridih is due to the protection given by village protection committees as observed by the FSI officials during field verification. Besides, Deoghar and Dumka have shown an increased forest cover owing to plantation of miscellaneous species.

Prasad and Siddiqui (2006) reported that natural resources of Jharkhand state that includes forest, minerals etc. is a boon to the inhabitants of the state. Plenty of the state land is covered by forest of valuable species like Sal, Mahua, Bidi leaf tree, Palas, etc. on which the tribal population has been surviving/dependent since long. The extraction techniques/ harvesting methods, adopted by tribal people are not sustainable as a result various types of forest products are facing problems. In the present paper protection measures of existing resources and enhancement of resources of livelihood of tribal people have been discussed.

Soderberg *et al.* (1998) found that forest diversity has become a new concern for society. It has introduced new regulations and new ways of thinking in areas of forest use and planning. The problem of maintenance of biodiversity can be looked at from different perspectives, such as species, ecosystem, landscape, regional and national. The method used was to analyse the relative changes of variables related to biodiversity over time. The results show that it is possible to follow the changes of substrata (prerequisites), which indicate a high forest biodiversity on a boarder scale. By introducing new variable more directly related to biodiversity and combining different information sources more effective methods can be developed.

Siddiqui (2001) reported detail account of medicinal plant biodiversity of Jharkhand State and suggested many conservation strategies. A list of 14 plant species including *Rauwolfia serpentine*, *Mesua ferea*, *Sterculia urens* etc. are given in endangered category, beside seven species are given in vulnerable and rare categories. Emphases were also given *in situ* and *ex situ* conservation methods.

2.2 Characteristics of Sal Forest

Sal is a large deciduous tree with shining foliage. Conical, elongated crown in young stage and rounded later on the bole is clean and straight with the bark having characteristic long, vertical fissures, (Troup, 1986).

Sal timber is very hard, tough and heavy, heartwood is very durable naturally. Sal seed yields a vegetable oil which is used for cooking; while leaves are used for fodder purposes and for making plats.

Sal one of the main commercial timbers of India, is widely distributed and occupies two main regions, the northern and central Indian region, separated by Gangetic plain. The main and continuous stretch of Sal forests in the northern region commences with Haryana and stretches East wards along the sub-Himalayan tract as par as Darang district in Assam through U.P., Jharkhand, Bihar, Assam, Meghalya and Tripura.

In the central region, Sal occurs in Jharkhand, Bihar, west-Bengal, Orissa, M.P, with isolated pockets in A.P. Sal forest occur in several forest types and sub-types of Northern Tropical Moist Deciduous and Dry Deciduous Forests, as classified by Champion and Seth (1968). The most favorable soil for Sal is a well-drained moist sandy loam with good sub-soil drainage. Deep clayey loam soils with good moisture supply carries good Sal forests and the growth is adversely affected on shallow, coarse and dry soils, sandy and gravely soils, which become very dry during summer, are not suitable for Sal.

Mishra *et al.* (2000) examined composition of forest vegetation and community structure of moist Bhabar and Tarai Sal forest on four different aspects, namely, North-East, North-West, South-east and South-West, in district Pauri Garhwal to understand the growth behaviour of *Shorea robusta* under different micro-climatic conditions. *S. robusta* was found dominating on all the aspects with maximum IVI, density, frequency & TBC (Total Basal Cover) values and has reflected regular and random distribution patterns. The highest TBC value of this species was recoreded on NE facing slope (5009.04 $cm^2/100m^2$) and the highest C.D. value (0.4321) on SW facing slope, where minimum diversity persisted. On the other hand the lowest C.D. value (0.3115) was observed on SE aspect where maximum diversity existed. The maximum accumulation of organic matter was noticed on NE aspect (average value 1.51 ± 0.61%) due to occurrence of mature Sal stand.

Biswas *et al.* (2006) described tree species composition of Idgaon Forest Reserve under Cox`s Bazar Forest Division of Bangladesh based on tree diameter class distribution. While superior tree species such as *Dipterocarpus turbinatus*, *Dipterocarpus alatus, Swintonia floriunda* and *Syzygium grade* was found to occupy the higher diameter classes, many inferior tree species such as *Bursera serrata* and *pterospermum acerifolium* were found to occupy the lower diameter classes. Lack in recruitment from regeneration of superior tree species may be attributable to the problem caused by human interference. Hence measures towards conservation of superior tree species through encouragement of natural recruitment from regeneration should be adopted while maintaining current trend of natural regeneration for inferior tree species.

Sharma and Nonhare (2004) opined that Sal forest in India are depleting due to various reasons. Sal forests are very important not only for timber but for maintaining biodiversity. Sal regeneration has always been a problem throughout the country. The paper discusses the result of regeneration traial of Sal carried out in South Sarguja Forest Division (Chhattisgarh) in 1985. The result of the trial indicates that seed broadcast in well ploughed soil immediately after seed fall in well protected area gives profuse regeneration. Seedlings were spaced out in second year by removing congested seedlings. The maximum height attained in thirteenth year of sowing is 13m and girth at breast height 61 cm. The adverse factors, e.g. grazing, fire and hardness of soil are eliminated, profuse regeneration and subsequent establishment of Sal is obtained. In Sal areas where regeneration is lacking, this technique of regeneration can be fruitful with providing strict protection to the area concerned.

Singh *et al.* (1988) prosecuted information on the influence of climate, soil and topographic factors for the growth and distribution of three important tree species namely *Anogeissus latifolia, Terminalia tomentosa,* and *Tectona grandis* in Mudumalai Forest Division of Tamil Nadu. *T. tomentosa,* was found suitable in regions have >1525 mm of annual rainfall, where as *A. latifolia* and *T. grandis*, performed well in the relatively lesser rainfall areas as well. *T. tomentosa*, prefers very deep soil (>120cm) where as good growth and density of *T. grandis,* and *A.latifola*, were recorded on moderately deep soils. Density and growth of *T. grandis*, was higer on medium textured soil where as the density of *A. latifolia*, was not affected by coarse textured soils. Higher growth and density of *T. tomentosa* was associated with poor p_2o_5, k_2o and Mg contents of the soil. *A. latifolia*, and *T. grandis,* were found on soil rich in ca and mg. soils rich in organic carbon and CEC occurred under better growth and density of teak.

Timilsina *et al.* (2007) studied Sal (*Shorea robusta*) forest found extensive in lowland of Nepal, which has been heavily used by Nepal Government and local people affected by both environmental and anthropogenic facers. Trees, saplings, seedling and shrubs were sampled along transects (2 km long) in two protected areas and two proposed community forests. The protected areas had three transects each, and a single transect covered two proposed community forests. Samplings were done every 200 m along the transects, a plot less technique sampled trees (>5cm dbh) with tree sampling point as the center, shrubs and saplings (1-5 cm dbh and >1 m height) were sampled in 5m radius circular plots and herbs and seedlings (<1m height) were sampled in $1m^2$ circular plots nested within shrub plots. Altogether 131 species were recorded: 28 trees, 10 shrubs, 6 climbers and 87 hers. The mean density across all plots was 220 tree/ha and the average basal area was 13.2

m^2/ha. Three different associations of Sal forest were identified by cluster analysis community types distinguished in the classification analysis were clearly separated in the site ordination. None of the environment variables measured (pH, percent organic matter, total nitrogen, available phosphorous, available potassium and soil texture) explained the distribution of plots in the site ordination. It was concluded that rainfall and past disturbances (fire and anthropogenic use) are mainly responsible for different community types. Community types were different in structure and composition, there by representing unique entities. The protection and maintenance of each of the different communities through forest management is important for biodiversity conservation.

Alam *et al*. (2008) found that Sal (S*horea robusta*) existed as a large continuous belt with rich biological resources until beginning of 20th Centaury in threatened ecosystem in Bangladesh. Most of the forest area at present is under occupation by encroachers and the remaining stands are stocked poorly. Biodiversity has declined rapidly and many animal species have become locally extinct. The Forest Department has established agroforestry and woodlot plantations as sustainable production system in the encroached and degraded forest area using a participatory approach. Some protected areas have also been established for conservation. Nevertheless, it is predicted that the present trend of management is inadequate and an intensive management policy is essential to restore the forest ecosystem.

2.3 Management system applied to Sal Forest in India

Primary object of good management is provision of the maximum benefit to the greatest number of people for all the time, thus forest may be managed primarily for productive purposes (direct material benefits) or protective purposes (indirect benefits). In case of Sal forests three main systems are adopted -

(a) Clear felling System – Under this system, a rotation age is fixed and the entire area clearfelled. Thus crop is of uniform age. Regeneration is obtained naturally or by planting or from seedling coppice. e.g. Clear – felling System as practiced in India are given below-

(i) Clear-felling followed by artificial regeneration - The artificial regeneration may be obtained either by departmental plantation or taungyas e.g., Allapalli technique for Teak, Casuarina plantations on costal sands and Cryptomeria & Cupressus plantation of West-Bengal, Sukna (kurseong Division) technique for Sal, South Gorakhpur technique for Sal (Parkash and Khanna, 1991).

(ii) Clear-felling followed by natural regeneration - Example of this method include *Acacia mearnsii* in Tamil Nadu, Avicennias in Andhra Pradesh, North Betul (Madhya Pradesh) technique for teak, Saranda (Jharkhand) technique for Sal, and South Raipur (Madhya Pradesh) technique for Sal, (Parkash and Khanna, 1991).

(b) Selection System – This system is adopted for Sal forest areas situated on difficult sites and where regeneration is a problem. Under this system, regeneration is obtained by natural means, which may be supplemented by planting. This systems aim to improve the conditions of the crop and it is known as the improvement felling system. e.g. Selection system applied in India are the Moist and Dry Siwaliiik Sal forests, Moist-bhabr and terai Sal, plains Sal and peninsular Sal forests of Bilaspur, Raipur and Bastar in M.P. (Parkash and Khanna, 1991).

(c) Coppice Systm - The coppice with standards system because a few standards are retained and the other trees above the exploitable diameter are clearfelled. Regeneration is obtained by means of coppice and stool dressing is carried out. e.g.- Coppice with standards system applied in India are Jamun (*Syzygium cumini*) belts along streams in South Gorakhpur and Gonda Divisions (U.P.), This system was also applied to Dry deciduous forests in Kangra and Una (Himachal Pradesh) and Anogeissus pendula forests in Rajasthan (Parkash and Khanna, 1991).

Sinha (1957) observed that various aspects of mortality in Sal occurs due to scarcity of water. In clear felled areas Sal mortality due to frost was invariably higher than the shelter wood system.

Rautiainen *et al.* (2000) presented optimal treatment schedules for even-aged *Shorea robusta* Gaertn. f. stands using varying management objectives viz. total wood production (WP), commercial timber production (CTP), saw log production (SLP), forest rent (FR) and soil expectation value (SEV). A simulation–optimisation system was developed based on a spatial yield model. The non-linear method of Hooke and Jeeves was used to solve the optimisation problems. The mean annual increments of the optimal treatment schedules were 8.5–25.1 m^3 ha^{-1} a^{-1} for the total wood production, 6.5–12.1 m^3 ha^{-1} a^{-1} for commercial timber production and 4.8–7.6 m^3 ha^{-1} a^{-1} for sawlogs.

Gautam *et al.* (2008) found that Doon valley famous for monocultures of moist Sal forest has been result of various silvicultural operations in the past. However, in recent years these forests were subjected to numerous anthropogenic perturbations, which have posed a great threat to their existence. It is found that these forests are still dominated by the Sal tree. However, the structure of shrub and herb layers has been changed. These layers, once dominated by shade loving C*lerodendrum viscosum*, are now being dominated by xerophytic species like *Mallotus philippensis*, *Litsea glutinosa*, *Flacourtia indica* etc. The general diversity of tree, shrub and herb layers has increased in these forests and so the heterogeneity.

Hartshorn *et al.* (1993) have found that countries are rich in tropical forests have set a side significant areas for protection, however, unprotected forests may represent up to 10 times the total area designated as conservation units. Management techniques are described that allow the use of forests without destroying habitats and have the potential to integrate conservation and development objectives.

2.4 Cause of Forest Damage

The causes of forest destruction and denudation are the population explosion of human as well as livestock population leading to more requirements of timber, fuel wood and grazing space. Similarly unprecedented increase in shifting cultivation, construction of hill roads, serious impact of industries, mining and querying in the forest areas and construction of hydro-electric projects have lead forest degradation in the strategic and also in ecologically most fragile belt in Himalaysa. Forests outside protected areas are being depleted. Between 1978 and 1991, about 99,000 ha of Sal (*Shorea robusta*) forest in the Terai were cleared with an average deforestation rate of 1.3% i.e. 8,300 ha per year (FRISP, 1994).

Disturbances are also important factors that shape the structure and composition of forest communities. Different factors cause disturbances; strong winds, fire and land slides destroy vegetation, open up the canopy and remove vegetation and soil cover. Human induced disturbances include removal of biomass and intentional fires. Other forms of disturbance such as herbivory also affect the natural course of forest regeneration and growth. Maintenance of forest cover is important to prevent the loss of nutrients, because the vegetation adsorps nutrients and holds soil particles, so removal of vegetation and reduced soil fertility will affect the inter-dependence of soil and vegetation. Disturbance is interactive with moisture, only in sites with high moisture (forests and bush lands) the effect of disturbance is significant (Ogutu 1996).

The forests representing a complex ecosystems contain many more species per unit area than other ecosystems; are subjected to human disturbances such as fire and grazing; go through successional changes; show geographical variability; and interact and influence other systems such as rivers, lakes, pastures and agricultural land. This complexity makes it difficult to establish cause and effect relationships and predict the results of human intervention in forested ecosystems (Lal, 1992).

Vegetation disturbance, especially grazing, increases species richness in some situations, due to the greater occurrence of non-endemic species (Green and Kauffman 1995). Low intensity and sustained human disturbance through selective logging, firewood extraction, grazing and land clearing for permanent agriculture may influence plant communities and their successional patterns (Attiwill 1994; Fujisaka et al. 1998). Within forests, disturbances influence the availability of resources such as light, water and nutrients necessary for the survival and growth of seedlings (Marks 1974; Carlson and Groot 1997).

With respect to the existing symbiotic relationship between local people particularly tribal people and forests, the agencies involved in forest management should be given priority to associate local people in regeneration, development and protection of forests in this variability.

Plant species show a varied range of requirements of and tolerance to environmental conditions, which is evident from their abundance and distribution along environmental gradients. The establishment of a forest in an area is determined by many factors. The local and regional climate, topographic position, disturbances, environmental factors and biotic interactions determine forest structure and composition (Spurr and Barnes, 1998).

The Nilgiri Biosphere Reserve, which is having countless micro flora, fauna and the germplasm of various rare, threatened and endemic species, are facing continuous pressure by one way or the other has been studied by Srivastava (2002). The greatest pressure on forest is by way of "forest fire", which beside retarding the growth of existing standing vegetation is also not allowing new recruits to emerge out on the forest floor. If the process is not checked, many of the endemic flora and fauna will disappear from the biosphere reserve even before its documentation is completed.

Tandel et al. (2009) studied the influence of tree cover on physical properties of soil at instructional farm, ASPEE College of Horticulture and Forestry, Navsari (Gujarat) under twelve -years old plantation during the year 2002-2003. The experiment was laid out in FCRD with eleven treatments viz; Arjun (*Terminalia arjuna*), Hed (*Adina cordifolia*), Teak (*Tectona grandis*), Sharu (*casuarina equisetifolia*), Eucalyptus (*Eucalyptus tereticornis*), Sissoo (*Dalbergia sissoo*), Bamboo (*Dendrocalamus strictus*), Biyo (*Pterocarpus marsupium),* Killal (*Albizia procera*), Khair (*Acacia catechu*) and control (open field) with three replications. The soil samples were collected from three depth (0-30, 30-

60 and 60-90 cm). Maximum improvement in physical characteristics of soil viz; Particle density, bulk density, porosity and water holding capacity were recorded under *D. Sissoo*, plantation and observed in upper layer (0-30 cm) of soil.

Chaudhuri *et al.* (2005) studied impacts of anthropogenic disturbances like cutting of Mangrove for fuel wood, making poles and fencing materials and also illegal encroachment of Mangrove area on the physico-chemical, biochemical and microbial characteristics of soils (0 - 30 cm) of major Mangroves of South Andamans viz; *Rhizophora mucronata, Rhizophora apiculata*, *Bruguiera gymnorrhiza*, *Xylocarpus granatum*, *Ceriops tagal* and Nypa fruticans. From inter-tidal areas of 10 disturbed and undisturbed Mangrove forest sites of south Andaman. The soil pH, clay, cation exchange capacity (CEC). Al_2O_3 and Fe_2O_3 levels exhibited minimum variation between the disturbed and undisturbed sites. In contrast, organic carbon, total N, Bray P and K levels exhibited marked variation between the sites and were considerably lower at the disturbed site. In comparison to the undisturbed sites, the levels of all the general and specific biochemical parameters were considerably lower at the disturbed sites mainly due to significant reductions in organic matter /substrate levels. The study also indicated N availability and the possibility of fungi dominating over bacteria at both the mangrove sites. Overall, the study suggested that the number and activity of soil micro-organisms depend mainly on the quantity of mineralizable substrate and the availability of nutrients in these mangrove soils.

Patterns of fuel wood collection and per capita daily consumption across seasons and altitudes in the buffer zone of Nanda Devi Biosphere reserve, western Himalayas was described by Silorri (2004). Three village, located at different altitudes were monitored during 1994-1995 in order to identify fuel wood collection pattern during 1995-1996 to quantify fuel wood consumption patterns. Rate of fuel wood collection was found to be highest just before the onset of winter during September-October. With declining altitude, per capita daily and seasonal consumption of fuel wood also declined. Average per capita daily consumption was, however, substantially higher in the study village when compared to other studies. At the household level there was a negative correlation between family size and per capita daily consumption of wood. Easy accessibility to fuel wood in the surrounding forest, cold climatic conditions and the lack of alternatives resources have been identified as the major factors for the higher consumption rate of fuel wood, especially in the higher altitude villages. The findings of the study have been concluded in the light of the sustainable use of wood fuel for the long-term conservation of the buffer zone forest.

Quli *et al.* (1997) studied the global concern for biodiversity conservation, magnitude of damages and threats to the natural resources which form the very base for human existence on the this planet. The conservation planning has been dealt under two main steps- (a) the status survey of the resources, and (b) conservation strategies followed by restorative measures to illustrate the most complex challenge of biodiversity conservation, a self explanatory flow chart has been drawn to facilitate the evaluation of resource status a standard format site data sheet is prepared. For implementation of conservation strategies some restorative measures have been suggested.

Sharma (1986) studied influence of biotic interference on the natural growth of forest flora of Patiala district. The present status of the forests in the district is indicated and some suggestion have been given to augment the fast- dwindling forest areas through social forestry suitable to the agro-climatic and edaphic conditions prevalent in the area. The role of farm forestry, extension forestry, reforestation of degraded forests, recreation forestry and urban forestry in the improvement of environment and service of society has been elaborated.

Ramakrishnan *et al.* (1997) have studied human interference and its effects in sujalkuttai –Bannari corridor and Kallar-Vedar colony corridor in Nilgiri Biosphere Reserve from December 1994 to April 1995. Most people visit the corridors primarily for fuel wood collection, some of them for grazing livestock and few for collecting minor forest produce. Female population depend on the corridors for fuel-wood, while the male population use the corridor predominantly for grazing their live stock, temporal use of the corridors by local people for fuel-wood collection and grazing considerably varies. In both the corridor fuel wood is extracted mostly from hill slopes and other inaccessible areas to elephants. Local people move more than 3 km from the villages in the Sujalkuttal-Bannari Corridor for fuel wood while the elephant population use the forests upto 2 km distance from village and thus there is an overlap in the habitat use by man and elephants.In both the corridors the elephant do prefer many of the plant species which are largely collected by villagers as fuel-wood.

Hartshorn *et al.* (1993) have fond that most countries rich in tropical forests have set a side significant area for protection. Management techniques described indicated use of forest without destroying habitats and have potential to integrated conservation and developments objective.

Mishra *et al.* (2004) analysed effects of anthropogenic disturbance on plant diversity and community attributes of a sacred grove (montane subtropical forest) at Swer in the East Khasi Hills district of Meghalaya in northeast India. The undisturbed, moderately disturbed and highly disturbed stands were identified within the sacred grove on the basis of canopy cover, light interception and tree (cbh_>15 cm) density. The undisturbed forest stand had >40% canopy cover, >50% light interception and a density of 2103 trees per hectare, whereas the highly disturbed stand had <10% canopy cover, <10% light interception and 852 tree per hectare. The moderately disturbed stand occupied the intermediate position with respect to these parameters. The study revealed that the mild disturbance favoured species richness, but with increased degree of disturbance, as was the case in the highly disturbed stand, the species richness markedly decreased. The number of families of angiosperms was highest (63) in the undisturbed stand, followed by the moderately (60) and highly disturbed (46) stands. The families Rubiaceae, Asteraceae, and Poaceae were the dominant families in the sacred forest Rubiaceae was represented by 11, 14 and 10 species in the undisturbed, moderately disturbed and highly disturbed stands, respectively, whilst the family Asteraceae had 16 species in the moderately disturbed stand and 14 species in the highly disturbed stand. The number of families represented by a single species was reduced significantly from 33 in the undisturbed stand to 23 in the moderately and 21 in the highly disturbed stand. The similarity index was maximum (71%) between the undisturbed and moderately disturbed stand and minimum (33%) between the undisturbed and highly disturbed stands. The Margalef index, Shannon diversity index and evenness index exhibited a similar trend, with highest values in the moderately disturbed stand. In contrast, the Simpson dominance index was highest in the highly disturbed stand. There was a sharp decline in tree density and basal area from the undisturbed (2103 trees ha^{-1} and 26.9 m^2 ha^{-1}) to the moderately disturbed (1268 trees ha^{-1} and 18.6 m^2 ha^{-1}) and finally to the highly disturbed (852 trees ha^{-1} and 7.1 m^2 ha^{-1}) stand. Density-girth curves depicted a successive reduction in number of trees in higher girth classes from the undisturbed to the moderately and highly disturbed stands. The log-normal dominance-distribution curve in the undisturbed and moderately disturbed stands indicated the complex and stable nature of the community. However, the short-hooked curve obtained for the highly disturbed stand denoted its simple and unstable nature.

