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Identify appropriate conservation strategies and their importance for the local people in Bangladesh

A thesis submitted to partial fulfilment of the requirements of Master of Science in Mountain Forestry

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Dedicated

to

Ralf Rappel

In a hard time of life he gave me support, trust, friendship and inspiration

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LIST OF ABBREVIATIONS

BNH = Bangladesh National Herbarium

DBH = Diameter at breast height

DFO = Divisional Forest Officer

FRA = Forest Resource Assessment

FD = Forest Department

FGR = Forest Genetic Resources

FUG = Forest User Groups

IPAC = Integrated Protected Area Co-management project

IVI = Importance Value Index

NGOs = Non Government Organizations

NWFPs = Non-wood forest products

PAs = Protected Areas

RA = Relative Abundance

RD = Relative Density

RDo = Relative Dominance

RF = Relative Frequency

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

This study analyzes the biodiversity, the related socio-economic effects and the perception of local people about conservation strategies at three conservation areas (Chunati wildlife sanctuary, Sitakunda eco-park, Dulahazara safari park) in Bangladesh. 75 sample plots were used to collect data on mature tree species and regeneration. By means of questionnaires the demands and perceptions of local people living close to the conservation areas have been observed. In total 46 tree families have been identified with 159 varieties of tree species in all three study areas. Chunati wildlife sanctuary had the highest mean basal area with 53.9 m^2/ha, and species diversity was highest in Sitakunda eco-park with 5.84. 15 years ago small scale farming was the main income source for all people in the study areas, but through the conservation strategies implemented their employment opportunities and turnover/capita increased. 61 % of all respondents were strongly satisfied about the conservation strategies. The survey shows, that there exists different perceptions about the perception and intensity of the socio-economic effects (e.g. infrastructure, education, employment opportunities, land prices) and the level of awareness about the role of conservation activities in the three study areas. While in Chunati wildlife sanctuary for 84 % of all respondents the tree planting programmes have increased, in Dulahazara safari park the literacy increased for 80 % and Sitakunda eco park land prices and infra-structure increased for 84 %. In contrast the intensity of illegal cutting or illegal thinning for serving the daily needs of the local people and the disturbances caused by tourism challenge conservation management. The results indicate that a combination of increasing both socio-economic conditions and the participation of local people in formulating conservation objectives can have positive effects on the development of appropriate conservation strategies. Based on a discussion of the results recommendations for the implementation of in-situ conservation strategies in Bangladesh are given.

Keywords: biodiversity, tree species richness, in-situ conservation, tourism, livelihood, income contribution.

Kurzfassung

Diese Arbeit untersucht die Effekte von Naturschutz-Strategien auf die Biodiversität, die damit verbundenen sozio-ökonomischen Rahmenbedingungen und die Wahrnehmung der lokalen Bevölkerung anhand von drei Fallbeispielen (Chunati Wildlife Sanctuary, Sitakunda Eco-Park, Dulahazara Safari Park) in Bangladesh. Auf 75 Stichprobenpunkten wurden Informationen über die vorhandenen Baumarten und die Naturverjüngung erfasst. Durch strukturierte Interviews wurden die Erwartungen und Beobachtungen der lokalen Bevölkerung, welche im Umkreis der geschützten Flächen leben, erfasst. Insgesamt wurden 46 Familien und 159 unterschiedliche Baumarten auf allen Stichprobenflächen beobachtet. Im Gebiet des Chunati wildlife sanctuary wurde die höchste mittlere Grundfläche mit 53.9 m^2/ha, und im Sitakunda eco-park die größte Baumartenvielfalt mit 5.84 festgestellt. Vor 15 Jahren war die kleinflächige Bewirtschaftung der Agrarflächen die einzige Einkommensquelle für die lokale Bevölkerung. Durch die Etablierung der Naturschutzgebiete konnten allerdings die Einkommensmöglichkeiten und der durchschnittliche pro Kopf Umsatz erhöht werden. 61 % aller Befragten äußerten sich positiv über die Effekte der Naturschutz-Strategien auf ihren Lebensunterhalt. Die Studie zeigt auch, dass es Unterschiede in der Wahrnehmung und im Ausmaß der sozioökonomischen Effekte (u.a. Infrastrukteinrichtungen, Bildung, Arbeitsmöglichkeiten, Grundpreise) und dem Bewusstsein zwischen den Naturschutzgebieten gibt. Während im Gebiet des Chunati Wildlife Sanctuary für 84 % aller Befragten die Intensität von Aufforstungsprogrammen zugenommen hat, wurde im Dulahazara Safari Park die erhöhte Bildung von 80 % und im Sitakunda Eco Park von 84 % eine Erhöhung der Grundstückspreise und der Infrastrukturleistungen beobachtet. Im Gegensatz dazu stehen die illegalen Nutzungen der Bevölkerung zur Deckung des täglichen Holzbedarfs und die Beeinträchtigungen durch den Tourismus, welche den Naturschutz beeinflussen. Die Ergebnisse zeigen, dass die Kombination von verbesserten sozio-ökonomischen Bedingungen und der Einbindung der Bevölkerung in die Formulierung von Naturschutzzielen positive Effekte auf die Umsetzung haben kann. Basierend auf einer Diskussion der Ergebnisse werden