Pradhan *et al.* (2007) studied the impact of elephant on colonizing Bardia National Park in lowland Nepal. The elephants were more selective on species in the nutrient-poor Sal forest was only partly supported; the niche breadth of impacted trees was slightly higher in the floodplain complex. Pushed-over trees accounted for the highest proportion of impact (55%), followed by killed trees (39%). Of the pushed trees, 10% were not used for food. Among food trees, elephants selectively impacted size 12-16 cm dbh, whereas non-food trees were impacted independently of size. A large proportion of the freshly browsed trees had been felled previously, indicting that most felled trees survived, enabling elephants to food on them again. Grewia spp. and *Desmodium oojeinense*, were a recently observed increase in the density of *M. phillippinensis* and the concurrent reduction of the hardly utilized *Shorea robusta* indicates that the rapidly growing elephant population may modify the composition of the forest by increasing its preferred food species.

Reddy *et al.* (2009) surveyed Sal mixed moist deciduous and in Orissa Sal mixed dry deciduous forests using Landsat MSS (1973), Landsat TM (1990) and IRS P6 LISS III (2004) satellite imagery which has been affected by extensive deforestation. From 1973 to 1990, more than 888.6 km^2 of dense forest (rate of deforestation = 3.62) and from 1990 to 2004, 429.7 km^2 (rate of deforestation = 3.97) were found to have been deforested. The analysis of results identified the reduction in area of dense forest and increase of agricultural land, degraded areas of abandoned agricultural land unproductive scrub. There is an urgent need for rational management of the remaining forest for it to be able to survive beyond next decades. From this study it is concluded that temporal changes and the factors affecting these changes should be determined for sustainable management of natural resources.

Addo-Fordjour *et al.* (2009) investigated the effects of human disturbances and plant invasion on liana community structure and relationship with trees in the Tinte Bepo forest reserve, Ghana, in three distinct forest types to reflect both human disturbances and invasion: Undisturbed, Disturbed-Invaded and Disturbed Forests (UF, DIF and DF respectively). Trees $\geq$ 10 cm dbh were identified and their dbh measured in two 0.25 ha plots in each forest type. The trees were examined for the presence of lianas ($\geq$ 2 cm dbh) and their dbh measured. A total of 380 lianas $\geq$ 2 cm dbh belonging to 20 genera and 12 families were identified in the 1.5 ha forest. Twelve liana species were unique to the DIF suggesting the probable positive influence of plant invasion on their colonization. Liana density differed significantly across the forest types (df = 2, p = 0.043) with the UF recording the greatest number. The mean liana stem diameter and basal area were greater in the DF. Large diameter lianas were absent in the UF. Tree density and number of trees hosting lianas were greater in the UF followed by the DIF and DF. Liana infestation was generally high with 90% in the DF, 88.2% in the UF, and 85.7% in the DIF. Both liana load per tree species and mean liana load per infested tree were highest in the UF followed by the DF and then the DF. Liana density was highly dependent on tree density in all the forest types (df = 1, r^2 = 0.50, p = 0.007; df = 1, r^2 = 0.99, p = 0.000 and df = 1, r^2 = 0.72 in the UF, DIF and DF respectively). There was a significant positive relationship between liana dbh and host dbh in the UF (df = 1, r^2

= 0.0096, p = 0.000), DIF (df = 1, r^2 = 0.11, p = 0.000) and DF (df = 1, r^2 = 0.16, p = 0.008). There was no significant relationship between host dbh and liana loads in all the forest types.

Pradeepkumar and Prathapasenan (2001) have given special emphasis for enlisting the different tree species in the area of shoolpaneshwar wildlife sanctuary. A total of 118 tree species have been observed and enlisted. They also pointed out that biotic factors as well as other environmental factors leading to the destruction of natural habitat of main concerned.

Khasa *et. al.* (1995) reported the decline and deterioration of tropical forest resources in Zaire. The main factors causing loss of biodiversity are shifting agriculture, fuelwood consumption and fires in open forests and savannas. Measures for maintenance of forest biodiversity are proposed. These include in situ and ex situ conservation, suitable agricultural and silvicultural management systems, based on knowledge of genetic structure, genecology, reproductive biology of tropical plant populations and biotic and edaphoclimatic factors. The active participation and support of Zairean people as a whole and policy and institutional reform are essential for a more effective utilization, management and protection of the forests so that socio-economic and environmental benefits are provided for present and future generations.

2.5 Species richness in disturbed and undisturbed forest areas

Agarwal *et al.* (2003) studied species composition and species diversity on two sites of tropical moist deciduous forest which was characterized by high density of tree (1040-1290 stems ha^{-1}) and understate vegetation (1100-1800 stems ha^{-1}) on closed forest site compared to open forest site which represents 390-930 stems ha^{-1} and

700-1090 stems ha^{-1} of trees and understudy vegetation, respectively. Basal cover too was high for both trees and undestory vegetation and ranges from 25.40 to 44.85 m^2h^{-1} and from 1.02 to 2.84 m^2h^{-1} for trees and under storey vegetation, respectively. Similar to plant density, basal cover was also low in open forest sites and ranges from 20.05 to 48.85 m^2 h^{-1} and 0.28 to 0.47 m^2h^{-1} for trees and shrubs, respectively. Similarly, diversity was also high on closed forest site than on open forest site. The ranges of diversity on these site were 1.99 – 2.92 (Shannon index), 1.34 – 4.76 (Richness index) and 0.78 – 1.04 (Equitability index). The beta diversity was high on open forest.

Bhuyan and Khan (2003) reported tree species richness, tree density, basal area, population structure and distribution pattern were investigated in undisturbed, mildly disturbed, moderately disturbed and highly disturbed stands of tropical wet evergreen forests of Arunachal Pradesh. The forest stands were selected based on the disturbance index (the basal area of the cut trees measured at ground level expressed as a fraction of the total basal area of all trees including felled ones): (i) undisturbed stand (0% disturbance index), (ii) mildly disturbed (20% disturbance index), (iii) moderately disturbed (40% disturbance index), and (iv) highly disturbed stand (70% disturbance index). Tree species richness varied along the disturbance gradient in different stands. The mildly disturbed stand showed the highest species richness (54 of 51 genera). Species richness was lowest (16 of 16 genera) in the highly disturbed stand. In the undisturbed stand, 47 species of 42 genera were recorded while in the moderately disturbed stand 42 species of 36 genera were found. The Shannon-Wiener diversity index for tree species ranged from 0.7 to 2.02 in all the stands. The highest tree diversity was recorded in the undisturbed stand and the lowest in the highly disturbed stand. The stands differed with respect to the tree species composition at the family and genetic level. Fagaceae, Dipterocarpaceae and Clusiaceae dominated over other families and contributed 53% in the undisturbed, 51% in the mildly disturbed, 42% in the moderately disturbed and 49% in the highly disturbed forest stands to the total density of the respective stand. Stand density was highest (5452 stem ha^{-1}) in the undisturbed stand, followed by the mildly disturbed stand (5014), intermediate (3656) in the moderately disturbed stand and lowest (338) in the highly disturbed stand. Dominance, calculated as the importance value index of different species, varied greatly across the stands. The highest stand density and species richness were represented in the medium girth class (51-110 cm) in all the stands. In the undisturbed stand, the highest density was found in the 111-140 cm girth class, while in the mildly disturbed stand the 51-80 cm girth range recorded the highest density. About 55, 68 and 52% species were found to be regenerating in the undisturbed, mildly disturbed and moderately disturbed stands, respectively. No regeneration was recorded in the highly disturbed stand. Variation in species richness, distribution

Hitimana *et al.* (2004) reported results of an ecological study carried out in Mt. Elgon moist lower montane forest, Kenya. The vertical and horizontal structure of the forest was investigated in a bid to better understand the ecological state and management needs of the forest. The assessed forest attributes were (a) stocking levels, (b) diameter size distribution structure for all tree species combined and for five dominant tree species individually, (c) vertical stratification – vegetation layers identification and differentiation, canopy continuity and foliage dispersion. Forest sampling was done in both heavily and lightly logged-over sites. From the results, Mt. Elgon moist lower montane forest can be classified as an under-stocked tropical mixed rain forest. Tree densities varied among sites either as a result of logging, site quality or both. Diameter size for all species combined followed the reverse J-curve, typical of uneven-aged mixed forests. Regeneration and recruitment patterns of the forest and of individual tree species varied among sites; and in spite of a good overall forest regeneration, this did not necessarily mirror the regeneration status of constituent tree species. Both vertical and horizontal forest structure characteristics seem to suggest a building phase for the forest.

Dinesh *et al.* (2004) studied soil quality of mangrove forests by determining general and specific biochemical characteristics of soils (0-30 cm) of inter-tidal areas of 10 undisturbed mangrove forest sites of S. Andaman, India. In order to determine the effects of disturbance, soils from the inter-tidal areas of 10 disturbed mangrove forest sites were also included in the study. The general biochemical properties included all the variables directly related to microbial activity and the specific biochemical parameters included the activities of extra cellular hydrolytic enzymes that are involved in the carbon, nitrogen, sulfur and phosphorus cycles in soil. The pH, clay, action exchange capacity, Al_2O_3 and Fe_2O_3 levels exhibited minimum variation between the disturbed and undisturbed sites. In contrast, organic c, total N, Bray P and K level exhibited marked variation between the sites and were considerably lower at the disturbed sites.

Rasingam and Parthasarathy (2009) investigated species richness and density of understory plants in eight 1 ha plots, distributed one each in undisturbed and disturbed tropical evergreen, semi-evergreen, deciduous and littoral forests of Little Andaman island, India, which falls under one of the eight hottest hotspots of biodiversity in the world viz. the Indo-Burma. One hundred 1 m^{-2} quadrats were established in each 1 ha plot, in which all the under story plants (that include herbs, under shrubs, shrubs and herbaceous climbers) where enumerated. The total density of under story plants was 6,812 individuals (851 ha^{-1}) and species richness was 108 species, representing 104 genera and 50 families. Across the four forest types and eight study plots, the species richness ranged from 10 to 39 species ha^{-1}. All the disturbed sites harbored greater number of species than their undisturbed counterparts. Herbs dominated by species (63%) and density (4,259 individuals). The grass *Eragrostis tenella* (1,860 individuals; IVI 40), the invasive climber *Mikania cordata* (803; IVI 20) and the shrub *Anaxagorea luzonensis* (481; IVI 17.5) were the most abundant species-rice families represented by 6 species each. The species-area curves attained an asymptote at 0.8 ha level except in sites DD and Dl, indicating 1 ha plot not sufficient to capture all the under story species in disturbed forests. The alien weeds formed about one-fourth of the species richness (31 species; 28%) and density (1,926 individuals; 28.3%) in the study sites, indicating the extent of weed invasion and the attention required for effective conservation of the native biodiversity of the fragile island forest ecosystem.

Yuksek *et al.* (2009) have reported that like most parts of the world, forest soils in the north-east of Turkey are being seriously degraded and destroyed due to extensive agricultural activities. Four disturbed and four undisturbed soil samples were taken randomly at soil depths of 0 -10cm. 10 - 30 cm and 30 -50 cm in each plot converted 60 years previously from alder coppice to tea cultivation (TC), the other remained as alder coppice (AC) in the study area. When the alder coppice was converted into tea cultivation, the bulk density (Db) increased from 0.84 g cm^{-3} to 1.02 g cm^{-3}, Soil Penetrometer Resistance (SPR) increased from 0.94 to 1.27 MPa, the Soil Organic Matter (SOM) decreased from 5.14 to 4.06%, saturated hydraulic conductivity (Ksat) decreased from 40.64 to 16.33mm h^{-1} at 0 to 10cm depth of soil.

Dhawan *et al.* (2008) studied cultural and religious significance of tree like Peepal, Banyan, Mango etc in Uttarakhand concluded that due to global warming and intense *biotic pressure,* regeneration has found to be abnormal. Increased *biotic pressure* threatened some existing species. There is need to examine the causal inhibitor factors responsible for establishment of regeneration and elimination of some species.

Srivastava (2003) noticed that S*antalum album* one of the most valuable species of peninsular India (Toppur Plateau in Eastern Ghats) is facing heavy biotic pressure in its natural habitat. Natural as well as artificial regeneration is having high mortality rate in its initial stage. The study has reflected the mortality rate of sandal plats at different age groups upto 5 years with suitable host plant *Albizia amara, Tamarindus indica and Azadirachta indica* and the impact of the water conservation on its regeneration. The results have reveled that the maximum mortality 86.68% was recorded in 1-3 months age group, while minimum 7.70% in 3-4 years age group of plants. The mortality rate found gradually decreasing with the increasing age of plants and zero percent mortality was observed in 4 - 5 years of seedlings. Thus care must be taken for sandal seedlings up to the age of 4 - 5 years after transplanting. Total nitrogen, available phosphorus and potassium in the soil of study area ranged between 0.101 to 0.291%, 0.55 to 60% and 0.07 to 0.145% respectively.

The effect of biotic disturbances in population structure of six important tree species of dry peninsular Sal forest has been studied by Kumar *et al.* (1994). The total reduction in tree density was recoded as 33% in disturbed (unprotected) forest site and 9% in protected forest site. The reduction in density of dominant trees species was 10% & 27% respectively for *Shorea robusta* and *Terminalia tomentosa* in disturbed forest site, while it was 4% and 10%, respectively in protected forest site.

It was inferred that the disturbance in forest effects the phytosociological status of the site.

Singh *et al.* (1990) noted that mangrove forests of Andaman Isalnds (in disturbed and undisturbed) are one of the best mangrove forests of the world having high floristic richness, complexity index and biomass production. Rapid development and population inflow in the Islands has resulted in the clearance of certain areas of mangrove forests due to which many species *Bruguiera gymnortiza, B. cylindrical, B. parviflora, B. sexangula, Rhizophora lamarckii, R stylosa, Ceriops tagal, Lumnitzera racemosa, Sonneratia apetala* and *Nypa fruticans* have been affected. The values of biomass, litter fall, letter decomposition, soil respiration were greater in undisturbed forests.

Pandey and Shukla (2003) observed was analysed forest vegetation of Sohagibarawa Wildlife Sanctuary, Gorakhpur, India to assess plant diversity, regeneration pattern and the status of species conservation. A total of 208 plant species representing 165 genera and 72 families were recorded. Species richness, mean density and basal area of individuals in the observed forest were compared with those of other Sal-dominated forests of India. The Sal forest was rich in Papilionaceae (23 species), which contributed maximally to the total number of individuals of <30 cm girth. After Sal, density was maximal for a leguminous shrub, *Moghania chappar*. In addition to the usual recruitment by seed, a number of species also showed non-seed regeneration through storage roots, sprouts or ramet proliferation. The individuals regenerating as sprouts from underground stem or storage organs contributed significantly to the sum total of individuals/ha. As much as 45.5% of the total individuals were of ramet origin and shared 10.6% of the total species richness of the forest. In stands facing moderate to low disturbance, thickets of dense entangled mass of vegetation, predominantly composed of thorny lianas, were identified that usually contained less common and rare species like *Rauwolfia serpentina, Desmodium latifolium, Crotalaria alata* and *Gloriosa superba* in addition to the frequent ones. These thickets help to conserve the special habitat conditions and provide protection for natural regeneration of several infrequent and rare plant species and thus contribute towards the maintenance and *in situ* conservation of overall diversity of recurrently disturbed forest vegetatio

Delgado and Finegan (1999) studied the vegetational diversity of managed forest revealed that the future of a major proportion of tropical biodiversity might depend on the way in which production forests were managed. Further, they enlisted some characteristics of tropical rain forests such as species richness, rareness of most of the species in small sample plots and the floristic variation that occur on a local scale as caused y soil conditions or disturbance gradients within the forest stand. They also described the methodology presently used by CATIE for evaluating plant biodiversity in a primary managed forest.

2.6 Plant biodiversity in disturbed & undisturbed forest

Kumar and Kushwaha (2002) opined that term Biodiversity means the variety and variability among living organism from all sources and ecosystems on the earth. It includes diversity within species, between species and of ecosystems. Classification is an essential process in our daily lives and a necessary tool for our survival. For example, we need to know which plant, animal, fungi are useful and which are poisonous or dangerous. It is hard to define Biodiversity in mathematical terms. Hence, the 'Biodiversity indices' are used for the purpose. The Shannon-wieaner Biodiversity Index, based on the proportionate abundance of the species, provides and alternate approach to the assessment of Biodiversity. Attempt has been made for the first time in the eight PAS of Madhya Pradesh, following standard sample techniques and formulae, to compute Biodiversity indices in order to find the present status of flora. The value of Shannon-wiener Biodiversity indices and Index of Evenness has been computed. The maximum value (2, 505, 2.511) was found for Madhav National park followed by Satpura National Park. The minimum value (1.717, 1.763) was found for pachmarhi wildlife Sancturary.

Sheil (2001) described a series of ten plots (1.4 and 1.86) as a successional progression of forest types vegetation of Budongo Forest, Uganda during the 1930s and 1940s in which tree species numbers show a unimodal rise-and-fall over time-a pattern best known from Connell's illustration of his intermediate disturbance hypothesis. Tree communities in five of the original plots have been intermittently re-assessed over the subsequent decades. One data-series provides observations spanning 54-years from one intact 'undisturbed' old-growth forest plot. The remaining four plots were assessed before and after controlled disturbances (tree poisoning) executed in the late 1950s and early 1960s, and the resulting data-series span c. 20 years of pre-disturbance and c. 35 years of post-disturbance changes. As richness declines in later succession, low abundance species occur predominantly in larger stem-sizes. All time-series show a rise in species richness ranging from 12 to 177% (over 50-60 years). Each of the disturbed plots ultimately reaches greater richness than was recorded anywhere in Eggeling's original series. Contrary to expectation a small rise was also recorded in the undisturbed late successioanl plot (c.42 species $\geq$ 10 diameter ha^-1, rising to c.47). The lowest species density observed in the study is a 1940s record of c.10 species $\geq$ 10 diameter ha^-1 in monodominant Cynometra (Caesalpinoidea) forest and the highest record is c. 61 recorded in 1992, in the youngest vegetation type monitored.

Parthasarathy (1999) investigated composition, abundance, population structure and distribution patterns of all woody species (≥ 30 cm gbh) in an undisturbed and two adjacent human-impacted sites of a tropical wet evergreen forest in Kalakad National Park, Western Ghats, South India. Three 1-ha plots were established, one each in (i) an undisturbed site (named site UD), (ii) in a site selectively felled 35 years ago (site SF – small stems felled leaving the large trees (as shade) for developing it into a cardamom estate, on the failure of which the site was abandaned) and (iii) a frequently disturbed site (site FD – round woods logged for use in ovens for curing cardamom). These sites are 1 to 3 km apart in the same wet evergreen forest. In the three study plots a total of 2150 stems (mean density 716 ha^{-1}) covering 122 species in 89 genera and 41 families were enumerated. Species richness was greatest (85 species ha^{-1}) in the undisturbed site UD, intermediate (83) in SF and lowest (80) in FD. Tree density was greatest (855 stems ha^{-1}) in site SF, intermediate (720) in UD and lowest (575) in FD. The forest stand was exceptionally voluminous in site UD (basal area 94.64 m^2 ha^{-1}), intermediate (66.9 m^2) in SF and least (61.7 m^2) in FD, due to tree removal for fuel in the latter sites. Species composition and abundance patterns markedly varied between the three sites. In UD and SF, primary forest species (*Cryptocarya bourdillonii*, *Cullenia exarillata*, *Myristica dactyloides* etc.) occurred in greater density. In FD heliophilic secondary forest species (*Elaeocarpus venustus*, *Litsea wightiana*, *Viburnum punctatum* and *Vitex altissima*) were abundant, while these were absent in UD and SF. The species-area curve did not reach an asymptote in any of the sites on the 1-ha scale. The stand population structure was clearly reverse 'J' shaped in UD and SF, while small stems were 2- to 3-fold fewer in FD. Most trees exhibited clumped distribution of individuals on the 1-ha scale. Variation in the kind and richness of species and their abundance is related to human interference and the need for forest conservation is emphasized.

Nath *et al.* (2005) studied species composition, diversity and tree population were studied in three stands of the tropical wet evergreen forest in and around Namdapha National Park, Arunachal Pradesh, India. Three study stands exposed to different intensities of disturbances were identified, viz., undisturbed (2.4 ha) in the core zone of the park, moderately disturbed (2.1 ha) in the periphery of the park and highly disturbed (2.7 ha) outside the park area. In total 200 plant species belonging to 73 families were recorded in three stands. Tree density and basal area showed a declining trend with the increase in disturbance intensity. The densities of tree saplings and seedlings were lower in the disturbed stands than in the undisturbed stand. Species like *Altingia excelsa, Olea dioica, Terminalia chebula, Mesua ferrea* and *Shorea assamica* in the undisturbed stand and *Albizia procera* alone in the moderately disturbed stand contributed more than 50% of the total tree density in respective stands. The undisturbed stand contained young tree population. In the highly disturbed stand, the tree density was scarce, but had uncut tree of higher girth class (>210 cm GBH). Low shrub density was recorded in both disturbed stands due to frequent human disturbances; the broken canopy and direct sunlight enhanced the abundance of herbs in the these stands. With a species rarity (species having <2 individuals) of ca. 50%, the tropical wet evergreen forests of the Namdapha National Park and its adjacent areas warrant more protection from human intervention and also eco-development to meet the livelihood requirements of the local inhabitants in the peripheral areas of the Namdapha National Parka in order to reduce the anthropogenic pressure on the natural resources of the park.

Brown and Boutin (2009) reported contributions of land use history and recent disturbance on the species richness and community composition of wooded areas in agricultural landscape in north-eastern North America. Woodlots were categorized according to land clearance history, past grazing, and recent disturbance, with as the presence of roads or selective cutting. Vegetation surveys resulted in the identification of 250 herbaceous plant species, 44 of which were classified as exotic. While no influence of recent disturbance on community composition was detected, past land use influenced species richness for all plant groups examined. General linear models indicated that herbaceous, native and forest species richness was highest in historically partially cleared sites; while exotic and invasive species richness was greatest in historically cleared sites.

The structural diversity of different tree-crop associations were studied at Gachabari Sal forest area of Madhupur Garh on Buffer and Peripheral Zone during 2006 by Rahman *et al.* (2007). The total density, basal area of trees in the Buffer and Peripheral Zone were 155.5 trees.hm -1, 795.4 trees.hm -2 and 3.9 m 2 .hm -2, 5.8 m 2 .hm -2, respectively. No regeneration and natural trees were found in Peripheral Zone and the Zone is totally occupied by exotic species where the Buffer Zone comprised of both natural and exotic trees. The Peripheral Zone belonged to younger and smaller trees whereas the Buffer Zone belonged to mixture of smaller, taller, younger and mature trees simultaneously. For the practicing of different agroforestry systems both Zones have lost their original characters of Sal forest.

Sapkota *et al.* (2009) investigated diversity and regeneration of woody species in two ecological niches *viz.* gap and intact vegetation in old-growth seasonally dry *Shorea robusta* (Gacrtn. f.) forests in Nepal. Varieties of varieties of diversity measures and regeneration attributes are studied to gap characteristics. Stem density of tree and shrub components in higher in the gap than in the intact vegetation. Seedling densities of *S. robusta* and *Terminalia alata* (B. Heyne ex Roth) are higher in the gap than in the intact vegetation, while contrary result is observed for *T. bellirica* (Gaertn, ex Roxb) and *Syzigium cumini* (L. Skeels) in term of seedling density. The complement of Simpson index, Evenness index, and species-individual ratio in the seedling layer are lower in the gap than the intact vegetation. Gap size can explain species richness and species establishment rate. Gaps created by multiple tree falls in different years have higher seedling density of *S. robusta* than gaps created by single and/or multiple tree falls in the same year.

Pande *et al.* (2002) studied vegetation composition, species diversity, distribution pattern and other parameter of vegetation analysis along with the population structure and regeneration behaviour of some tree species in a western Himalayan forest of Chakrata forest division (Uttaranchal). The whole area was divided into three sites as per their aspect and altitudes (Site-I alt. 1,700 mast, aspect N-E; Site-II-alt 2,050masl, aspect, N & site-III; alt 2, 100 masl, aspect, N-W). The communities for these rites were identified as *cedrus deodara* (site-I), C*edrus deodara, Quercus leucotrichophora, Pinus wallichinana* (site-II) and *Q. leucotrichophora, C. deodara, P. wallichiana* (site-III). Total density range for the tree species (Plant $100m^{-1}$) was 4.51 – 6.64; 23.56 – 41.62 for shrubs and 7,280 – 11,920 for herbaceous species; while the range for total basal cover (cm^2 $100m^{-2}$)was in between 0.332-0.938 for trees; 9.50-18.81$cm^2 100m^{-2}$ for shrubs and 235 – 323 cm^2 $100m^2$ for herbaceous species. Most of the species in all the sites showed contiguous pattern of distribution, however some species were also randomly distributed. Maximum diversity of trees was observed for site-III and for herb and shrubs species diversity values were highest for site-

II & site-III respectively. However, lowest diversity was recorded for the herbaceous layer in site-III. In all the studies sites, the dominant species has shown good regeneration potential as evidenced by the presence of adequate number of seedling, sapling & distribution of boles among all gbh classes.

Variation in life form, dominance and diversity of the vegetation during succession was studied by Boral (1995) in a protected Jhum fallow. The species number was found to decline with succession where as the total (community) density increased consistently on the Jhum follow. *Arundinella bengalensis* was a dominant grass species, however, other species of grasses like *Eulaia fastigiata* and *imperate cylindrical* were also important in the community *A. bengalensis* showed a consistent increase in density and IVI with succession. Various indices like dominance, diversity, richness and evenness were influenced by the seasons. Diversity and richness were highest in rainy season while dominance and evenness were in summer with succession the dominance diversity curves also changed from log normal distribution of the geometric series of riche pre-emption model of Whittakar (1975).

Singh and Kaushal (2006) studied diversity, composition and quantitative analysis of dominant tree species in twelve different sites varying from 1700 m to 2800m above MSL of district Chamba. Himachal Prades. Overall diversity of tree species in their number, varied from 4 to 12. Forests having high basal area, canopy cover and average tree height were mostly dominated by the conifers, comparatively with less disturbance. The sites with low basal area supported mixture of broadleaved with coniferous species, with high level of degradation. Ban oak (*Quercus Leucotrichophora*) is heavily lopped as winter fodder, fuel wood, to prepare agricultural implements and for the pre parathion of coal. It is observed that species diversity and density decreases with increasing basal area. Species richness, Hill diversity indices (N and N_2), Simpson's (I) and Shannon's diversity indices (H) are reported maximum for the sites, dominated by mixed coniferous broadleaved forests. The minimum diversity value is observed in the localities that are occupied by pure confer stands. The present study reflects that the sites possessing maximum diversity are under high level of disturbance and needs priority for conservation measures.

Behera and Misra (2007) reported floristic composition of four regenerating forest stands in the Kandhamal district of orissa, India. Higher number of species (69) was observed in 2 years regenerating stand which declined with increase in age. The number of species was 55, 55 and 51 in 4 years, 6 years and 10 years stands respectively. Altogether 87 species under 71 genera and 32 families were recorded in the forest stands. The change in the number of species with age is mainly due to the elimination of herb species in the undergrowth. Tree and shrub species maintain their number in all stands.

2.7 Growth of tree species in disturbed and undisturbed forest

Behera and Misra (2006) reputed aboveground biomass of individual tree species by component and total biomass per unit area for four different stages of a recovering tropical dry deciduous forest stands, dominated by Sal (Shorea robusta) of the Eastern Ghats, India were investigated during 2001-2002. Different periods of recovering (2, 4, 6 and 10-year) Forest stands (84^0 13'E, $20^0$29'N) were selected in the Kandhamal district of Orissa, India and sample trees of all species were harvested. Tree species diversity was 23, 23, 21 and 22 in 2, 4, 6, and 10-year recovering stands, respectively. Species-wise *Ixora pavetta* showed the highest biomass in 2 and 4 -year stands, while *Shorea* *robusta* in 6 and 1—year stands. component-wise, in all species, bole-wood contribution ranged between 22.6% and 60.9%. Aboveground tree biomass, in all the stands, was dominated by *Shorea robusta*, which ranged between 12.68% and 231.91 Mg ha-1. Total aboveground tree biomass was 30.12, 49.21, 107.54 and 261.08 Mg ha-1 2, 4, 6 and 10-year stands, respectively.

Chhetri (1999) presented methods for estimations of aboverground tree biomass (combined for boles and branches) in Nepal's *Schima Castanopsisdominated* warm-temperate forests. The biomass estimations are presented for five forest stands purposively sampled in a larger study to represent different harvesting intensities. Two categories of biomass estimates are provided: (a) for living trees that are standing, and (b) for cut trees that have been removed. Biomass of standing trees were estimated by using diameter at breast height (dbh) and total height measurements as predictor variables in appropriate regression models. Biomass of cut trees were estimated in two steps: measurements of stump diameters and heights were used first to predict dbh and total heights of cut trees; these values were then regressed to obtain biomass estimates for the missing trees. Data were gathered from 2,361 live trees and 2,962 stumps in 170 sample plots across the five forest stands. estimates of mean standing-alive biomass ranged from a minimum of 16 ton/ha in the severely disturbed forest to a maximum of 479 ton/ha in a relatively undisturbed (reference) forest. Estimates of mean cut biomass ranged from a minimum of 24 ton/ha in a second reference forest to a maximum of 183 ton/ha in the severely disturbed forest. The biomass estimates in the relatively-undisturbed, reference forests are well above the 95% upper confidence interval of the global mean. Similar findings of high productivity have been reported for temperate forests of the Central Himalaya in India and Eastern Himalaya in Sik-kim. The findings of this study in the Nepalese Central Himalaya support the conclusion that productivity potential is high in the temperate Himalayan forests. The study's findings and methodology should be useful for preliminary development of guidelines in the region to regulate forest biomass growth, yield and harvest.

Mishra *et al.* (1998) studied biomass structure of two sites (biotically disturbed (BD) and un-disturbed (UD) and found total basal area as 7.9m^2/ha in BD site and 9.7 m^2/ha in UD site. Three important tree species *Anogeissus latifolia, Acacia catechu* and *Terminlia tomentosa,* accounted 88% in BD area and 66% in UB area, of total tree density. Total above ground tree biomass was 22.05 t/ha in BD area and 31.17 t/ha in UD area. Total above ground tree biomass of two sites differ significantly (p 0.01). In present study it is observed that the undisturbed has much higher biomass and tree diversity than the of the biotically disturbed.

Sha (1990) studied forest of Pattighat (Western Ghat-karnataka) to define the distribution pattern of different tree species and their growing stock. There is significant variation in the composition of tree species and their *basal area* in different localities. Analysis of B.A. (Basal Area) from different compartments reveal grouping of certain species in specific localities, similarly the locality is distinguishable into two groups based on difference in mean yield. The association of tree species and their stocking has also shown a similar trend. Among the 21 species, V*ateria indica* and K*ingiodendron pinnatum* form a strong group differing totally from another group of species consisting of F*icus mysorensis, Antiaris toxicaria, Garcinia morella, Schletchera oleosa, Artocarpus heterophyllus, Cinnamomum-zeylanicum, Mangifera indica, Pterygota alata and Dimocarpus longan.* Such information may be useful in choice of species in enrichment planting.

Mishra *et. al.* (1996) reported the properties of the soils under coppice and plantation of *Shorea robusta* to determine properties important for optimum growth of the species. Slightly different results were obtained for coppice and plantation Sal. Spatial variation in soil physicochemical attributes under *Shorea robusta* and differences between soils in stands of differentages and the effects of individual trees on the soil were also investigated and effective management methods for coppice Sal evaluated.

Rautiainen (1999) observed *a* spatial yield model is presented for even-aged *Shorea robusta* stands in Southern Nepal. The model consists of a single-tree, distance-dependent diameter-growth model, a single-tree, distance-independent height model, and a distance-independent mortality model. The data were collected from 29 plots of varying density, tree spatial pattern, and stand age. The diameter-growth model is based on measurements made from 580 trees, while 1336 trees were measured to provide data for the height model. The competition situation of individual trees was described by means of a competition index depending on the vertical angle sum defined by a horizontal plane placed at the top of the subject tree and by the heights and distances to competitors. The predictors in the diameter-growth model were: diameter at breast height, tree height, past growth (diameter/age), stands basal area, and competition index; tree height and past growth rate had positive coefficients. The model explained 53% of the variation in diameter growth. Simulations were carried out to examine the yield and stand development under selected management systems.

2.8 Regeneration of tree species in disturbed and undisturbed forest

The problem of Sal regeneration has been causing considerable difficulty. Reproduction of Sal is affected by diverse factors so interdependent and variable that it is difficult to assign reasons for its success or failure in any particular locality.

The most important single factor affecting natural regeneration is the time lag between the falling of seed and the commencement of the monsoon. With timely rains and other conditions being favorable, natural regeneration of Sal is good. The most obvious factor that limits the establishment of vegetation in an area is the amount of solar radiation, which determines the climate of an area. Since light is the main source of photosynthesis in plants, the amount of solar radiation also determines the availability of light for photosynthesis. In the temperate zone, photoperiod affects processes such as dormancy and germination of seeds, leaf fall and flowering (Champion and Seth, 1968).

The natural regeneration of Sal has been causing much difficulty for the last many decades and in recent years the problem has assumed serious magnitudes. In a few localities the problem had become so acute that normal felling in Sal forests had to be curtailed or suspended either for lack of natural regeneration or due to heavy mortality in the standing mature crop by drought or borer attack. The problem of natural regeneration involves two major aspects - One is recruitment and the other is establishment of Sal seedlings under natural conditions. It may be noted that Sal seedling do not die-back when grown artificially in *taungyas* but die-back occurs only in natural forests and the period of dieback or stagnation varies considerably (Maithani *et al.,*1989).

Singh and Singh (1987) reported the Levins response width for *Shorea robusta* in relation to temperature, light quantity and moisture as 0.944, 0.927 and 0.899 respectively. Thus observation suggests that the germination of Sal seed does not pose much problem, though exceptionally short period of seed viability requires a synchronization of seed fall with the advent of rainy season.

Pande (2006) analyzed regeneration behavior and population structure of important tree species in nine village forests under joint forest management in these forests were explored. The greater contribution of seedlings, saplings and individuals in lower diameter-class for sites-I, II, VII and IX showed "extending population structure", which is indicative of better regeneration on these sites. However, sites-VI,VIII and II were highly disturbed sites, the proportion of individuals were greater in larger diameter-classes as compared to smaller diameter-classes. This is indicative of "decline" population structure. Present and past disturbances adversely affect the regeneration and composition of different tree species at different sites. Besides the protection of these forests, artificial regeneration is suggested for the improvement of tree regeneration and maintenance of vegetation composition in near future.

Gautam *et al.* (2006) found that regeneration of Sal has been matter of great concern for the forest managers. A lot has been written about Sal and its requirements at herb, shrub and tree layer stages. But an integrated approach has always been lacking. In the present study all these layers were taken simultaneously for TWINS PAN classification. The results of the analysis reveal that soil moisture (indicator species used) is the main requirement for the sal seedlings. *Urean lobata* and Seedlings of *Urena lobata* and *Jasminum multiflorum* are the negative indicators and M*illettia auriculata, Pogostemon plectranthocides,* *Jasminum multiflorum* etc. are the positive indicators of good Sal regeneration.

Prasad and Mishra (1981) found that dying back phenomenon appears to lengthen the regeneration period considerably. The period of dying back varies from species to species depending upon their ability to develop extensive root system in shortest time, while in *Tectona grandis*, the dying back was observed to last upto 1-5 years of age, in *Anogeissus latifalia* and *Pterocarpus marsupium*. It was found to operate up to 5-10 years of age on the other hand in case of *Terminalia tomentosa* the dying back appeared to continue even beyond 20 years of age. Dying back was observed not only in tree species but in ground flora also. These plants were found to develop underground mechanisms to store water and food material for utilization during dry periods. Some plants were found to develop root bulbs while other possessed rhizomes or other such subterranean growth. Food and water reserves in the from of bulbs, thicker and longer tap roots and proper lateral roots enable the ground flora species to survive in spite of excessive grazing, trampling, drought and recurring annual fires, above ground parts.

Ilorkar and Totey (1999) studied 22 plant species in seedling stage existing at 300 – 400m, 26 at 400 – 500mt and 33 at 500 – 600m elevation and found that percent contribution of seedlings to that of total enumerated varies from 27 to 96%, 28 to 100% and 37 to 100% respectively. Regeneration of *Aegle marmelos* and *Dalbergia paniculata* is confined to 300 – 400m while *Stereopermum suaveolens, Boswellia serrata, Terminalia chebula, Semicarpus anacardium* and *Sterculia urens* to 400 – 500m and *Anthocephalus cadamba, Soymida febrifuga, Gardenia gumifera, Butea monosperma, Cassia fistula* to 500 – 600m elevation. The distribution pattern of natural regeneration is characterized by contagious distribution. Ratios of individuals of mature trees and seedling of the same species vary from 1 : 166 to 1 : 4 at 300 – 400m, 1 : 128 to 1 : 0.86 at 400 – 500m and 1 : 98 to 1 : 3 at 500 – 600m elevation.

Chandra *et al.* (2001) conducted a study on regeneration survey and soil profile in a ANR (Assisted Natural Regeneration) protected mixed forest area (5 Bclc & C^2 and 5A Clb & C^3) of Barhi, Katni (MP), ANR area supported higher number of regenerated species (18 species) as compared to unprotected adjacent area (12 species). Dominancy of regenerated species in ANR area showed variation from control area. ANR area is dominated by regeneration of *Shorea robusta* (comprised 30.56% of total regeneration), *Chloroxylon swietenia* (14.44%) and *Dendrocalamus strictus* (11.67%) in comparison to unprotected area dominated by regeneration of *Acacia catechu* (12.5%), *C. swietenia* (27.27%), *Diosphyros melanoxylon* (18.18%) and *Butea monosperma* (9.09%). Regeneration status was improved upto 26.64% through ANR production while stocking index was increased upto 18.43%. The organic matter recorded 16.52% higher while there were no changes in soil pH.

Gupta and Tripathy (1997) have correlated regeneration of different forest species in the area of Garhwa South Forest Division with various factors affecting the natural regeneration by stool coppice. The species like kekar (*Garuga Pinnata*), Karam (*Adinacordifolia*), Sidha (*Lagerstroemiaparviflora*), Sal (*Shorea robusta*), Khair (*Acacia catechu*), Dhaura (*Anogeissus latifolia*), Gijan (*Lannea coromandelica*) etc., which have better coppicing power, can be allowed to be exploited to meet the basic needs as well as to promote natural regeneration by stool coppice. The species like Kahua (*Terminalia arjuna*), Mahua (*Madhyca indica*) and other fruits bearing species may be left for soil cover to check soil erosion and to get seeds to promote natural regeneration by seedling fruit bearing species may be left for soil cover to check soil erosion and to get seeds to promote natural regeneration by seedling coppice. Also the stumps bearing the height 15 cm and below has been found much suitable for the natural regeneration and hence the tree should be cut preferable almost flush to the ground level. Among the silvicultural systems applied in this area, applied in this area, system like coppice with selection system has been observed to be working better to some extent in achieving natural regeneration by stool copping and hence this system may be extensively used in this area. And last but not least it has been observed that the stool of some species produces numerous shoots, sometimes more than 17 in number and therefore tending operation is needed on selective basis for such type of species to get the good crop.

Rao and Singh (1984) reported findings of regeneration of Sal *(Shorea robusta)* in two forest stands on the foot hills they found that in the old growth stand the regeneration was quite active from short seedlings (10 cm or less tall) to small sapling size class ‹ 50 cm tall and circumference at ground level 10 cm or less) but was arrested from this size class to large sapling size class (dbh more than 10 cm 30 cm). On the other hand in seedling coppice stand the regeneration was arrested from a very early stage (Le., the medium size class seedling; 10 'cm -20 cm tall). However, once the individuals reached the large sapling size class (dbh 10 cm - 30 cm), they become resistant to die backs and mortality. They also stated that die back seems to be an inherent property of the species, which helps it to survive in the adverse condition such as frost and hydric, deficiency.

Khan *et al.* (1986) observed that intropical and sub-tropical forest dominated by *Manglietia insignis, Pinus kesiya, Quercus dealbata, Q. griffithii, Rhododendron arboreum, Schima khasiana* and *Prunus undulata* whereas the tropical deciduous forest lying at lower altitude (Burnihat) is dominated by *Artocarpus chaplasa, Duabanga sonneratoides* and *Shorea robusta*. Upper Shillong and Burnihat 40% of the tree species regenerated through both seedlings and sprouts, whereas the percentage of such trees in the undisturbed forest at Mawphlang was only about 22%. Survival of seedlings and sprouts was higher at the forest periphery than under the dense canopy, signifying the role of light in forest regeneration. Although the seedling mortality occurred throughout the year, it was particularly high during winter season due to prevailing low temperature and high soil moisture stress. The sprouts, however, were less susceptible to adverse environmental conditions.

Chapter – III

MATERIALS AND METHODS

The experiment is conducted at Rarha Forest area which is located on Ranchi- Patratu road at a distance of 14 km from BAU Campus. A part of the forest under possession of Faculty of Forestry, Birsa Agricultural University, Ranchi since 1984 has been protected by trench all around for laying out research experimental. Due to protection the area has resulted coppice Sal forest of approximately 25 years age. However, in the adjacent area where there is no protection degraded condition still prevailed, which is selected for study.

The entire experimental area identified as biotically disturbed site lies at an elevation of 535m above MSL and situated at 23^{0} 33.544” N and 085^{0} 18.00” E direction, whereas biotically disturbed site selected for study lies at an elevation of 629m above MSL and is situated at 23^{0} 33.186” N and 085^{0}17.899” E direction. However, both the experimental site are almost plain having minor slope not excuding beyond 5%. The surrounding topography is rugged with serrated hills and hillocks. The Rarha river passes by at a distance of about ½ km towards south side from the experimental site, which runs dry in summer month.

The two types of area selected for collection of data are-

(a) Undisturbed area - The undisturbed area is selected at a distance of 500m from main nursery of Rarha Research Station towards North-west side. The undisturbed area comprised of coppice Sal forest having developed on over exploited area due to protection affords of faculty of forestry, which has now available in the form of lush green coppice Sal forest. from this area 5 ha. area extending 500m towards west and 100m towards north side was selected.

In undisturbed area, entrance of grazing animals, collection of firewood/fuelwood, cutting of vegetation, etc. are not done due to regular watch & word. As such this area is fully protected and is termed as undisturbed forest area.

(b) Disturbed area - This area is characterized by heavy biotic interference like, animal grazing, removal of fuelwood and leaf litter, illicit cutting of vegetation etc. It lies adjacent to undisturbed area at a distance of about 2 km towards north-east side in the vicinity of village Chharra Dipa. The biotic interferences observed in biotically disturbed area are-

(i) Cattle grazing (approximately 30-50 cattle's at a time)

(ii) Collection of firewood and leaf litter

(iii) Illicit felling of tree, etc.

(iv) Tress passing in the area by human and livestock

(v) Removal of soil/ murram

(vi) Soil erosion

3.1 Climate

In general the climate of the study area is "Sub-humid mega thermal". Usually the area is characterized by hot in summer season and cold in winter season. In winter season the mean January temperature (coldest month) dropping down to 14.8^{0}C, while in summer may month records a temperature of about 29.3^{0}C the maximum temperature ranges from 22.5^{0}C to as high as 42.8^{0}C and the minimum temperature as low as from2.6^{0}C to 21.8^{0}C. The mean relative humidity recorded in the area is about 64% and the annual rainfall in the study area is about 1450mm.

The details of weather parameter recorded during the experiment period i.e. Jan. 2009 to December 2009 is given in Table 3.1, based on the recording of meteorological observation of Birsa Agricultural University situated at 15 km away from the experimental site.

3.2 Existing vegetation

The study area represents reminants of Tropical Dry Deciduous Sal Forest (5B/C2 Northern Dry Mixed Deciduous Forest, 5B/C1c Dry Peninsular Sal), Comprising natural vegetation of Sal (*Shorea robusta),* Mahua *(Madhuca indica),*Arjun *(Terminalia arjuna),* Asan *(Terminalia tomentosa),* Semal *(Bombax ceiba*), Dhaunta *(Anogeissus latifolia),* Gamhar *(Gmelina arborea),* Palas *(Butea monosperma),* Amla*(Emblica officinalis)* Kend *(Diospyros melanoxylon),* Bans *(Dendrocalamus strictus), etc*. Many shrubby species like Putush *(Lanatana camara),* Karaunda (*Carissa opeca)* etc. are also found all over the area.

3.3 Data collection methodologies

For collection of data 5.00 ha area each from biotically disturbed and undisturbed forest is selected from both the area different sized sample plots were selected for collection of data on tree, shrubs and herbs separately. For this, sample plots of the size 10.0m X10.0m, for tree, 5.00m X 5.00m for shrubs and 1.0m X 1.0m for herbs are selected and demarcated as per Mishra, (1968). The total numbers of sample plots were 50 each for tree, shrubs and herbs (Annexure-I). The sample plots are selected randomly in such a manner to cover almost all kinds of variability existing throught out the biotically disturbed and biotically undisturbed forest areas.

For selection of sample plot a central longest diagonal cruise line across the area in laid down and sample plots were selected on either side of the cruise line. In sample plots besides tree, the seedling of any species were considered as herb, while sapling as shrub. Thus, for any available species in any sample plot, type of species, its total number, its common name with the help of local people and scientific name with Haines Flora were recorded (Haines, 1925).

3.3.1 Phytosociological character

Data on some of tree phytosociological character, such as Frequency, Density and Abundance are collected form each sample plot.

The **density**, which refers the numerical strength of a species, is calculated from the following formula -

$$\text{Density} = \frac{\text{Total number of individuals of a species in all sample plots}}{\text{Total number of sample plots sampled}}$$

On the other hand **frequency** that refers to degree of dispersion of individual species in an area and is expressed in terms of percentage occurrence and is calculated from following formula –

$$\text{Frequency} = \frac{\text{Number of sample plots in which a species occurs}}{\text{Total number of sample plots sampled}} \times 100$$

“A higher frequency value shows greater uniformity of its spread or dispersion.”

The **abundance** refers to the number of individual of different species in the community per unit area and is calculated from following formula:-

$$\text{Abundance} = \frac{\text{Total number of individuals of a species in all sample plots}}{\text{Total number of sample plots in which the species occurred}}$$

The ratio of **abundance to frequency (A/F)** was used to interpret the distribution pattern of the species in terms of regular, random and contagious distribution following the method of curtis and cottam (1956). The distribution of species was decided on the base of –

(i) If A/F ratio is < 0.025, than species distribution is Regular.

(ii) If A/F ratio lies between 0.025 to 0.05, than species distribution is Random.

(iii) If A/F ratio is > 0.05, than species distribution is Contagious.

The **relative dominance**, which represents the area of ground occupied by the above ground parts of plant in per unit area or in other terms ecological dominance refers to the exertion of a major controlling influence of one or more species upon all other species by virtue of their number, size, productivity or related activities and is calculated from following formula-

$$\text{Relative Dominance} = \frac{\text{Total Basal Area of a species in all the sample plots}}{\text{Total Basal Area of all species in all the sample plots}} \text{X } 100$$

Importance value Index (IVI) - In order to have an over all picture of ecological importance of a species with respect to the community structure importance value index (IVI) has been calculated by adding values of Relative Density, Relative Frequency and Relative Dominance. Therefore, IVI = Relative Density (RD) + Relative Frequency (RF) + Relative Dominance (R. Dom).

The relative density and frequency is calculated by following formula-

$$\text{Relative Density} = \frac{\text{Density of the species}}{\text{Total density of all the species}} \times 100$$

$$\text{Relative Frequency} = \frac{\text{Frequency of the Species}}{\text{Total Frequency of all the Species}} \times 100$$

The basal area is calculated form the average diameter of emerging stems of shrub, herb or tree species. The average diameter of an individual species is multiplied by its corresponding density to get basal area of the individual species and calculated from following formula -

$$\text{Basal Area} = \pi d^2 / 4$$

3.3.2 Growth Parameters

For comparison of growth parameters (height, diameter, volume, etc.) of different tree species, the diameter (cm) of tree species was recorded at breast height level (i.e., at 1.37m vertically from ground level) on tree trunk with while for shrub and herb diameter was recorded at base of each individual with the help of Vernier Calliper. Total height and bole height of individual tree species was measured with the help Ravi Altimeter.

Mean height is used for determining the volume of a crop but when the object is to assess the quality of the locality, the top height is measured.

The height corresponding to the mean diameter (calculated from basal area) of 250 biggest diameters per hectare as read from height diameter curve, is called top height. Therefore, the top height relates to only 250 biggest diameters (or about 125 trees) of the crop.

Similarly diameter corresponding to the mean basal area of the biggest trees in a uniform, generally pure crop, taking into consideration 250 biggest diameters per hectare is termed as "top diameter". The top height and top diameter were measured for comparison of growth of economically important tree species.

In general diameter growth of tree species are not uniform through out the area is not in cylindrical in shape, but due to climatic condition, site condition, age etc. the stems of trees starts tapering from base to crown and the rate of taper is called as Form.

The form of a tree is studied either from factor or from quotient. Which is defined as the ratio between the mid-diameter and d.b.h. of individual tree using following formula:-

$$\text{From Quotient} = \frac{\text{Mid-diameter}}{\text{d.b.h}}$$

For calculation of Total volume of individual tree species, the diameters and height is used as-

$$\text{Total Volume} = \pi\, d^2/4 \cdot h$$

Where, $\pi = 22/7$,

d = diameter (cm) at breast height level.

h = height of the tree (m).

Where as for calculation of Actual volume form quotient is also included as-

Actual Volume = $\pi d^2/4 \cdot h \cdot F{\cdot}Q$

Where, π = 22/7,

d = diameter (cm) at breast height level.

h = height of the tree (m).

F.Q = From Quotient.

3.3.3 Physico-Chemical properties of soil

The physico-chemical property of soils obtained from biotically disturbed and undisturbed area is calculated taking composite soil samples from both the sites. The composite soil samples were collected by Jakson (1978) method. For collection of soil samples first of all the surface litter layer is removed up to a depth of few cm and collect the soil samples up to depth of 0 – 15cm to 15-30cm depending upon surface conditions of the area. In a sample plot the soil is collected from different corner, then mixed together to get composite soil sample. The soil samples collected were brought in the laboratory and allowed to air-dry at room temperature. The big clods were broken. The soil was grounded on a wooden plank with a roller clearing no aggregates. Soil samples were kept in polythene bags separately for analyses.

The distribution of the size groups of ultimate particles is also called Mechanical-analysis. Based upon percentage of sand, silt and clay in composites soil samples, the soil types is decided as per the Texture classification of USDA.

The different method followed for analyses of physical and chemical properties of soil are in given Table-3.2.

3.3.4 Measurement of Regeneration of tree species

The regeneration survey is done in quadrat size of 2m X 2m for all the economically important tree species in both the areas (biotically disturbed and undisturbed) by adopting strip sampling method (Khanna, 1996). To know the regeneration, the regeneration categories are grouped into 5 types (i.e., Established, Woody shoot, Whippy, Sub-whippy, and now Recruit) available in each quadrat of the size 2m × 2m on either side of cruise line totaling 50 quadrats. The details of regeneration categories are-

(i) **Established -** (Symbol- E; Weightage value- 5.00) – Established regeneration represents a pole whose height is 2.5m or more and dbh 10cm and presence of at least one such plant is sufficient to stock the quadrat

(ii) **Woody shoot -** (Symbol- W^+ & W, Weightage value - 4.00) – These category belongs to the unbrowsed & browsed. Woody shoot, which is neither browsed nor established but vigorous is represented by W^+, Whereas Woody shoot, which has been browsed is shown by W presence of at least one W^+ or W is sufficient to stock the quadrat.

(iii) **Unbrowsed Whippy –** (Symbol- U^+, Weightage value - 2.00) Whippy unbrowsed unestablished seedling whose height is more than 50 cm, and in absence of E, W and W^+, presence of more than one U^+ indicates possibility of establishment of quadrant.

(iv) **Browsed whippy**- (Symbol- U, Weightage value - 1.00) – Whippy unbrowsed Seedling whose height is more than 50 cm U in a quadrat.

(v) **Unbrowsed Sub-whippy** – (Symbol- S+, Weightage value - 0.50) - More than one Sub-Whippy unbrowsed and unestablished seedlings whose height is less than 50cm.in quadrat in absence of all about categories.

(vi) **Browsed Sub-whippy-** (Symbol- S, Weightage value – 0.25) – Presence of one browsed Sub-Whippy unestablished seedling whose height is less than 50cm in the quadrat in absence of all about categories.

(vii) **Recruit** -(Symbol- R, Weightage value – 0.00) – In absence of symbols viz. E, W, W^+, U^+, U, S^+ and S) R indicates that there are only current year's seedlings in the quadrat.

3.4 Statistical Analysis

The statistical analysis of data recorded was done to obtain meaningful inferences. For this S.D., C.V. and significant of test (t- test) was carried in a PC using Microsoft excel software.

(i) **Standard Deviation (S.D.) –** The sample standard deviation to estimate the population standard deviation. The square root of the mean of the squared deviations of individual values from their mean.

(ii) **Coefficient of Variation (C.V.)** – The C.V. is mostly used to compare the variability, homogeneity, stability, uniformly or the combination between any two series.

The series having a higher value of C.V. is said to be more variable than the other, and the latter with lesser C.V. is said to be more stable, uniform, homogenous consistent.

(iii) **Tests of Significance** – The test of significantly the two samples or any sample from its population or form a hypothetical is measured by using test of significance.

RESULT AND DISCUSSION

To study the impact of biotic pressure on forest vegetation and its different ecological, physico-chemical and growth parameters, a study was undertaken at Rarha Forest area. Two types of forest areas, i.e. biotically disturbed and biotically undisturbed forest area were undertaken for this study. The detailed study was done on parameters like taxonomic distribution of plant species, its density, frequency, abundance, relative dominance etc. Growth parameters such as average diameter, average height, top diameter, top height, form quotient, total and actual volume of economically important tree species has also been studied. The regeneration status of economically important tree species was also studied. Besides, these physico-chemical parameters of soils found on both sites were also studied. In present chapters details of the finding are presented.

4.1 Species Composition

The species composition of biotically disturbed and undisturbed sites has been presented in Table-4.1. To facilitate the study, species composition is classified into four categories, i.e. tree, shrub, herb and climber. In these groups, a total of 73 species was observed. Maximum number of species was observed in herbaceous category (31), while in case of tree, only 19 species were found. Out of the 19 tree species, 12 species namely Asan (*Terminalia tomentosa*), Gamhar (*Gmelina arborea*), Jamun (*Syzyzium cumini*), Kendu (*Diospyros melanoxylon)*, Mahua *(Madhuca latifolia),* Piar (*Buchanania lanzan*), Palash (*Butea monosperma*), Sal (*Shorea robusta*), Semal (*Bombax ceiba*), Aamla (*Embilica officinalis*), Bahera (*Terminalia belerica*) and Dhaunta

(*Anogeissus latifolia*) was found at both the sites viz. biotically disturbed as well as undisturbed sites.

In addition to these species, four the additional species found only at disturbed sites were four and these are Amaltas (*Cassia fistula*), Kusum (*Schleichera oleosa*), Rori (*Mallotus philippinensis*) and Sidha (*Lagerstroemia parviflora*), while three tree species found only at undisturbed sites in addition to 12 tree species were Kala siris (*Albizia lebbek*), Bara jirhul (*Sophora bakeri*) and Harra (*Terminalia chebula*).

In the shrub section, only ten species were found at Rarha Forest area. Out of which six shrubby species were common at both biotically disturbed and undisturbed area. Common shrubs found on both the location were Beri (*Casearia tomentosa*), Doka (*Odina wodier*), Karond (*Carissa opeca*), Lodh (*Symplocos racemosa*), Putri (*Croton olongifolius*) and Ratangaura (*Elaeodendron glaucum*). In addition to the common species, shrubs namely Pituar (*Zizyphus regosa*) and Rendi (*Casearia graveolens*) are only found at disturbed sites. Similarly, at undisturbed sites two more species namely Bhabri (*Embelia robusta*) and Matta (*Antidesma diandrum*) are found in addition to commonly found species.

At both the sites, total number of herbaceous species was noticed as 31. Out of these, 19 herbaceous species were common at both the sites, while at undisturbed sites 12 more herbaceous species are found in addition (Table– 4.1).

The climbers are represented by a total of 13 species on both the sites and all were noticed at biotically undisturbed site, while only eight climber species such as Dudhialar (*Cryptolepis buchanani*), Hasualar (*Porana paniculata*), Karjanilar (*Abrus precatorius*), Kujri Lar (*Celastrus paniculata*), Kundarilar (*Cephalandra indica)*, Maholan (*Bauhinia vahlii*), Ramdatoon (*Smilex macrophylla*) and Satawar (*Asparagus racemosus*) were found at biotically disturbed sites. Out of 13 climber species, five species namely Barbati (*Vigna catjang*), Bilaikand (*Ipomea digitata*), Getilar (*Dioscorea belophylla*), Kalmi Lata (*Rivea hypocrateriformis*) and Panlati (*Vitis repanda*) are only found at biotically undisturbed sites.

The species composition at biotically disturbed and undisturbed sites of Rarha Forest area is shown in Figure 4.1.

From the figure it is evident that under tree category, out of 19 species, 12 are common to both the sites, however the number of species at disturbed site was found more, i.e. 16 as compared to undisturbed sites (15), while under shrub category, total 10 species found on both the sites, in which six are common at both the sites, i.e. at biotically disturbed and undisturbed sites. Equal number of occurrence of shrubby species was noticed at both the sites. In case of herbaceous category, total recorded numbers of herbs are found at undisturbed sites, which is much higher than disturbed site (19). Similar, pattern is also found in case of climber category, i.e. at disturbed sits higher (13) number of species are recorded as compared to the disturbed sites (8). In this way overall plant composition was recorded as 73, out of which 51 was recorded at disturbed site and 67 at undisturbed sites. Total number of common species at both the biotically disturbed and undisturbed sites was recorded as 45.

The percentage occurrence of total species for biotically disturbed and undisturbed sites are shown with pi-chart (Figure- 4.2 and 4.3).

It is clear from pi-chart that number of species of undisturbed sites has contributed major share to total number of species.

The taxonomic distribution of all the species (73) recorded from biotically disturbed and undisturbed sites of Rarha Forest area with respect to the plant families is represented in Table- 4.2.

Perusal of the data has indicated that species from both the sites are distributed in 35 families, out of this at biotically disturbed site tree, shrubs, herbs and climber were found distributed in 13, 7, 14 and 7 families, respectively, whereas in case of biotically undisturbed sites the distribution of tree, shrubs, herbs and climbers were 14, 5, 19 and 8 families, respectively.

Among tree species members from Combretaceae represented maximally at biotically disturbed (3) and undisturbed sites (4). In case of shrubby category maximum species represented into Flacourtiaceae (2) for biologically disturbed and Euphorbiaceae (2) for undisturbed sites. On disturbed as well as on undisturbed sites maximum number of species form herbaceous group belonged to Papilionaceae family, as 4 & 5, respectively.

However in case of climber category, Liliaceae family dominated on disturbed sites while on undisturbed sites Convolulaceae family, (3) had maximum number of genera. Thus, at disturbed sites the family that has significantly represented was found as Papilonaceae (6) and similar trend is also recorded for undisturbed sites (9).

Similar to the present findings Pandey and Shukla (2003) have reported richness of Papilionance families in Sal forest at Sohagiarawa Wildlife Sanctuary, Gorakhpur, India.

Similar to the present study Timilsina *et al.* (2007) found a total of 131 species comprising of recorded: 28 trees, 10 shrubs, 6 climbers and 87 herbs. The mean density across all plots was 220 tree/ha and the average basal area was 13.2 m^2/ha for Sal (*Shorea robusta*) forest in lowland Nepal.

Similar to the present findings, Dyer (1874) described nine genera and 92 species in South Asia, while FAO (1985) reported that a total of ten genera and 99 species of dipterocarps were found in South Asia. They are *Anisoptera* (3 species), *Balanocarpus* (1), *Cotylelobium* (2), *Dipterocarpus* (19), *Hopea* (18), *Parashorea* (2), *Shorea* (27), *Stemonocarpus* (15), *Vateria* (3), and *Vatica* (9).

Mishra *et al.* (2004) have found the number of families of angiosperms was highest (63) in the undisturbed stand, followed by the moderately (60) and highly disturbed (46) stands. The families Rubiaceae, Asteraceae, and Poaceae were the dominant families in undisturbed, moderately disturbed and highly disturbed stands. On the other hand Asteraceae family had 16 species in the moderately disturbed stand and 14 species in the highly disturbed stand.

Similarly Bhuyan and Khan (2003) showed that mildly disturbed stand showed the highest species richness (54 of 51 genera) as compared to highly disturbed and undisturbed stand in tropical wet evergreen forests of Arunachal Pradesh.

Behera & Misra (2007) found that change in the number of species with age is mainly due to the elimination of herb species in the undergrowth, whereas Tree and shrub species maintain their number in all stands in the Kandhamal district of Orissa, India.

4.2 Phyto - Sociological Characters

The population characteristics of ten economically important species recorded at biotically disturbed and undisturbed sites is presented in term of density, frequency and abundance as shown in Table – 4.3.

4.2.1 Density

The density which refers to the numerical strength of a species in an ecosystem has been calculated for economically important plant species.

The density of *Shorea robusta* (Table 4.3) was found maximum on both the sites and at undisturbed sites its value is 10.48, which is more than twice of the density of at disturbed site. This indicates enormous biotic pressure on Sal. At disturbed sites maximum density of Sal (4.16) was followed by *Butea monosperma* (1.60) and *Diospyros melenoxylon* (1.36), while minimum by *Schleichera oleosa* (0.12) and *Mallotus philippinensis* (0.20). The density of economic tree species like *Syzyzium cuminii*, *Diospyros melanoxylon*, *Madhuca latifolia* and *Butea monosperma* is higher at disturbed sites than the undisturbed site. The density of *Buchanania lanzan* at disturbed and undisturbed site is same, i.e. 0.24. At undisturbed site drastic reduction in density was observed in case of rest of the species (other than *Shorea robusta*). Similar to Sal, the density of *Terminala tomentosa* and *Bomax ceiba* was found high at undisturbed site as compared to disturbed sites.

Comparative density of economically important tree species in biotically disturbed and undisturbed sites of Rarha Forest Area in shown in Figure- 4.4.

From the graph, it is viewed that density of Sal (S*horea robusta)* at undisturbed sites is nearly double of the disturbed site. However, the density of Palash (*Butea monosperma)* and Kendu (*Diospyros melanoxylon)* at disturbed sites is more than undisturbed site. Similar trend is also observed in case of Jamun (S*yzyzium cuminii)* and Mahua (*Madhuca latifolia).*

In contrast to present findings Addo-Fordjour *et al.* (2009) found that *Liana* density differed significantly across the forest types with the recording of greatest number in undisturbed forest. Tree density and number of trees hosting *lianas* were greater in the undisturbed forest and The effects of human disturbances and plant invasion on community structure of liana community was noticed in the Tinte Bepo forest reserve, Ghana.

Similar to the present findings, Bhuyan and Khan (2003) noticed highest tree diversity in the undisturbed stand and the lowest in the highly disturbed stand of tropical wet evergreen forest of Arunachal Pradesh. Joshi *et. al.* (1994) have found maximum density of ground flora in *Eucalyptus* plantation followed by brushwood and Sal forest area in Dun Valley in U.P.

In a protected Jhum fallow Boral (1995) found to decline in member of species with succession whereas the total (community) density increased consistently.

Similarly Singh *et al.* (1988) have observed good growth and density of *Tectona grandis,* and *Anogeissus latifola*, on moderately deep soils in disturbed and undisturbed mangrove forest of Andaman Island. On the other hand Mishra *et al.* (2004) found sharp decline in tree density and basal area from undisturbed (2103 trees ha-1 and 26.9 m2 ha -1) to the moderately disturbed (1268 trees ha-1 and 18.6 m2 ha-1) and finally to the highly disturbed (852 trees ha-1 and 7.1 m2 ha-1) stand. Reduction in number of trees in higher girth classes from the undisturbed to the moderately and highly disturbed stands was in successive order in East Khasi Hills district of Meghalaya in northeast India.

Kumar *et al.* (1994) noticed total reduction in tree density (33%) in disturbed (unprotected) forest site as compared to protected forest site (9%),due to the disturbances in forest.

4.2.2 Frequency

Frequency referring to the degree of dispersion of individual species in an area has been measured for ten economically important tree species (Table 4.3).

At disturbed sites maximum frequency was observed in case of Sal (*Shorea robusta*) 88% and minimum in case of Kushum (*Schleichera oleosa)* 6%. At disturbed sites, the tree species having more than 50% frequency are Sal (*Shorea robusta)* 88%, Palash (*Butea monosperma)* 62% and Kendu (*Diospyros melenoxylon)* 52%, while in remaining tree species less than 50% frequency was observed.

At undisturbed sites, 100% frequency was observed for Sal (*Shorea robusta*), but rest of the species shown very less frequency, i.e. less than 50%. Therefore, maximum frequency was observed in case of Sal and minimum in case of Piar (*Buchanania lanzan).*

Frequency of economically important tree species at biotically disturbed and undisturbed sites is also represented with graph (Figure-4.5).

Among the ten selected economically important species, the frequency of Sal (*Shorea robusta)* was found maximum at both the sites. Other species showing significant frequency at both the sites are Kendu (*Diospyros melenoxylon)*, Palash (*Butea monosperma)* and Semal (*Bombax ceiba).* The frequency of Mahua (*Madhuca latifolia)*, Jamun (*Syzyzium cuminii), Piar (Buchanania lanzan)* was found more at disturbed sites than undisturbed sites, however the frequency of Asan (*Terminalia tomentosa)* was more at undisturbed sites than disturbed sites.

Similar to the present finding, Mishra, *et al.* (2000) found maximum IVI, density, frequency and TBC (Total Basal Cover) values of Sal (Shorea robusta), the dominating species in moist Bhabar and Tarai

Sal forest. Highest frequency (100%) of dominant tree *Symplocos racemosa* was also reported by Verma and Totey (1996) in permanent preservation plot at Malyagiri, Orissa.

4.2.3 Abundance

The abundance is studied to know the number of individual of different species in the community per unit area. The abundance value of economically important tree species as shown in Table- 4.3 has indicated maximum vale (4.72/ha) for Sal (*Shorea robusta)* at disturbed sites. Six tree species namely Jamun (*Syzyzium cumini),* Kushum *(Schleichera oleosa),* Mahua *(Madhuca latifolia),* Piar *(Buchanania lanzan),*Rori (*Mallotus philippinensis)* and Semal (*Bombax ceiba)* have shown equal abundance (2.00/ha), while remaining three tree species showed greater than two abundance value.

Similar to the disturbed site, at undisturbed site, the abundance value of Sal (*Shorea robusta)* was found significantly higher (10.48/ha) as compared to other species of same site as well as from Sal (*Shorea robusta)* of disturbed sites. The abundance value of other species was found more than 2.0/ha. Three tree species namely Asan (*Terminalia tomentosa)*, Jamun (*Syzyzium cuminii)* and Mahua (*Madhuca latifolia)* have shown equal abundance (2.00/ha).

Similar to density and frequency, abundance of ten economically important tree species at biotically disturbed and undisturbed sites is graphically represented in Figure – 4.6.

The abundance of Sal (*Shorea robusta)* at undisturbed sites was found almost double than at disturbed sites, however the abundance value of Jamun (*Syzyzium cuminii)* and Mahua (*Madhuca latifolia)* at both the sites was found same. The abundance value of *Terminalia tomentosa*, *Diospyros melanoxylon* and Palash *(Butea monosperma)* was found more at disturbed sites than undisturbed sites. However, abundance value of Piar (*Buchanania lanzan)* and Semal (*Bombax ceiba)* was found more at undisturbed sites than disturbed sits.

The ratio of abundance to frequency (A/F) was used to interpret the distribution pattern of 10 selected economically important tree species in term of regular, random and contagious and shown in Figure- 4.7.

Among the studied species, the A/F ratio of Kushum (*Schleichera oleosa)* was found maximum at disturbed sites, while the A/f ratio of Piar (*Buchanania lanzan)* was found more at undisturbed sites than disturbed sites. The species having more A/F value at undisturbed sites were Jamun (*Syzyzium cumini)*, Mahua (*Madhuca latifolia)*, Palash (*Butea monosperma)* and Sal (*Shorea robusta)*. However, at disturbed sites the A/F ratio of Asan (*Terminalia tomentosa)* and Kendu (*Diospyros melenoxylon)* were found more. The A/F value of Semal (*Bombax ceiba)* was found same at disturbed as well as undisturbed sites. Therefore, Random distribution (A/F value between 0.025 to 0.050) was observed in case of Kendu, Palash and Sal at disturbed site while, at undisturbed sites random distribution was found in case of Kendu only. In rest of the species location at both sites, the distribution was contagious (when A/F value >0.050).

Similar to the present finding, Verma and Totey (1996) have observed random and contagious distribution of most of the species found in Tabada preservation plot in Orissa. However, a few species like *Terminalia tomentosa, Gmelina arborea, Antidesma diandrum, Terminalia balerica* and *Zizyphus regosa* etc. showed regular distribution.

Parthasarathy (1999) found variation in the kind and richness of species and the abundance of all woody species in Kalakad National

Park, Western Ghats, South India, as main reason for human interference.

4.3 Relative Dominance and Importance Value Index

The relative dominance (RD) which refers to the exertion of a major controlling influence of one or more species upon all other species by virtue of their number, size, productivity or related activities is calculated for ten selected economically important tree species (Table- 4.4).

Although three quantitative parameters such as Density, Frequency and abundance have been calculated but these parameters did not give over all picture of ecological importance of the species with respect to the community structure. As such the percentage value in terms of relative frequency, relative density and relative dominance are added together to find out Importance Value Index (I.V.I.) of the species (Table-4.4).

The relative dominance Sal (*Shorea robusta)* was found more at undisturbed sites (57.25) than disturbed site (29.35). In contrast to Sal, in remaining species the value of relative dominance of remaining species was found more at disturbed sites than undisturbed sites. Besides, Sal (*Shorea robusta)*, more relatives dominance was observed in case of Palash (*Butea monosperma)* (18.96) and Kendu (*Diospyros melenoxylon)* (12.06), and minimum value was observed for Kushum (*Schleichera oleosa)* (1.72). At undisturbed site, the relative dominance of Kendu (*Diospyros melanoxylon)* (8.87) was found next to Sal (*Shorea robusta)*, followed by Semal (*Bombax ceiba)* (8.06). The relative dominance of Asan (*Terminalia tomentosa)* and Jamun (*Syzyzium cuminii)* were in same range, i.e. 4.83 and 4.43, respectively. Similarly the relative dominance of Palash (*Butea monosperma)* and Mahua (*Madhuca latifolia)* was found as 7.66 and 6.85, respectively.

Various indices like dominance, diversity, richness and evenness were found influenced by the seasons, because diversity and richness were highest in rainy season while dominance and evenness were in summer. The dominance diversity curves also changed from log normal distribution of the geometric series of riche pre-emption model (Whittakar, 1975).

Similar to the present study Bhuyan and Khan (2003) also studied dominance in undisturbed, midly disturbed, moderately disturbed and highly disturbed of tropical wet evergreen of Arunachal Pradesh and found much variations in different types of forest stands.

Pande *et al.* (2002) found reverse trend of concentration of dominance to diversity. In all the study sites, the dominant species has shown good regeneration potential as evidenced by the presence of adequate number of seedling, sapling & distribution of boles among all gbh classes in a western Himalayan forest of Chakrata forest division (Uttaranchal).

Perusal of the data on IVI for disturbed and undisturbed site has indicated highest I.V.I for *Shorea robusta* (Sal) among ten tree species on biotically undisturbed site (171.21), while on disturbed site its value was found as 101.6.

In case of Piar lowest values of IVI was noticed both on disturbed (9.81) and undisturbed sites (7.59). Except Asan, the IVI value of other species was found more on disturbed site.

Similar to the present finding Mishra *et. al.* (2000) have reported maximum value of IVI for Sal (*Shorea robusta*) in moist Bhabar and Tarai. Sal forest on four different aspects (NE, NW, SE and SW). Different in Value of IVI have also been reported by Bhuyan and Khan (2003) for undisturbed, midly disturbed, moderately disturbed and highly disturbed stands of tropical wet evergreen forest of Arunachal Pradesh.

4.4 Growth of tree species

The growth parameters of ten economically important tree species recorded from biotically disturbed and undisturbed sites has been studied in term of parameters such as diameter (dbh & top diameter), height (total height and top height), form quotient, tree volume (total volume actual volume) etc.

4.4.1 Diameter

The average diameter of ten selected economically important tree species is show in Table- 4.5. Out of the 10 species, among the eight commonly occurring species at both the sites (disturbed and undisturbed) in seven tree species namely Asan (*Terminalia tomentos),* Jamun (*Syzyzium cuminii),* Kendu *(Diospyros Melenoxylon*), Mahua *Madhuca latifolia*, Piar (*Buchanania lanzan),* Palash *(Butea monosperma),* and Sal (*Shorea robusta)* more average diameter at undisturbed sites than disturbed sites was found. However, Semal (*Bombax ceiba*) was shown less diameter at undisturbed sites (13.24cm) than disturbed sites (13.67cm).

At disturbed site, maximum average diameter was recorded for Semal (*Bombax ceiba*) 13.67cm, followed by Mahua (*Madhuca latifolia*) 12.80 cm and Jamun (*Syzyzium cuminii*) 12.54 cm and minimum average diameter was recorded for Rori (*Mallous philippinensis*) 4.78 cm. At undisturbed site maximum average diameter was recorded for Sal

(*Shorea robusta*) 18.95 cm, followed by Mahua (*Madhuca latifolia*) 15.86 cm and Palash (*Butea monosperma*) 13.22 cm.

The minimum average diameter at undisturbed site was found for Piar (*Buchanania lanzan)* as 9.18 cm. From the value of Test of significance, it is found that the three tree species namely Jamun (*Syzyzium cumini*), Piar (*Buchanania lanzan)* and Semal (*Bombax ceiba)* have shown at par average diameter value at both disturbed and undisturbed sites. The other species such as Asan (*Terminalia tomentosa*), Kendu (*Diospyros melenoxylon*), Mahua (*Madhuca latifolia*), Palash (*Butea monosperma*) and Sal (*Shorea robusta*) have shown highly significant average diameter at undisturbed sites as compared to disturbed sites.

Top diameter, which represents the diameter corresponding to the mean basal area of the biggest tree in a uniform, generally pure crop, taking into consideration 250 biggest diameters per hectare, has been also calculated for the economically important given species and in Table- 4.6.

Top diameter usually is taken to calculate top height, which is an important parameter to decide site quality. Top diameter at undisturbed site for Asan (*Terminalia tomentosa)*, Jamun (*Syzyzium cumminii),* Kendu (*Diospyros melenoxylon),* Mahua (*Madhuca latifolia)*, Palash (*Butea monosperma)* and Sal (*Shorea robusta)* was found greater than disturbed sites. However, the top diameter of Semal (*Bomax ceiba)* 16.20 cm and Piar (*Buchanania lanzan)* was found more at disturbed site than undisturbed site. At disturbed site maximum top diameter (16.20 cm) was observed in case of Semal (*Bombax ceaba)* followed by Asan (*Terminalia tomentosa)* and minimum 12.05 cm in Kendu *(Diospyros melenoxylon)*. At undisturbed site, maximum top diameter (23.79 cm) was calculated for Sal (*Shorea robusta)*, followed by Jamun (*Syzyzium cuminii)* and minimum in case of Piar (*Buchanania lanzan)*.

Rautiainen (1999) presented predictor diameter growth model for d.b.h, tree height, basal area etc. uneven is a Sal forest in Southern Nepal.

4.4.2 Height

The average height, another growth parameter for tree species measured for ten economically important tree species are given for biotically disturbed and undisturbed site in Table- 4.7.

Perusal of the data has indicated that average height of Sal (*Shorea robusta)* was found more at undisturbed sites (17.86 m) than disturbed site (13.33 m). Similarly, average height of Asan (*Terminalia Tomentosa)* 9.60 m, Mahua (*Madhuca latifolia)* 11.33 m and Piar (*Buchanania lanzan)* 9.10 m was recorded more at undisturbed site. In four species of common occurrence on both sites, viz. Jamun (*Syzyzium cuminii)* 13.56 m, Kendu *(Diospyros melanoxylon)* 8.65 m, Palash (*Butea monosperma)* 9.66 m and Semal *(Bombax ceiba)* more average height was found disturbed site.

At disturbed site, maximum average height was found for Jamun 13.56 m followed by Sal 13.33 m, whereas minimum average height was recorded for Rori (3.25 m.). At undisturbed site, maximum average height was recorded for Sal (17.86 m), followed by Semal (11.50 m) and Mahua (11.33 m), minimum average height was recorded for Kendu (8.61 m). As for as the level of significance is concerned, the average height of Sal (*Shorea robusta),* Asan (*Terminalia tomentosa)* and Piar (*Buchanania lanzan)* was found highly significant at undisturbed site than its value on disturbed sites, however the average height of Mahua (*Madhuca latifolia)* and Kendu (*Diospyros melanoxylon)* were found at par at both the sites. On the other hand the average height of Jamun (*Syzyzium cuminii)*, and Semal (*Bombax ceiba)* was found highly significant at disturbed sites than undisturbed sites, while for Palash (*Butea monosperma)* it was found significant at disturbed site.

Top height which represents the height corresponding to the mean diameter (calculated from basal area) of 250 biggest diameter per hectare as read from height diameter curve has been also calculated for ten selected tree species and presented is Table- 4.8.

The top height is calculated to know site quality of a forest area. In case of top height, only three tree species namely Kendu (11.50 m*),* Piar (13.00 m*)* and Sal (20.41 m*)* have shown greater value at undisturbed site than disturbed site. The top height of Mahua (*Madhuca latifolia)* was found equal at both the sites, i.e. 13.00 m. However, the top height of species like Asan (*Terminalia tomentosa)*, Jamun (*Syzyzium cuminii)*, Palash (*Butea monosperma)* and Semal (*Bombax ceiaba)* was found greater at disturbed site. At disturbed site maximum top height was observed in case of Jamun (15.50 m*)*, followed by Semal (15.00 m) and minimum in case of Rori (9.75 m*)*, while at undisturbed site, maximum top height was calculated for Sal (20.41 m*)* and minimum in case of Kendu (11.50 m).

Biswas, *et al.* (2006) reported that superior tree species such as *Dipterocarpus turbinatus*, *Dipterocarpus alatus, Swintonia floriunda* and *Syzygium grade* was found to occupy the higher diameter classes, while many inferior tree species such as *Bursera serrata* and *Pterospermum acerifolium* were found to occupy the lower diameter classes in Idgaon Forest Reserve under Cox`s Bazar Forest Division of Bangladesh.

Singh and Gupta (2008) found less variation in crop height of different periodic blocks. The higher crop height in periodic block-4 in comparision to periodic block-3 was observed.

4.4.3 Tree Form

Tree form is one of important factor in growth of tree and for deciding tree shape either is cylindrical or conical shape. It represent rate of taper of tree form base to upward. The tree from has a bearing to calculate the actual volume of tree, which is represented in the form of "Form Quotient" for all the ten selected tree species found at both biotically disturbed & undisturbed sites (Table-4.9).

The greater value of form quotient indicates cylindrical shape of tree trunk while lower value, i.e. below 0.7 shows the conical shape. The form quotient of tree species found at disturbed site like *Terminalia tomentosa* (0.88), *Diospyros melenoxylon* (0.86), *Butea monosperma* (0.85) and *Bombax ceiba* (0.88) have shown higher value than its value at undisturbed site. However, for *Syzyzium cumini*, *Madhuca latifolia* and *Shorea robusta*, the form quotient at undisturbed site was higher than its value at disturbed site. The form quotient of *Buchanania lanzan* was found same (0.84) at both the sites.

At disturbed site maximum form quotient was found for *Schleichera oleosa* (0.90), followed by *Terminalia tomentosa*, *Shorea robusta* & *Bombax ceiba* (0.88 each) and minimum in the case of *Mallotus philippinensis* (0.57), while at undisturbed site, maximum form quotient was calculated for *Shorea robusta* (0.90), followed by *Syzyzium cuminii* (0.87) and minimum for *Diospyros melenoxylon* and *Bombax ceiba* (0.79 each).

Therefore, at disturbed site except *Syzyzium cuminii* and *Mallotus philippinensis*, tree trunk of all species was observed in almost cylindrical shape. However, in case of *Mallotus phillippinensis* maximum tapering was observed.

At undisturbed site the two species indicate tapering of tree trunk, while in rest of the species (six species) tree trunk was found almost towards cylindrical shape because value varied from 0.81 to 0.90.

SK-Uhlig (1989) calculated form factor of 25 years old *Eucalyptus globules* plantation at spacing of 2.5 m at East Ethiopian highland (Alemaya, Ethiopia) for volume estimation. RE-Moya-Santelices (1989) calculated Natural and artificial form factors for Lingue (*Persea lingue*) in Andean foothills and Manio (*Podocarpus nubigena*) in the costal range of Chile.

Similar to present study, da –JAA -Silva *et. al*. (1994) studied cylinder form factor of tree species like Loblolly (*Pinus taeda*), Slash (*Pinus elliottii*) and Caribbean (*Pinus caribaea* var. *hondurensis*). The estimated form factor was used to calculate the total stem volume of 2509 trees distributed over seven large stands.

Tague (1992) found that Pressler volume and natural form factor equations provided consistently superior estimates of total volume.

4.4.4 Basal Area

Basal area actually represents cross sectional area of a stem at breast-height level (1.37m vertical height). Total basal area calculated for per unit area is used to specify characteristic of a stand. The basal area of ten economically tree species at biotically disturbed and undisturbed sites of Rarha Forest Area is shown in Figure- 4.8.

For Sal, the basal area coverage at undisturbed site was found almost seven times greater (15) than its value at disturbed site (2.5). However, for Palash a reverse trend is observed, i.e. at disturbed site almost double (0.9) than its value on undisturbed site (0.45). In case of Mahua and Piar, the basal area coverage was almost equal at both the sites. For Kendu slightly higher value of basal area was observed at disturbed site (0.55) than undisturbed site (0.45), however incase of Asan and Jamun more basal area coverage was found at undisturbed site than disturbed site. Therefore, courage of Kendu and Palash was more at disturbed site, while at undisturbed site Sal courage was maximum.

Similar to the present finding Timilsina *et. al.* (2007) have reported the 131 species, respectively 28 tree, 10 shrubs, 6 climber and 87 herbs. The density of all plots was 220 trees/ha and the average basal area was 13.2 m2/ha in Sal forest in lowland Nepal.

4.4.5 Tree Volume

The total standing volume of ten selected tree species for both the sites (disturbed and undisturbed) have been calculated and presented in Table – 4.10, in term of total volume and actual volume (cu.m / ha). The total volume has been calculated without inclusion of form (rate of taper), while actual volume is calculated by multiply total volume of individual tree species with respective form quotient value.

Perusal of the data on total volume has indicated that total volume production of tree species like *Terminalia tomentosa*, *Syzyzium cuminii*, *Madhuca latifolia*, *Buchanania lanzan*, *Shorea robusta* and *Bombax ceiba* was found greater at undisturbed sites than disturbed sites. On contrarily to this, two tree species, viz. *Diospyros melanoxylon* and *Butea monosperma* have shown higher total volume at disturbed sites than undisturbed sites. The total volume of *Shorea rubusta* at undisturbed sites (268.90 cu.m./ha) was found almost eight times greater than its value at disturbed sites (33.17 cu.m/ha). However, for tree species like *Bombax ceiba*, *Buchanania lanzan*, *Madhuca latifolia*, *Syzyzium cumini* and *Terminalia tomentosa*, no significant difference in total volume production was observed at biotically disturbed and undisturbed sites. For *Butea monosperma*, the total volume production at disturbed sites was found double (8.49 cu.m/ha) than its value at undisturbed sites (3.89 cu.m/ha). Similarly, more volume was observed for *Diospyros melanoxylon* at disturbed sites (5.02 cu. m./ha) than undisturbed sites (4.30 cu. m./ha). Only *Shorea robusta* has shown significant total volume production at disturbed (33.17 cu. m/ha) and at undisturbed site (268.90 cu. m./ha). The volume production by rest of the species was not found significant at both the sites.

Calculation of actual volume by inclusion of form quotient was found maximum in case of *Shorea robusta* (29.18 cu. m./ha) and minimum in the case of *Mallotus philippinensis* (0.51 cu. m./ha) at disturbed site. However, in case of undisturbed site, maximum actual volume production was also observed for *Shorea robusta* (242.01 cu. m./ha), but minimum actual volume production was observed for *Buchanania lanzan* (1.19cu.m./ha) followed by *Terminalia tomentosa* (2.49 cu.m./ha). No significant difference was observed in actual volume production at disturbed and undisturbed sites for *Terminalia tomentosa*, *Madhuca latifolia*, *Buchanania lanzan* and *Bombax ceiba*.

In case of *Shorea robusta*, the actual volume production at undisturbed sites (242.01 cu. m./ha) was almost nine times greater than its value at disturbed site (29.18 cu. m./ha). However, higher actual volume production was observed for *Diospyros melenoxylon* and *Butea monosperma* at disturbed sites than undisturbed sites. But in case of *Syzyzium cumini*, the actual volume production at undisturbed site (2.75 cu.m./ha) was found grater than disturbed site (1.96 cu. m./ha).

The comparative view of total and actual volume production is shown with bar diagram (Figure- 4.9).

In case of Asan, Jamun, Kendu, Mahua, Piar and Semal, no significant difference was observed at both the sites for both actual and total value. However, significant difference in case of Palash and Sal was noticed for disturbed and undisturbed sites. In case of Palash, the actual volume at disturbed sites was almost double than undisturbed sites, while in case of Sal, highly significant difference was observed between both the sites was found, i.e. about nine times at undisturbed sites. The actual volume production of Palash was found almost double at disturbed sites and for Sal, it was found almost nine times greater at undisturbed sites.

Similar study Singh and Gupta (2008) found that the total standing volume was maximum in Periodic block-2, followed by Periodic block-1, Periodic block-3 and Periodic block-4.

4.5 Regeneration status of tree species

In any forest, successfully regenerating ability of existing species are considered as good sign for sustained management. In context to this, regeneration status of all the ten selected species is studied to find out its existing status in both the biotically disturbed and undisturbed forest area.

To determine status of regeneration of different species, data on different categories of seedling- viz. Established, Woody shoot (unbrowsed & browsed), Whippy (unbrowsed & browsed), Sub-whippy (unbrowsed & browsed), and Current year's recruits are observed and given in Table – 4.11.

Perusal of the data has indicated varied results for different species with respect to regeneration. In case of *Terminalia tomentosa*, no established tree was found at disturbed sites, however at undisturbed site, one such tree having more than 2.5 m height and 10 cm dbh was found in one sample unit. Same number (4) of wood shoot (unbrowsed & browsed) was found at both disturbed & undisturbed sites, but the number of unbrowsed whippy seedling was found more at undisturbed site (4) as compared to the disturbed site (3). The browsed woody seedling was found more at disturbed site and at undisturbed site. The unbrowsed sub- whippy & browsed sub-whippy seedlings were found only in disturbed site. As far as current year's seedlings of *Terminalia tomentosa* is concerned no such seedlings existed neither in disturbed nor in undisturbed sites. Total Weightage value of *Terminalia tomentosa* at disturbed and undisturbed sites was calculated as 28.25 and 31.00, respectively.

In case of *Syzyzium cuminii* established tree, unbrowsed whippy and browsed sub-whippy seedlings as well as current year seedlings was not found at undisturbed sites, while one established regeneration was observed at disturbed sites. The number of woody shoot (unbrowsed & browsed) was found twice (8.00) at undisturbed sites than at disturbed sites (4.00). Unbrowsed whippy seedlings of *Syzyzium cuminii* was recorded only at disturbed sites. However, browsed whippy seedlings having height less than 50 cm was found at both the sites, but the number at disturbed sites (3) was thrice than their number at undisturbed site (1). The number of unbrowsed Sub-whippy seedlings was found same (1.00) at both the sites. Over all the regeneration value of *Syzyzium cumini* was calculated as 17.50 and 10.00 for disturbed and undisturbed sites, respectively.

In case of *Diospyros melanoxylon,* total weightage regeneration value was more that undisturbed site (57.50) than disturbed site (45.25). No current year seedling was found at both the sites. Established tree of *Diospyros melanoxylon,* was found more at disturbed site (4) than undisturbed site (3), but the number of woody shoot (unbrowsed & browsed) was found more at undisturbed sites (4) than at disturbed sites (3). The number of unbrowsed whippy shoot and browsed whippy seedling having height greater or less than 50cm was found more at undisturbed sites. The number of unbrowsed sub whippy & browsed sub-whippy unestablished seedlings having height less than 50cm was found twice at undisturbed site than disturbed site.

The *Schleichera oleosa*, which found only, at disturbed site has recorded established tree, unbrowsed sub-whippy and browsed sub-whippy seedlings having height more or less 50 cm was not fount at disturbed sites. However, at disturbed sites, four woody shout (unbrowsed & browsed), two unbrowsed whippy seedlings (>50 cm) and three unbrowsed whippy seedlings was found at undisturbed site. No current year's recruitment is noticed. The total weightage regeneration value of Kusum at disturbed sites was calculated as 23.00.

In case of *Madhuca latifolia*, no established tree having more than 2.5 m height was founds either at disturbed nor at undisturbed sites. Same trend was also observed in case of current year seedlings. The number of woody shoot (unbrowsed & browsed) was double at disturbed sites (2) than undisturbed site. Unbrowsed whippy seedlings three in number having more than 50 cm height was found only at disturbed site. But browsed whippy seedling was found double in disturbed site than undisturbed site. Similarly unbrowsed sub whippy seedlings having less than 50cm height were found only at disturbed site, but browsed sub-whippy was found more in disturbed. Overall, total weightage regeneration value of *Madhuca latifolia* was calculated as 17.75 and 5.50 for disturbed and undisturbed sites, respectively.

In case of *Buchanania lanzan*, no current year's seedling was found either at disturbed or undisturbed sites. The number of established crop was found more (3) at undisturbed site, than at disturbed sites (1). Similarly, the number of woody shoot (unbrowsed & browsed) was twice in number at undisturbed site than disturbed site. But in case of unbrowsed whippy seedlings, the number of seedlings was found three at disturbed sites and at undisturbed sites, it was only one. Same number of browsed whippy seedlings having less than 50 cm height was found at both the sites. The number of unbrowsed sub-whippy seedling having height less than 50 cm was found more at disturbed site than undisturbed site. Total weightage regeneration status of *Buchanania lanzan* was calculated as 19.25 and 28.50 for disturbed and undisturbed site, respectively.

In case of *Butea monosperma*, the number of established crop at disturbed sites was calculated as five, while at undisturbed site it was only three. The number of woody shoot (unbrowsed & browsed) at disturbed site was found more (seven) than at undisturbed sites (three). Some number of unbrowsed whippy & browsed whippy seedlings having heights greater or less than 50 cm was found at both the sites. Similar trend was also observed in case of unbrowsed Sub-whippy seedlings having height less than 50 cm. Over all, the weightage regeneration value of *Butea monosperma* was calculated as 73.75 and 48.75, for disturbed and undisturbed sites, respectively.

Mallotus philippinensis was found only at disturbed site only but its established crop and current year seedlings was absent in the sample plots. One woody shoot (unbrowsed & browsed) was observed in the sample area at disturbed site. The number of browsed whippy seedlings having height less than 50 cm was found as two, while one unbrowsed and three browsed sub-whippy seedling was found. Total weightage regeneration value was found as 7.25.

In case of Sal (*Shorea robusta)* total weightage value calculated for disturbed and undisturbed site was found as 91.75 and 149.50, respectively. The number of established crop of Sal at disturbed site was calculated as six, while at undisturbed site it is fourteen. In case of woody shoot (unbrowsed & browsed) the number was found also more at undisturbed sites (fifteen) than disturbed sites (eleven). Unbrowsed whippy seedling of *Shorea robusta* was found only one in number at disturbed site, but at undisturbed sites, it was found as seven. Browsed whippy seedling having height less than 50 cm was found only at disturbed sites. The number of unbrowsed sub-whippy seedling having height more than 50 cm was found double at undisturbed sites than its number on disturbed sites, however in case of browsed sub-whippy seedling having height less than 50 cm, reverse trend was observed.

As regards to *Bombax ceiba*, no current year seedlings was found neither at disturbed sites nor at undisturbed sites, but the number of established crop was calculated as only one at both the sites, respectively. The number of woody shoot (unbrowsed & browsed) was found double at disturbed sites than undisturbed sites. Similarly the number of unbrowsed whippy & browsed whippy seedling having height greater or less than 50 cm was found same at both the sites. In case of unbrowsed and browse sub whippy seedlings their number was also observed more disturbed sites than at undisturbed sites. Over all the regeneration status of *Bombax ceiba* was calculated as 29.75 and 21.00 for disturbed and undisturbed sites, respectively.

The percentage regeneration values calculated for all the selected tree species are given in Table- 4.12 along with regeneration status.

The percentage value for *Terminalia tomentosa* was found as 11.30 and 12.4 for disturbed and undisturbed sites, showing deficient regeneration at both the sites. The percentage regeneration value of *Syzyzium cuminii* was found as 7 and 4 respectively, there by giving deficient regeneration at both sites. The percentage regeneration of Kendu was found higher (20.6) at undisturbed site than disturbed site (18.1).

In case of Mahua, more regeneration percentage (71) was found at disturbed site. Based on regeneration percentage (9.2), the regeneration status of Kushum was recorded as deficient. However, in case of Piar and Sal more value was found as undisturbed site as 11.4 and 59.8 respectively. In case of Plash and Semal at disturbed site more value of regeneration percentage was observe, while in case of Rori recorded at only disturbed site it was found as 2.9.

Over all, highest value was found for Sal for both disturbed and undisturbed site. The regeneration status of *Terminalia tomentosa*, *Syzyzium cumini*, *Schleichera oleosa*, *Madhuca latifolia*, *Buchanania lanzan*, *Mallotus philippinensis* and *Bombax ceiba* was found deficient at both the sites. Fair regeneration status of *Diospyros melenoxylon* was observed at undisturbed sites and deficient at disturbed site, but in case of *Butea monosperma*, it was found fair at disturbed sites and deficient at undisturbed site. The regeneration status of *Shorea robusta* was found maximum at both the sites and it was fair at disturbed sites and moderate at undisturbed sites. The poor regeneration of many species under study was found due to soil as well as biotic disturbances.

Similar to present finding Chandra *et al.* (2001) have reported that natural regeneration in protected mixed forest area supports higher number of regenerated species (18 species) as compared to unprotected adjacent area (12 species). Natural regeneration is dominated by *Shorea robusta* (comprised 30.56% of total regeneration), *Chloroxylon swietenia* (14.44%) and *Dendrocalamus strictus* (11.67%) in comparison to unprotected area dominated by regeneration of *Acacia catechu* (12.5%), *Chloroxylon swietenia* (27.27%), *Diosphyros melanoxylon* (18.18%) and *Butea monosperma* (9.09%).

Gupta and Tripathy (1997) have found that the species like Kekar (*Garuga Pinnata*), Karam (*Adina cordifolia)*, Sidha (*Lagerstroemia parviflora*), Sal (*Shorea robusta*), Khair (*Acacia catechu*), Dhaura (*Anogeissus latifolia*), Gijan (*Lannea coromandelica*) etc., having better coppicing power, can be allowed to be exploited to meet the basic needs as well as to promote natural regeneration by stool coppice. The species like Kahua (*Terminalia arjuna*), Mahua (*Madhyca indica*) and other fruits bearing species may be left for soil cover to check soil erosion and to get seeds to promote natural regeneration by seedling, while fruit bearing species may be left for soil cover to check soil erosion and to get seeds to promote natural regeneration by seedling coppice.

Khan, et al. (1986) observed that in tropical dominated by Manglietia insignis, Pinus kesiya, Quercus dealbata, Quercus griffithii, Rhododendron arboreum, Schima khasiana and Prunus undulata and sub-tropical dominated by Artocarpus chaplasa, Duabanga sonneratoides and *Shorea robusta.* The Survival of seedlings and sprouts was higher at the forest periphery than under the dense canopy, signifying the role of light in forest regeneration**.** Although the seedling mortality occurred throughout the year, it was particularly high during winter season due to prevailing low temperature and high soil moisture stress. The sprouts, however, were less susceptible to adverse environmental conditions.

Bhatnagar (1959) found that intense competition between Sal and its associate species like Mallotus philippensis, Clerodendrum viscosum, and Murraya paniculata exists during the growth period of Sal seedlings thus affecting their regeneration.

Rao & Singh (1984) reported finding of regeneration of Sal *(Shorea robusta)* in two forest stands on the foot hills they found that in the old growth stand the regeneration was quite active from short seedlings (10 cm or less tall) to small sapling size class ‹ 50 cm tall and circumference at ground level 10 cm or less) but was arrested from this size class to large sapling size class (dbh more than 10 cm 30 cm).

Trivedi, (1990) reported that in moist alluvial high level Sal forests of Bihar, regeneration in general is poor, saplings being more or less absent. Excessive grazing is the main cause. In moist peninsular Sal forests of Singhbhum district, regeneration is normally abundant, practically in quality class III on middle slopes with a northerly aspect. In many areas it has been found spreading into dry mixed forests in the vicinity.

Dhawan *et al.* (2008) found concluded that due to global warming and intense *biotic pressure,* regeneration has found to be abnormal.

Biswas, *et al.* (2006) the found that lack in recruitment from regeneration of superior tree species may be attributable to the problem caused by human interference. Hence measures towards conservation of superior tree species through encouragement of natural recruitment from regeneration should be adopted while maintaining current trend of natural regeneration for inferior tree species in Idgaon Forest Reserve under Cox`s Bazar Forest Division of Bangladesh based on tree diameter class distribution.

4.6 Physico - Chemical Properties of the soil

The physical as well as chemical properties of the composite soil sample of biotically disturbed and undisturbed sites of Rarha Forest Area were calculated and presented in the table 4.11 and 4.12, respectively.

4.6.1 Physical parameter

The physical parameter such as texture, particle composition and water holding capacity of soils obtained from biotically disturbed and undisturbed site in shown in Table-4.13.

The texture of both the sites was found as sandy loam. As regards to particle composition, the percentage of silt and sand was found more at undisturbed site than disturbed areas. However in case of clay, a reverse trend was noticed. The percentage of sand at disturbed sites (68.88 to 78.88 %) was found at par with the Sand composition of undisturbed area (71.40 to 79.44 %). The silt percentage at both the sites varies highly significantly and its value was form 11.28 to 17.28 % at disturbed site, while 15.44 to 17.44 % undisturbed areas. Highly significant difference was also observed in case of clay composition of both the sites. The water holding capacity recorded for disturbed sites varied form 44.00 to 44.50 %. Differs highly significantly with respect to its value at undisturbed sites.

4.6.2 Chemical parameter

The chemical parameters in soils of biotically disturbed and undisturbed sites of Rarha Forest Area is presented in term of pH, Organic carbon (%), Available Nitrogen (kg/ha), Available Phosphorus (kg/ha) and Available Potassium (kg/ha) (Table-4.14).

The soil pH range of disturbed sites measured from 5 soil samples randomly was found more from 6.15 to 6.93 and was highly significant from its corresponding value of undisturbed sites (5.27 to 5.90). Similarly, the percentage Organic carbon (%) was also found more at undisturbed sites i.e. form 0.51 to 0.49, which also differed highly significantly from disturbed sites (from 0.44 to 0.46). The difference of available nitrogen between two sites (undisturbed and disturbed) was highly significant than phosphorus and potassium.

Similar to present findings Tewari, (2007) have studied the physical and chemical properties of the soils under different vegetative covers in Maldeota area of Mussoorie Forest Division, Uttarakhand (altitude 750 to 1,050m above msl). The results showed that range in pH was from 6.0 to 8.2, while water holding capacity varied from 28.9 to 60.7. Organic matter content was generally high with maximum accumulation in the surface horizon.

Mishra *et al.* (2000) found that the maximum accumulation of organic matter noticed on NE aspect (average value 1.51± 0.61%) due to occurrence of mature Sal stand.

Similar to the present study Paudel and Sah (2003) studied the physiochemical properties of soils of two different types of forests (pure *Shorea robusta* and mixed *Shorea robusta* forest) and represent that in both the pure and mixed forest, soil was sandy loam (60.12% and 50.58% sand, 28.59% and 35.24% silt and 11.12 and 22.41% clay, respectively). The pH value was lower in pure forest (4.33) than in the mixed forest (5.26), and so were phosphorus and water holding capacity. The higher values of humus, organic matter, nitrogen and potassium (7.34%, 2.42%, 0.117%, 267.73 kg/ha, respectively) were found in pure forest.

Srivastava, (1972) observad that the maximum height growth, foliage development and uptake of potassium and phosphorus of Sal was at 37 % moisture and at 85 % of the water-holding capacity, but it did not with stand water logged condition because of bad soil aeration.

SUMMARY AND CONCLUSION

5.1 Summary

The present investigation entitled "Growth of biotically disturbed and undisturbed forest at Rarha of Ranchi East Forest Division." was carried out in Rarha Forest area. Earlier it was degraded Sal forest area but by the efforts of the Forestry Faculty the area has resulted into Sal forest of approximately 25 years age. In this forest various species belonging to Tree, Herb, Shrub and climber were studied by laying out sample plots in biotically disturbed site and in undisturbed site.

The data on total number of species, total number of individual species, basal diameter (in case of shrub, herb and climber), diameter at breast height (d.b.h), total height, top height, top diameter, form quotient and regeneration status of economically impotent tree species were recorded (both the sites biotically disturbed and undisturbed sites). The plant diversity was represented by presence of a total 73 species belonging to 51 on disturbed site (species to tree -16, shrub-8, herb-19 and climber-8) and 67 on undisturbed site (tree-15, shrub-8, herb-31 and climber-13). The 73 plant species was found distributed among 35 families. On disturbed site the distribution of trees, shrubs, herbs and climers was found in 13, 7, 14 and 7, respectively. Similarly on undisturbed site trees, shrubs, herbs and climbers, were found distributed in 14, 5, 19, and 8 respectively. The maximum number of species belonged to both the sites in the family Papilonaceae.

Among tree species density, frequency and abundance was maximum for Sal (S*horea robusta*) on both the site i.e. 4.16 ha^{-1}, 88% and 4.72 ha^{-1} for disturbed and 10.48 ha^{-1}, 100% and 10.48 ha^{-1} for undisturbed site respectively. The Relative Dominance (RD) was also maximum for Sal (*Shorea robusta*) at biotically disturbed (29.35) and undisturbed (57.25) respectively.

The Abundance/Frequency ratio indicated random distribution (A/F value between 0.025 to 0.050) in case of Kendu, Palash and Sal at disturbed site, while, at undisturbed sites random distribution was found in case of Kendu only. In rest of the species available at both the sites, contagious (when A/F value >0.050) distribution was observed.

At biotically disturbed site maximum average diameter was recorded for Semal (13.67 cm) and at undisturbed site maximum average diameter was recorded for Sal (18.85 cm). The tree species such as Asan (*Terminalia tomentosa*), Kendu (*Diospyros melenoxylon*), Mahua (*Madhuca latifolia*), Palash (*Butea monosperma*) and Sal (*Shorea robusta*) have shown highly significant average diameter at undisturbed sites as compared to disturbed sites. Maximum top diameter was found for Semal (16.20 cm) at disturbed site, while on undisturbed site maximum top diameter was recorded for Asan (15.26).

The maximum average height (13.56m) was noticed for Jamun (*Syzyzium cumini*) in biotically disturbed site while for Sal (*Shorea robusta*) maximum value (17.86 m) was found at undisturbed site. The average height of Jamun (*Syzyzium cumini*) and Semal *(Bombax ceiba*) was found highly significant at distured site than undisturbed sites. At disturbed site maximum top height was observed in case of Jamun (15.50m), while at undisturbed site maximum top height was for Sal (20.41 m).

The maximum form quotient value was observed for Kushum (*Schleichera oleosa*) as 0.90 at disturbed site. However at undisturbed site, maximum form quotient (0.90) of Sal (*Shorea robusta*) was observed. There findings indicated cylindrical form of Kushum and Sal.

Maximum basal area of Sal (*Shorea robusta*) was found for both biotically disturbed (2.45 sq. m/ha) and undisturbed sites (14.98 sq. m/ha). Similarly total volume and actual volume of Sal (*Shorea robusta*) was found maximum at biotically distured site as 33.17 cu. m/ha and 268.90 cu. m/ha, respectively, while on undisturbed site it was 29.18 cu. m/ha and 242.01 cu. m/ha respectively.

On disturbed site, among the ten economically important tree species Sal (*Shorea robusta*) has shown fair regeneration (36.7%), while Palash (*Butea monosperma*) on disturbed sites as fair regeneration (29.5%). However, moderate and fair regeneration of Sal (59.8 %) and Kendu (20.6%) was found at undisturbed sites.

The soil texture of both the sites (disturbed and undisturbed) was found as sandy loam. Percentage of silt and sand was found more at undisturbed site than disturbed sites. However, in case of clay, a reverse trend was noticed. The water holding capacity on disturbed site varied form 44.00 to 45.50%, while on undisturbed sites its value were from 45.50% to 46.50%. Higher soil pH was found for disturbed site. Similarly, organic carbon percentage was also found more at undisturbed site. The difference of between available Nitrogen of two sites (undisturbed and disturbed) was highly significant than Phosphorus and Potassium.

5.2 Conclusion

1. At Rarha forest area species composition is represented by a total of 73 species belong to 35 families. Out of these, tree was represented by 16 species, shrub layer by 8, herb layer by 19 and

climber by 8 species at biotically disturbed site, while at undisturbed site tree is represented by 15 species, shrub layer by 8 species, herb layer by 31 and climber by 13 species.

2. At both the sits (biotically disturbed and undisturbed site) maximum species belong to papilonaceae family.

3. Sal (*Shorea robusta*) showed highest density among tree species at biotically disturbed and undisturbed site.

4. Frequency and abundance value of Sal (*Shorea robusta*) tree was also found highest among ten economically important group of tree at both the disturbed site and undisturbed site.

5. Relative dominance of Sal (*Shorea robusta*) was highest at both the sites.

6. Maximum average diameter of Semal (*Bombax ceiba*) was at disturbed site and for Sal (*Shorea robusta*) was on undisturbed site among all the species.

7. The top diameter of Semal (*Bombax ceiba*) was maximum at disturbed site while Sal (*Shorea robusta*) it was maximum on undisturbed site.

8. The average height of Jamun (*Syzyzium cumini*) at disturbed site while for Sal (*Shorea robusta*) it was on undisturbed site.

9. Jamun (*Syzyzium cumini*) showed maximum top height at disturbed site where as Sal (*Shorea robusta*) gave maximum value at undisturbed site.

10. Form quotient of Kushum (*Schleichera oleosa*) at biotically disturbed site was maximum, while at undisturbed site, it was maximum for Sal (*Shorea robusta*).

11. Highly Significant difference in total volume production of Sal (*Shorea robusta*) at biotically disturbed (33.17 cu. m/ha) and undisturbed site (268.90 cu. m/ha) is observed.

12. The regeneration status of Sal (*Shorea robusta*) was fair at biotically disturbed site and moderate on undisturbed site, while for other species it varies form 36.7% to 59.8%.

13. The physical characteristics of soil has indicated Sandy loam texture on both the sites (disturbed and undisturbed). The particle percentage of Silt (68.88% to 78.88%) and Sand (71.41% to 79.44%) was more at undisturbed site than disturbed sites. Highly significant difference was also observed in case of clay composition of both the sites. The water holding capacity differs highly significant with respect to the undisturbed site.

14. Higher soil pH was found for disturbed sites.

15. Percentage organic carbon (%) on disturbed site differed highly siginificantly than undisturbed sites. Similarly available Nitrogen between two sites was highly significant than Phosphorus (P_2O_5) and Potassium (K_2O).

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Annexure– I

Location of sample plots at biotically disturbed and undisturbed sites at Rarha forest area.

Plot-No.	Disturbed Site	Undisturbed Site
1	Elevation-535m, Location-N23^0 33.544' E 085$^{0.}$18.00'	Elevation-629m,Location- N23^0 33. 186' E 085$^{0.}$17
2	Elevation-537m, Location-N23^0 33.541' E 085$^{0.}$18.00'	Elevation-621m Location-N23^0 33.189' E 085$^{0.}$17.899'
3	Elevation-538m, Location-N23^0 33.550' E 085$^{0.}$18.012'	Elevation-610m Location-N23^0 33.190' E 085$^{0.}$17.883'
4	Elevation-539m, Location-N23^0 33.556' E 085$^{0.}$18.011'	Elevation-600m Location-N23^0 33.201' E 085$^{0.}$17.876'
5	Elevation-541m, Location-N23^0 33.542' E 085$^{0.}$18.00'	Elevation-591m Location-N23^0 33.202' E 085$^{0.}$17.858'
6	Elevation-542m, Location-N23^0 33.543' E 085$^{0.}$18.23'	Elevation-612m, Location-N23^0 33.204' E 085$^{0.}$17.887'
7	Elevation-544m, Location-N23^0 33.545' E 085$^{0.}$17·992'	Elevation-613m, Location-N23^0 33.206' E 085$^{0.}$17.889'
8	Elevation-546m, Location-N23^0 33.545' E 085$^{0.}$17·994'	Elevation-614m, Location-N23^0 33.208' E 085$^{0.}$17.890'
9	Elevation-548m, Location-N23^0 33.548' E 085$^{0.}$17·996'	Elevation-615m, Location-N23^0 33.209' E 085$^{0.}$17.892'
10	Elevation-545m, Location-N23^0 33.549' E 085$^{0.}$17·973'	Elevation-616m, Location-N23^0 33.210' E 085$^{0.}$17.893'
11	Elevation-549m, Location-N23^0 33.550' E 085$^{0.}$17·972'	Elevation-617m, Location-N23^0 33.212' E 085$^{0.}$17.894'
12	Elevation-551m, Location-N23^0 33.552' E 085$^{0.}$17·973'	Elevation-618m, Location-N23^0 33.215' E 085$^{0.}$17.895'
13	Elevation-552m, Location-N23^0 33.553' E 085$^{0.}$17·992'	Elevation-621m, Location-N23^0 33.217' E 085$^{0.}$17.896'
14	Elevation-553m, Location-N23^0 33.554' E 085$^{0.}$17·997'	Elevation-622m, Location-N23^0 33.218' E 085$^{0.}$17.897'
15	Elevation-555m, Location-N23^0 33.556' E 085$^{0.}$17·998'	Elevation-624m, Location-N23^0 33.219' E 085$^{0.}$17.898'
16	Elevation-557m, Location-N23^0 33.557' E 085$^{0.}$17·992'	Elevation-625m, Location-N23^0 33.220' E 085$^{0.}$17.899'
17	Elevation-558m, Location-N23^0 33.558' E 085$^{0.}$17·998'	Elevation-626m, Location-N23^0 33.222' E 085$^{0.}$17.924'
18	Elevation-559m, Location-N23^0 33.559' E 085$^{0.}$17·999'	Elevation-627m, Location-N23^0 33.224' E 085$^{0.}$17.925'
19	Elevation-560m, Location-N23^0 33.560' E 085$^{0.}$18.008'	Elevation-626m, Location-N23^0 33.225' E 085$^{0.}$17.926'
20	Elevation-563m, Location-N23^0 33.562' E 085$^{0.}$18.017'	Elevation-628m, Location-N23^0 33.225' E 085$^{0.}$17.928'
21	Elevation-565m, Location-N23^0 33.563' E 085$^{0.}$18.022'	Elevation-629m, Location-N23^0 33.226' E 085$^{0.}$17.932'
22	Elevation-568m, Location-N23^0 33.564' E 085$^{0.}$18.022'	Elevation-630m, Location-N23^0 33.227' E 085$^{0.}$17.933'
23	Elevation-569m, Location-N23^0 33.565' E 085$^{0.}$18.013'	Elevation-591m, Location-N23^0 33.186' E 085$^{0.}$17.911'
24	Elevation-572m, Location-N23^0 33.567' E 085$^{0.}$18.013'	Elevation-592m, Location-N23^0 33.177' E 085$^{0.}$17.12'

25	Elevation-574m, LocationN23^0 33.569’ E 085$^{0.}$18.024’	Elevation-539m, Location-N23^0 33.165’ E 085$^{0.}$17.14’
26	Elevation-576m, Location-N23^0 33.570’ E 085$^{0.}$18.011’	Elevation-600m, Location-N23^0 33.153’ E 085$^{0.}$17.15’
27	Elevation-579m, Location-N23^0 33.571’ E 085$^{0.}$18.026’	Elevation-542m, Location-N23^0 33.187’ E 085$^{0.}$17.16’
28	Elevation-582m, Location-N23^0 33.572’ E 085$^{0.}$18.027’	Elevation-544m, Location-N23^0 33.098’ E 085$^{0.}$17.18’
29	Elevation-583m, Location-N23^0 33.573’ E 085$^{0.}$18.027’	Elevation-546m, Location-N23^0 33.084’ E 085$^{0.}$17.19’
30	Elevation-554m, Location-N23^0 33.574’ E 085$^{0.}$18.012’	Elevation-548m Location-N23^0 33.085’ E 085$^{0.}$17.21’
31	Elevation-556m, Location-N23^0 33.575’ E 085$^{0.}$18.026’	Elevation-549m, Location-N23^0 33.086’ E 085$^{0.}$17.23’
32	Elevation-564m, Location-N23^0 33.576’ E 085$^{0.}$18.012’	Elevation-552m, Location-N23^0 33.089’ E 085$^{0.}$17.934’
33	Elevation-567m, Location-N23^0 33.578’ E 085$^{0.}$18.014’	Elevation-554m, Location-N23^0 33.092’ E 085$^{0.}$17.935’
34	Elevation-573m, Location-N23^0 33.579’ E 085$^{0.}$18.014’	Elevation-562m, Location-N23^0 33.093’ E 085$^{0.}$17.936’
35	Elevation-584m, Location-N23^0 33.580’ E 085$^{0.}$17·992’	Elevation-564m, Location-N23^0 33.094’ E 085$^{0.}$17.935’
36	Elevation-586m, Location-N23^0 33.590’ E 085$^{0.}$17·992’	Elevation-567m, Location-N23^0 33.095’ E 085$^{0.}$17.937’
37	Elevation-589m, Location-N23^{0}33. 590’ E 085$^{0.}$17·992’	Elevation-568m, Location-N23^0 33.097’ E 085$^{0.}$17.938’
38	Elevation-593m, Location-N23^{0}33. 590’ E 085$^{0.}$17·994’	Elevation-569m, Location-N23^0 33.098’ E 085$^{0.}$17.39’
39	Elevation-591m, Location-N23^{0}33. 595’ E 085$^{0.}$18.027’	Elevation-572m, Location-N23^0 33.103’ E 085$^{0.}$17.42’
40	Elevation-585m, Location-N23^{0}33. 597’ E 085$^{0.}$18..26’	Elevation-610m, Location-N23^0 33.105’ E 085$^{0.}$17.41’
41	Elevation-594m, Location-N23^{0}33. 598’ E 085$^{0.}$17·992’	Elevation-611m, Location-N23^0 33.107’ E 085$^{0.}$17.857’
42	Elevation-595m, Location-N23^{0}33. 621’ E 085$^{0.}$18.012’	Elevation-631m, Location-N23^0 33.112’ E 085$^{0.}$17.862’
43	Elevation-596m, Location-N23^{0}33. 623’ E 085$^{0.}$18.013’	Elevation-632m, Location-N23^0 33.113’ E 085$^{0.}$17.864’
44	Elevation-597m, Location-N23^{0}33. 626’ E 085$^{0.}$17·992’	Elevation-633m, Location-N23^0 33.114’ E 085$^{0.}$17.865’
45	Elevation-598m, Location-N23^{0}33. 628’ E 085$^{0.}$18.014’	Elevation-634m, Location-N23^0 33.115’ E 085$^{0.}$17.867’
46	Elevation-599m, Location-N23^{0}33. 632’ E 085$^{0.}$17·975’	Elevation-635m, Location-N23^0 33.116’ E 085$^{0.}$17.868’
47	Elevation-567m, Location-N23^{0}33. 634’ E 085$^{0.}$17·965’	Elevation-638m, Location-N23^0 33.118’ E 085$^{0.}$17.869’
48	Elevation-578m, Location-N23^{0}33. 635’ E 085$^{0.}$17·035’	Elevation-649m, Location-N23^0 33.119’ E 085$^{0.}$17.873’
49	Elevation-568m, Location-N23^{0}33. 636’ E 085$^{0.}$17·973’	Elevation-640m, Location-N23^0 33.220’ E 085$^{0.}$17.874’
50	Elevation-579m, Location-N23^{0}33. 626’ E 085$^{0.}$17·968’	Elevation-641m, Location-N23^0 33.221’ E 085$^{0.}$17.875’

IMPLICATION OF THE RESULT

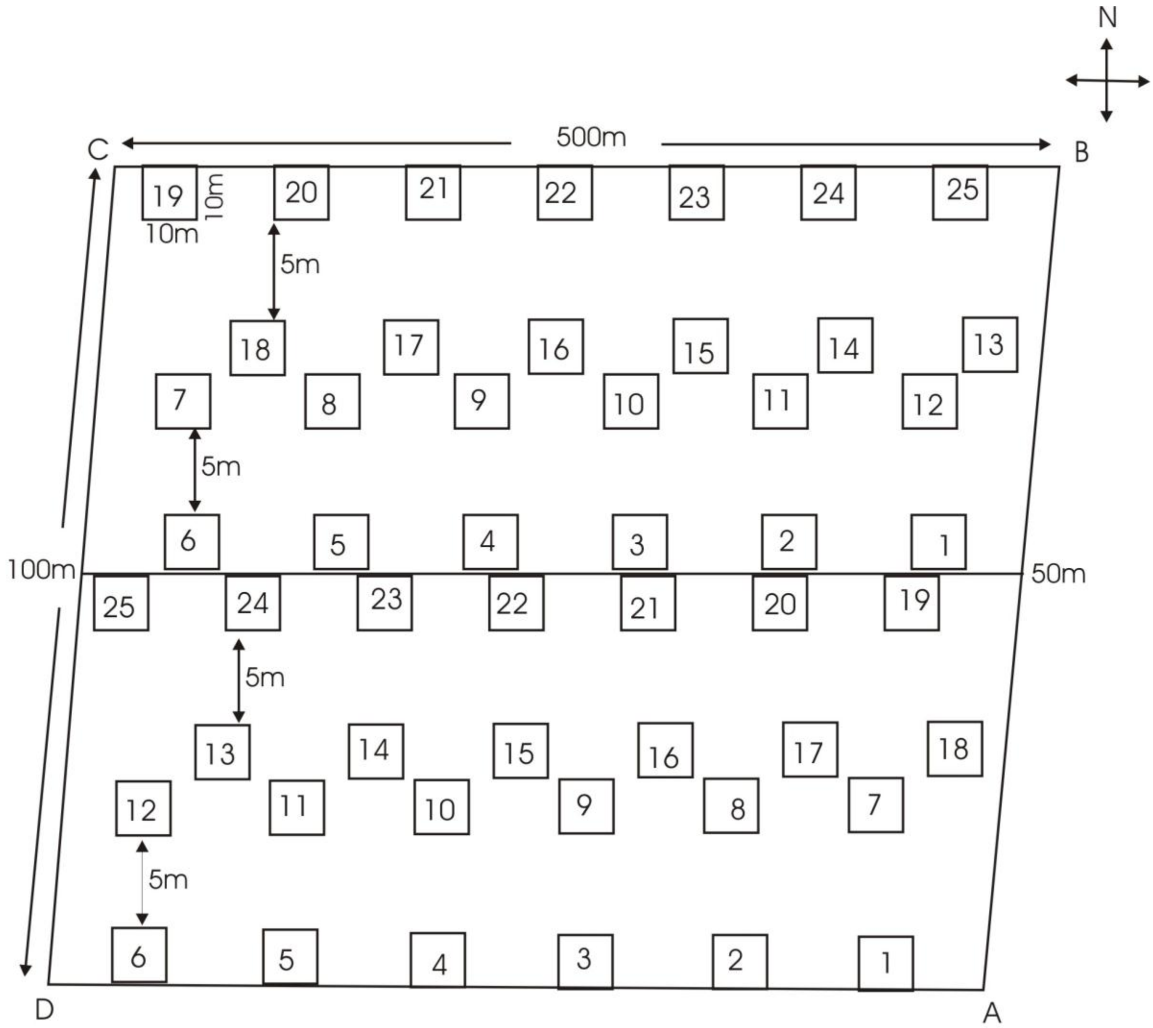
The findings of present study has guided to adopt protection measures for conservation of plant biodiversity in disturbed forest areas by means of avoidance of human and livestock entrances in these areas. Similar studies conducted on other areas will help to survey the area and to enlist complete plant spectrum of the area.

Biotically disturbed site

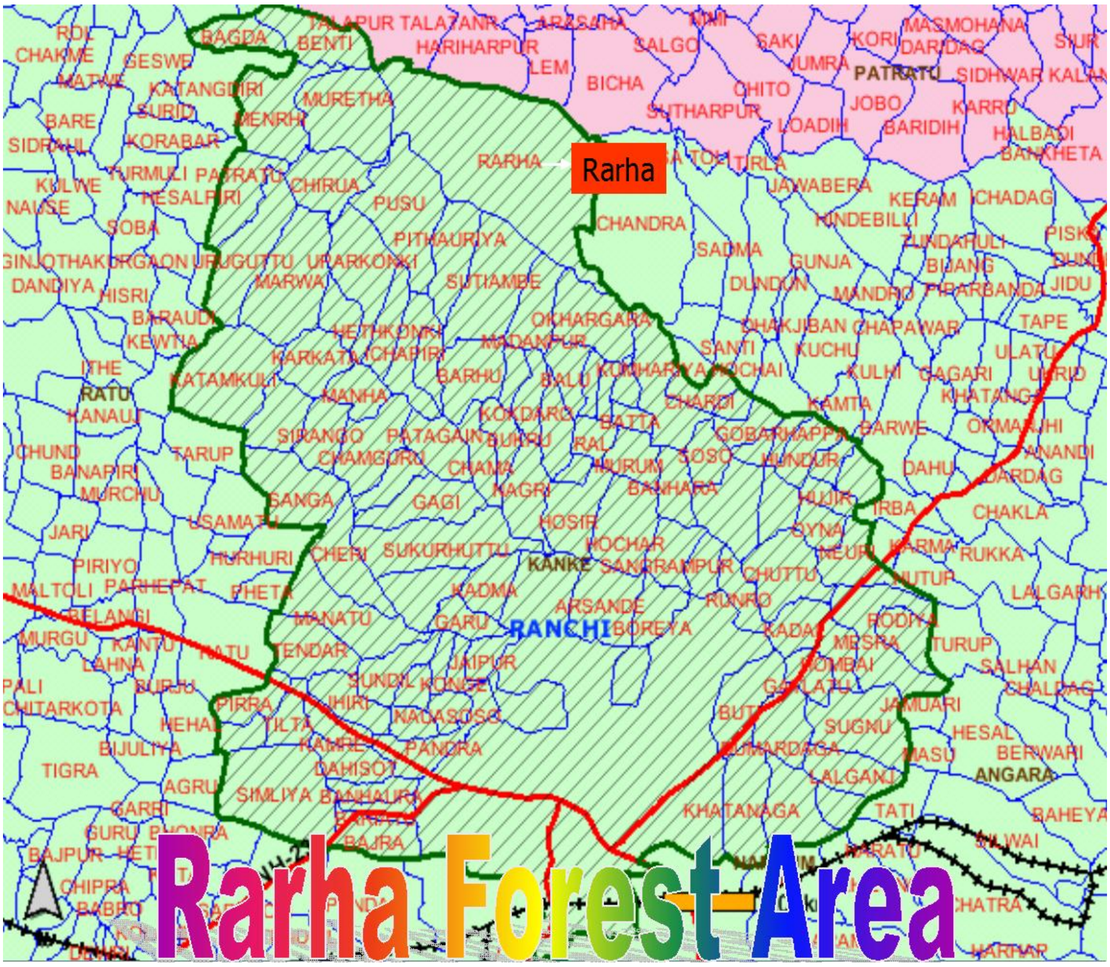
Biotically disturbed site

Biotically undisturbed site

Biotically undisturbed site



Lay out of sample plots for data collection in
disturbed and undisturbed sites


Rarha
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CHANDRA
PITHAURIYA
SUTIAMBE
MADANPUR
OKHARGARA
BICHA
SUTHARPUR
CHAKLA
LALGARH
TIGRA
Rarha Forest Area

Table-3.1: Monthly meteorological data for the year 2009.

Sl. No.	Month	Temperature (^0C)				Rel. Humidity (%)		Av Wind Speed (Km/hr)	Total Sun Shine Hrs	Rainfall (mm)			Total Evaporati on (mm)
		Av. Max.	**Max. (Date)**	**Av. Min**	**Min. (Date)**	**7:00 AM**	**2:00 PM**			**Total**	**No. of. rainy days**	**Cum. Rain.**	
1	Jan.'09	24.5	30.2(27th)	8.1	4.4(17th)	88.5	50.9	3.6	245.3	1.8	0	1.8	123.3
2	Feb.'09	28.2	31.6(28th)	8.9	4.4(3rd)	86.8	42.5	4.3	276.1	0.0	0	1.8	143.0
3	Mar.'09	31.9	35.3(30th)	13.5	8.2(13th)	84.8	34.9	5.1	256.6	5.6	1	7.4	210.5
4	Apr.'09	35.5	40.8(29th)	17.9	13.9(2nd &12th)	77.8	40.2	6.0	295.7	2.6	1	10.0	261.9
5	May.'09	35.6	41.2(3rd)	21.4	17.8(13th)	79.4	47.6	6.3	251.8	132.7	10	142.7	254.7
6	Jun.' 09	36.2	41.1(24th)	23.0	19.0(9th)	80.1	43.8	5.3	249.0	40.5	8	183.2	287.7
7	Jul.'09	30.0	38.4(12th)	22.6	21.4(22nd)	87.6	66.5	5.5	83.5	267.8	18	451.0	176.5
8	Aug.'09	29.9	33.0(5th)	22.7	20.8(23rd)	86.8	74.7	5.0	106.4	256.4	16	707.4	171.0
9	Sep.'09	29.8	32.2(1st)	19.4	18.1(29th)	92.1	69.5	3.9	203.3	430.2	14	1137.6	143.4
10	Oct.'09	28.0	29.8(21st)	15.4	8.5 (28th)	86.9	62.1	3.5	244.7	86.0	7	1223.6	160.6
11	Nov.'09	25.7	30.0(12th)	12.1	5.0(29th)	88.2	63.9	2.6	226.5	15.6	3	1239.2	122.7
12	Dec.'09	23.4	25.9(17th)	7.2	3.6(24th)	87.2	59.3	2.6	262.8	9.6	1	1248.8	110.9

Table 3.2: Methodologies for measurement of physico-chemical property of soil

A. Physical properties -		
Sl.No.	**Particulars**	**Methods used**
1	Soil Texture	The soil particle size distribution in the collected soil sample was determined by Bouyocicous Hydrometer method (Bouyoucos, 1927)
2	Water Holding Capacity	Water holding capacity is determined by means of keen box as described by Soil Survey Manual IARI (1960).
B. Chemical properties -		
1	Soil pH	Determined by using electronic pH meter in soil water suspension prepared in the ratio of 1:2.5 (W/V).
2	Organic Matter	First of all Organic Carbon is determined by rapid titration method of Jackson (1967). The Organic Carbon is then converted into percent by multiplying with the factor 1.728.
3	Available Nitrogen (N_2)	Determined by Alkaline Permanganate Method of Subbiah and Asija (1956). The available nitrogen is expressed in terms of **Kg ha^{-1}**
4	Available Phosphorus (P_2O_5)	Determined colorimetrically in Spectrophotometer using dilute H_2SO_4 for dissolving soil sample and Stannous Chloride & Ammonium sulpho-molybdate as colour developing reagents of colour developing reagent of Jackson (1967). The available P_2O_5 is expressed in terms of **Kg ha^{-1}**.
5	Available Potassium (K_2O)	Determined by Flame photometer in soil solution prepared in extraction solution of normal Ammonium acetate (pH 7.0) in ratio of 1:5 (W/V), as per Jackson (1967). The available K_2O is expressed in terms of Kg ha^{-1}.

Table-4.1: Species composition of biotically disturbed and undisturbed sites of Rarha Forest Area.

Sl. No.	Common Name	Botanical Name	Disturbed Site	Undisturbed Site
Tree -				
1	Amaltas	*Cassia fistula*	+	-
2	Aasan	*Terminalia tomentosa*	+	+
3	Gamhar	*Gmelina arborea*	+	+
4	Jamun	*Syzyzium cumini*	+	+
5	Kala siris	*Albizia lebbek*	-	+
6	Kendu	*Diospyros melanoxylon*	+	+
7	Kushum	*Schleichera oleosa*	+	-
8	Mahua	*Madhuca latifolia*	+	+
9	Piar	*Buchanania lanzan*	+	+
10	Palash	*Butea monosperma*	+	+
11	Rori	*Mallotus philippinensis*	+	-
12	Sal	*Shorea robusta*	+	+
13	Semal	*Bombax ceiba*	+	+
14	Sidha	*Lagerstroemia parviflora*	+	-
15	Aamla	*Embilica officinalis*	+	+
16	Bahera	*Terminalia belerica*	+	+
17	Bara jirhul	*Sophora bakeri*	-	+
18	Dhaunta	*Anogeissus latifolia*	+	+
19	Harre	*Terminalia chebula*	-	+
Shrub -				
1	Beri	*Casearia tomentosa*	+	+
2	Bhabri	*Embelia robusta*	-	+
3	Doka	*Odina wodier*	+	+
4	Karond	*Carissa opeca*	+	+
5	Lodh	*Symplocos racemosa*	+	+
6	Matta	*Antidesma diandrum*	-	+
7	Pituar	*Zizyphus regosa*	+	-
8	Putri	*Croton oblongifolius*	+	+
9	Ratangaura	*Elaeodendron glaucum*	+	+
10	Rendi	*Casearia graveolens*	+	-
Herb -				
1	Ban Chalita	*Lea crispa*	-	+
2	Ban Kurthi	*Atylosia scarabaeoides*	-	+
3	Ban Tulsi	*Perilla ocimoides*	+	+
4	Banhardi	*Curcuma amada*	+	+
5	Banpiyaj	*Alliums spp*	+	+
6	Bariar	*Sida cordifolia*	-	+
7	Bharangi	*Clerodendron siphonanthus*	-	+

8	Bhuichappa	*Kaempferia rotunda*	+	+
9	Chirchiri	*Achyranthes aspera*	+	+
10	Dub-grass	*Cynodon dactylon*	+	+
11	Dudhi	*Cryptolapis buchanani*	+	+
12	Galphuli	*Flemingia chappar*	-	+
13	Ghanto	*Clerodendron infortunatum*	+	+
14	Hadpat	*Justicia betonica*	-	+
15	Handiphuta	*Pueraria tubcrosa*	+	+
16	Jhumki	*Sida veronicaefolia*	+	+
17	Jhunjhunia	*Vernonia cinerea*	-	+
18	Jirahul	*Indigophera pulchella*	+	+
19	Karjani	*Abrus precatorious*	+	+
20	Kher-grass	*Heteropogon contortus*	+	+
21	Khijur	*Phoenix acaulis*	-	+
22	Koraiya	*Wrightia tomentosa*	+	+
23	Kukurand	*Ageratum conyzoides*	+	+
24	Lajwanti	*Mimosa pudica*	+	+
25	Latlatia	*Cardiospermum halicacabum*	+	+
26	Mauna	*Casearia tomentosa*	-	+
27	Mirubaha	*Abutilon indicum*	-	+
28	Motha-grass	*Cyprus rotundus*	+	+
29	Premjori	*Crotolaria striata*	+	+
30	Sabai-grass	*Pollinidium angustifolium*	-	+
31	Siarkucchi	*Argemone mexicana*	-	+
Climber -				
1	Barbati	*Vigna catjang*	-	+
2	Bilaikand	*Ipomea digitata*	-	+
3	Dudhialar	*Cryptolepis buchanani*	+	+
4	Getilar	*Dioscorea belophylla*	-	+
5	Hasualar	*Porana paniculata*	+	+
6	Kalmi Lata	*Rivea hypocrateriformis*	-	+
7	Karjanilar	*Abrus precatorius*	+	+
8	Kujri Lar	*Celastrus paniculata*	+	+
9	Kundarilar	*Cephalandra indica*	+	+
10	Maholan	*Bauhinia vahlii*	+	+
11	Panlati	*Vitis repanda*	-	+
12	Ramdatoon	*Smilex macrophylla*	+	+
13	Satawar	*Asparagus racemosus*	+	+

+ Presence

- Absence

Table 4.2: Taxonomic distribution of plant species in different plant families of biotically disturbed and undisturbed sites at Rarha Forest Area

Sl. No.	Family Name	Disturbed site					Undisturbed site				
		Tree	Shrub	Herb	Climber	Total	Tree	Shrub	Herb	Climber	Total
1	Ampelidaceae	_	_	_	_	_	_	1	1	_	2
2	Papilonaceae	1	_	4	1	6	2	_	5	2	9
3	Labiatae	_	_	1	_	1	_	_	1	_	1
4	Zingiberaceae	_	_	2	_	2	_	_	2	_	2
5	Liliaceae	_	_	1	2	3	_	_	1	2	3
6	Malvaceae	1	_	1	_	2	1	_	3	_	4
7	Verbenaceae	1	_	1	_	2	1	_	2	_	3
8	Amarantaceae	_	_	1	_	1	_	_	2	_	2
9	Gramineae	_	_	2	_	2	_	_	3	_	3
10	Asclepidaceae	_	_	1	1	2	_	_	2	1	3
11	Acanthaceae	_	_	_	1	1	_	_	1	1	2
12	Compositeae	_	_	1	_	1	_	_	2	_	2
13	Palmaceae	_	_	_	_	_	_	_	1	_	1
14	Apocynaceae	_	1	1	_	2	_	1	1	_	2
15	Mimosaceae	_	_	1	_	1	1	_	1	_	2
16	Sapindaceae	1	_	1	_	2	_	_	1	_	1
17	Flacourtiaceae	_	2	_	_	2	_	1	1	_	1
18	Cyperaceae	_	_	1	_	1	_	_	1	_	1
19	Papaveraceae	_	_	_	_	_	_	_	1	_	1
20	Convolulaceae	_	_	_	1	1	_	_	_	3	3
21	Dioscoreaceae	_	_	_	_	_	_	_	_	1	1
22	Cucurbitaceae	_	_	_	1	1	_	_	_	1	1
23	Caesalpiniaceae	1	_	_	1	2	_	_	_	1	1
24	Combretaceae	3	_	_	_	3	4	_	_	_	4
25	Myritaceae	1	_	_	_	1	1	_	_	_	1
26	Ebenaceae	1	_	_	_	1	1	_	_	_	1
27	Sapotaceae	1	_	_	_	1	1	_	_	_	1
28	Anacardiaceae	1	1	_	_	2	1	1	_	_	2
29	Euphorbiaceae	2	1	_	_	3	1	2	_	_	3
30	Dipterocarpaceae	1	_	_	_	1	1	_	_	_	1
31	Lythraceae	1	_	_	_	1		_	_	_	_
32	Myrsinaceae	_	_	_	_	_	1	_	_	_	1
33	Styraceae	_	1	_	_	1	1	_	_	_	1
34	Rhamnaceae	_	1	_	_	1		_	_	_	_
35	Celastraceae	_	1	_	_	1	1	_	_	_	1
Total		**16**	**8**	**19**	**8**	**51**	**18**	**6**	**32**	**12**	**67**

Table 4.3: Density, Frequency and Abundance of economically important tree species at biotically disturbed and undisturbed sites at Rarha Forest Area

Sl. No.	Botanical Name	Density (ha^{-1})		Frequency (%)		Abundance (ha^{-1})	
		Disturbed Site	Undisturbed Site	Disturbed Site	Undisturbed Site	Disturbed Site	Undisturbed Site
1	*Terminalia tomentosa*	0.28	0.32	12	16	2.33	2.00
2	*Syzyzium cuminii*	0.32	0.24	16	12	2.00	2.00
3	*Diospyros melenoxylon*	1.36	0.96	52	46	2.61	2.08
4	*Schleichera oleosa*	0.12	-	6	-	2.00	-
5	*Madhuca latifolia*	0.56	0.36	28	18	2.00	2.00
6	*Buchanania lanzan*	0.24	0.24	12	10	2.00	2.40
7	*Butea monosperma*	1.60	0.64	62	28	2.58	2.28
8	*Mallotus philippinensis*	0.20	-	10	-	2.00	-
9	*Shorea robusta*	4.16	10.48	88	100	4.72	10.48
10	*Bombax ceiba*	0.56	0.64	28	30	2.00	2.13

Table 4.4: Relative dominance and Importance Value Index of economically important tree species of biotically disturbed and undisturbed sites at Rarha Forest Area

Sl. No.	Common Name	Botanical Name	Relative Dominance (%)		Importance Value Index (IVI)	
			Disturbed Site	Undisturbed Site	Disturbed Site	Undisturbed Site
1	Asan	*Terminalia tomentosa*	5.17	4.83	11.97	13.29
2	Jamun	*Syzyzium cuminii*	5.17	4.43	13.67	10.78
3	Kendu	*Diospyros melenoxylon*	12.06	8.87	43.09	33.47
4	Kushum	*Schleichera oleosa*	1.72	-	4.91	-
5	Mahua	*Madhuca latifolia*	9.77	6.85	24.64	16.36
6	Piar	*Buchanania lanzan*	3.44	2.01	9.81	7.59
7	Palash	*Butea monosperma*	18.96	7.66	55.73	23.04
8	Rori	*Mallotus philippinensis*	2.87	-	8.18	-
9	Sal	*Shorea robusta*	29.31	57.25	101.6	171.21
10	Semal	*Bombax ceiba*	11.49	8.06	26.37	24.21

Table 4.5: Average diameter (cm) of economically important tree species of biotically disturbed and undisturbed sites at Rarha Forest Area

Sl. No.	Botanical Name	Mean		S. D.		CV %		*t*
		Disturbed Site	Undisturbed Site	Disturbed Site	Undisturbed Site	Disturbed Site	Undisturbed Site	
1	*Terminalia tomentosa*	5.49	12.26	*7.52*	*7.40*	*136.93*	*60.36*	*7.19***
2	*Syzyzium cuminii*	12.54	12.56	*0.83*	*8.90*	*6.67*	*70.91*	*0.01*
3	*Diospyros melenoxylon*	10.04	11.22	*1.00*	*0.78*	*10.04*	*7.03*	*10.35***
4	*Schleichera oleosa*	7.60	-	*6.98*	-	*91.86*	-	*12.21***
5	*Madhuca latifolia*	12.80	15.86	*0.54*	*3.27*	*4.28*	*20.67*	*10.32***
6	*Buchanania lanzan*	7.38	9.18	*6.79*	*5.23*	*92.02*	*57.03*	*2.35**
7	*Butea monosperma*	11.55	13.22	*0.44*	*3.40*	*3.86*	*25.77*	*5.46***
8	*Mallotus philippinensis*	4.78	-	*6.56*	-	*137.37*	-	*8.17***
9	*Shorea robusta*	12.15	18.95	*0.52*	*1.00*	*4.30*	*5.32*	*67.14***
10	*Bombax ceiba*	13.67	13.24	*0.97*	*2.28*	*7.14*	*17.27*	*1.82*

t value for 8 df at 5% - 2.306, t value for 8 df at 1% - 3.355

Table 4.6: Top diameter parameters of economic tree species of biotically disturbed and undisturbed sites at Rarha Forest Area.

Sl. No.	Common Name	Botanical Name	Top Diameter (cm)	
			Disturbed Site	Undisturbed Site
1	Assan	*Terminalia tomentosa*	15.26	17.50
2	Jamun	*Syzyzium cuminii*	13.50	21.25
3	Kendu	*Diospyros melenoxylon*	12.06	13.2
4	Kushum	*Schleichera oleosa*	13.40	-
5	Mahua	*Madhuca latifolia*	14.30	20.95
6	Piar	*Buchanania lanzan*	13.00	12.30
7	Palash	*Butea monosperma*	13.07	16.60
8	Rori	*Mallotus philippinensis*	12.90	-
9	Sal	*Shorea robusta*	13.35	23.79
10	Semal	*Bombax ceiba*	16.20	15.80

Table–4.7: Average height (m) of economically important tree species of biotically disturbed and undisturbed sites at Rarha Forest Area

Sl. No.	Botanical Name	Mean		S. D.		CV %		t
		Disturbed Site	Undisturbed Site	Disturbed Site	Undisturbed Site	Disturbed Site	Undisturbed Site	
1	*Terminalia tomentosa*	4.95	9.60	6.82	5.65	137.87	58.94	5.88**
2	*Syzyzium cuminii*	13.56	10.40	1.80	1.01	13.33	57.83	5.65**
3	*Diospyros melenoxylon*	8.65	8.61	0.72	0.93	8.40	10.90	0.41
4	*Schleichera oleosa*	8.20	-	7.75	-	94.62	-	11.86**
5	*Madhuca latifolia*	11.13	11.33	0.96	1.29	8.63	11.44	1.39
6	*Buchanania lanzan*	5.96	9.10	5.52	5.10	92.56	56.08	4.67**
7	*Butea monosperma*	9.66	8.92	1.10	2.37	11.43	26.63	3.15*
8	*Mallotus philippinensis*	3.25	-	4.45	-	136.95	-	8.19**
9	*Shorea robusta*	13.33	17.86	0.72	0.60	5.41	3.38	53.88**
10	*Bombax ceiba*	12.35	11.50	1.51	1.17	12.24	10.24	4.97**

t value for 8 df at 5% - 2.306, t value for 8 df at 1% - 3.355

Table 4.8: Top height parameters of economic tree species of biotically disturbed and undisturbed sites at Rarha Forest Area.

Sl. No.	Common Name	Botanical Name	Top Height (m)	
			Disturbed Site	Undisturbed Site
1	Asan	*Terminalia tomentosa*	13.33	13.00
2	Jamun	*Syzyzium cuminii*	15.50	15.00
3	Kendu	*Diospyros melenoxylon*	10.51	11.5
4	Kushum	*Schleichera oleosa*	17.00	-
5	Mahua	*Madhuca latifolia*	13.00	13.00
6	Piar	*Buchanania lanzan*	11.50	13.00
7	Palash	*Butea monosperma*	12.75	11.52
8	Rori	*Mallotus philippinensis*	9.75	-
9	Sal	*Shorea robusta*	14.88	20.41
10	Semal	*Bombax ceiba*	15.00	13.00

Table 4.9: Form quotient of economic tree species of biotically disturbed and undisturbed sites of Rarha Forest Area.

Sl. No.	Common Name	Botanical Name	Form-quotient	
			Disturbed Site	Undisturbed Site
1	Asan	*Terminalia tomentosa*	0.88	0.83
2	Jamun	*Syzyzium cuminii*	0.76	0.87
3	Kendu	*Diospyros melenoxylon*	0.86	0.79
4	Kushum	*Schleichera oleosa*	0.90	-
5	Mahua	*Madhuca latifolia*	0.84	0.86
6	Piar	*Buchanania lanzan*	0.84	0.84
7	Palash	*Butea monosperma*	0.85	0.81
8	Rori	*Mallotus philippinensis*	0.57	-
9	Sal	*Shorea robusta*	0.88	0.90
10	Semal	*Bombax ceiba*	0.88	0.79

Table 4.10 – Volume (Total and Actual) of economic tree species of biotically disturbed and undisturbed sites at Rarha Forest Area.

Sl. No.	Common Name	Botanical Name	Total Volume (cu. m. /ha)		Actual Volume (cu. m. /ha)	
			Disturbed Site	Undisturbed Site	Disturbed Site	Undisturbed Site
1	Asan	*Terminalia tomentosa*	2.59	3.00	2.27	2.49
2	Jamun	*Syzyzium cuminii*	2.59	3.17	1.96	2.75
3	Kendu	*Diospyros melenoxylon*	5.02	4.30	4.31	3.39
4	Kushum	*Schleichera oleosa*	1.05	-	0.94	-
5	Mahua	*Madhuca latifolia*	4.03	4.16	3.38	3.57
6	Piar	*Buchanania lanzan*	1.35	1.42	1.13	1.19
7	Palash	*Butea monosperma*	8.49	3.89	7.21	3.15
8	Rori	*Mallotus philippinensis*	0.91	-	0.51	-
9	Sal	*Shorea robusta*	33.17	268.90	29.18	242.01
10	Semal	*Bombax ceiba*	5.34	5.36	4.69	4.23

Table 4.11: Existence of regeneration categories of economically important tree species at biotically disturbed and undisturbed sites of Rarha Forest Area

Sl. No	Botanical Name	Site	E (5.00)	W^+ & W (4.00)	U^+ (2.00)	U (1.00)	S^+ (0.50)	S (0.25)	R (0.00)	Weig. Value
1	*Terminalia tomentosa*	**Disturbed Site**	0.00	16.00	6.00	3.00	2.00	1.25	0.00	28.25
		Undisturbed Site	5.00	16.00	8.00	2.00	0.00	0.00	0.00	31.00
2	*Syzyzium cuminii*	**Disturbed Site**	5.00	4.00	4.00	3.00	1.00	0.50	0.00	17.50
		Undisturbed Site	0.00	8.00	0.00	1.00	1.00	0.00	0.00	10.00
3	*Diospyros melenoxylon*	**Disturbed Site**	20.00	12.00	8.00	3.00	1.50	0.75	0.00	45.25
		Undisturbed Site	15.00	16.00	12.00	4.00	3.00	1.50	0.00	51.50
4	*Schleichera oleosa*	**Disturbed Site**	0.00	16.00	4.00	3.00	0.00	0.00	0.00	23.00
		Undisturbed Site	-	-	-	-	-	-	-	-
5	*Madhuca latifolia*	**Disturbed Site**	0.00	8.00	6.00	2.00	1.00	0.75	0.00	17.75
		Undisturbed Site	0.00	4.00	0.00	1.00	0.00	0.50	0.00	5.50
6	*Buchanania lanzan*	**Disturbed Site**	5.00	4.00	6.00	2.00	1.50	0.75	0.00	19.25
		Undisturbed Site	15.00	8.00	2.00	2.00	1.00	0.50	0.00	28.50
7	*Butea monosperma*	**Disturbed Site**	25.00	28.00	12.00	5.00	2.50	1.25	0.00	73.75
		Undisturbed Site	15.00	12.00	12.00	5.00	3.50	1.25	0.00	48.75
8	*Mallotus philippinensis*	**Disturbed Site**	0.00	4.00	0.00	2.00	0.50	0.75	0.00	7.25
		Undisturbed Site	-	-	-	-	-	-	-	-
9	*Shorea robusta*	**Disturbed Site**	30.00	44.00	2.00	12.00	2.50	1.25	0.00	91.75
		Undisturbed Site	70.00	60.00	14.00	0.00	5.00	0.50	0.00	149.50
10	*Bombax ceiba*	**Disturbed Site**	5.00	16.00	4.00	3.00	1.00	0.75	0.00	29.75
		Undisturbed Site	5.00	8.00	4.00	3.00	0.50	0.50	0.00	21.00

Table 4.12: Regeneration statuses of ten economically important tree species found at biotically disturbed and undisturbed sites at Rarha Forest Area

Sl. No	Botanical Name	Disturbed site		Undisturbed site	
		Regeneration percentage	Regeneration Status	Regeneration percentage	Regeneration Status
1	*Terminalia tomentosa*	11.3	Deficient	12.4	Deficient
2	*Syzyzium cuminii*	7	Deficient	4	Deficient
3	*Diospyros melenoxylon*	18.1	Deficient	20.6	Fair
4	*Schleichera oleosa*	9.2	Deficient	-	-
5	*Madhuca latifolia*	7.1	Deficient	2.2	Deficient
6	*Buchanania lanzan*	7.7	Deficient	11.4	Deficient
7	*Butea monosperma*	29.5	Fair	19.5	Deficient
8	*Mallotus philippinensis*	2.9	Deficient	-	-
9	*Shorea robusta*	36.7	Fair	59.8	Moderate
10	*Bombax ceiba*	11.9	Deficient	8.4	Deficient

Table 4.13: Soil physical parameters of biotically disturbed and undisturbed sites of Rarha Forest Area

Sl. No.	Parameters	Disturbed Site	Undisturbed Site	Mean		S. D.		CV %		t
				Disturbed Site	**Undisturbed Site**	***Disturbed Site***	***Undisturbed Site***	***Disturbed Site***	***Undisturbed Site***	***t***
1.	**Texture.**	Sandy loam.	Sandy loam.							
2.	**Particle Composition**									
		Range (%)	Range (%)							
	Sand (%)	68.88–78.88	71.40 – 79.44	74.48	75.04	*4.33*	*2.96*	*5.81*	*3.94*	*1.19*
	Silt (%)	11.28–17.28	15.44 – 17.44	14.86	16.64	*2.58*	*1.09*	*17.41*	*6.58*	*7.09***
	Clay (%)	7.84 – 13.84	7.12 – 11.12	10.64	8.32	*2.28*	*2.28*	*21.42*	*27.40*	*8.09***
3.	**Water holding Capacity**	44.00–44.50	45.50 – 46.50	44.30	46.00	*0.27*	*0.50*	*0.61*	*1.08*	*33.47***

t value for 8 df at 5% - 2.306, t value for 8 df at 1% - 3.355

Table 4.14: Soil chemical parameters of biotically disturbed and undisturbed sites of Rarha Forest Area

Sl. No	Parameters	Disturbed Site	Undisturbed Site	Mean		S. D.		CV %		t
				Disturbed Site	Undisturbed Site	*Disturbed Site*	*Undisturbed Site*	*Disturbed Site*	*Undisturbed Site*	
1.	Soil pH	6.15 – 6.93	5.27 – 5.90	6.45	5.49	*0. 31*	*0.24*	*4.82*	*4.40*	*27.30***
2.	Organic Carbon (%)	0.44 – 0.46	0.51 – 0.49	0.44	0.49	*0.01*	*0.01*	*1.85*	*1.66*	*47.46***
3.	Available Nitrogen (kg/ha)	222.52–224.58	226.61–228.60	223.34	227.55	*1.05*	*0.70*	*0.47*	*0.31*	*37.36***
4.	Available Phosphorus (kg/ha)	16.53–17.90	18.42–19.77	17.32	19.15	*0 .55*	*0.57*	*3.17*	*2.99*	*25.78***
5.	Available Potassium (kg/ha)	186.36–187.96	187.57–189.95	187.00	188.71	*0.65*	*0.99*	*0.34*	*0.52*	*16.17***

t value for 8 df at 5% - 2.306, t value for 8 df at 1% - 3.355

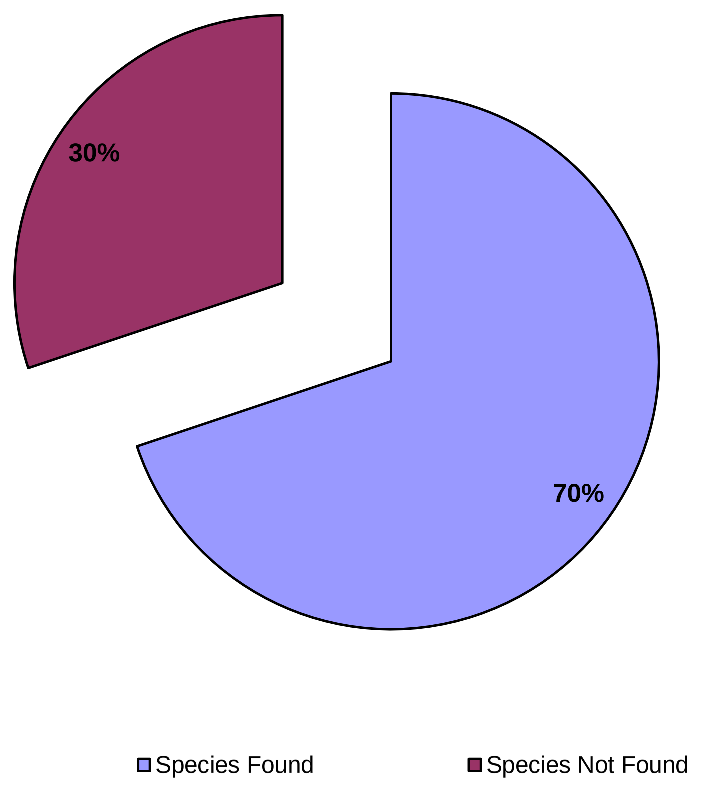

Figure 4.2: Percentage contribution of plant species to the total population of plants at biotically disturbed sites.