Empfehlungen für die Implementierung von in situ Naturschutzstrategien in Bangladesh gegeben.

Schlagwörter: Biodiversität, Baumartenvielfalt, In-situ Naturschutz, Tourismus, Lebensunterhalt, Einkommensmöglichkeiten.

1. INTRODUCTION

Bangladesh is a small country of 14.39 million hectares area and comprises diverse ecosystems with hills, plains, coastal areas and wetlands as a result of the diverse agro ecological- conditions [38 agro-ecological zones and 88 subzones]. Bangladesh, located in the humid tropical region is rich in species diversity and is unique in the diversity of genetic resources. It contains about 5700 species of angiosperms and four species of gymnosperms (Firoz, et al, 2004, Khan 1977; Troup 1975) of which about 2260 species are reported from the Chittagong region (Anon 1993).

According to FD and some other sources (Khan et. al. 2007; Mukul et. al. 2006 and Hossain, 2005) the forest coverage of the country is nearly about 2.53 million ha representing approximately 17.5 % of the country's total surface area. Officially, Bangladesh Forest Department (FD) manages 1.53 million hectares of forest land (Roy, 2005).

The hilly forests cover an area of 0.67 million ha. The unclassed state forests include 0.73 million ha of hilly land located at the southeast corner of the country. The village forest area is 0.27 million ha. The growing stock of the woodlots and bamboo resources are estimated to be 54.7 million m^3 and 7480 million culms respectively. About 20000 ha of plantations have been established (Islam, 2003). The estimated average annual forest growth is 2.5 $m^3 ha^{-1}$. Annual depletion of the growing stock stands at 1.65 %. A large portion of this forest land has been encroached. About 24000 ha of forest are lost annually as a result of homestead development, urbanization and deforestation (Anon 1992). Forests in Bangladesh are declining at an alarming rate. Some species are disappearing fastly and are considered as threatened.

Khan (1996) reported that there are about 86 timber species, 130 species of yielding fiber and 29 medicinal plant species available in the country. The Bangladesh National Herbarium (BNH) prepared a list of 500 medicinal plants. Bamboo resources of 18 taxa,

both wild and planted can be found (Alam 1982). There are at least ten species of rattans, along with 12 other palm species (Khan 1996).

Major international efforts to conserve FGR (Forest Genetic Resources) began in the 1960s with the guidance and support of FAO. Conservation efforts of FGR have been implemented with the in-situ conservation, ex-situ conservation and conservation of provenances within species. In-situ conservation is carried out in the following areas: nature reservations, national parks, wildlife sanctuaries and world heritage sites. Ex-situ conservation includes all practices that conserve genetic material outside the natural habitat of the parent population. Ex-situ conservation methods and materials include gene banks for seeds or pollen as well as clone banks, arboreta, preservation plots, sample plots, botanical gardens, seed storages and tissue culture banks (Islam, 2003).

Many rural people in developing countries are dependent on local natural resources and the conservation rules put into place in many protected areas frequently forbade all extraction and in many cases also all entries except for tourism or research. This created a climate of increasing conflicts that in many cases compromised conservation goals and led to a refocus in protected areas management and research in the social sciences worldwide (Heinen, 2010). Protected area covers 10.7 % of total forest area in Bangladesh (http://www.bforest.gov.bd/conservation.php, 20.11.2011). Protected areas are the cornerstones of most conservation strategies around the world; they conserve biodiversity, safeguard ecosystem health and provide an array of many ecosystem services (Hockings 2003).

The contribution of forestry to the national Gross Domestic Product (GDP) at current prices has been estimated to be 5 % (BBS 2008). The supply of various forest products such as timber, poles, fuel wood and bamboo cannot meet the present demand. Village forest areas, being one-tenth of the national forest area, supply 70 % of sawlogs, 90 % of fuel wood and 90 % of bamboo consumption of the country. The annual per capita consumption of timber and fuel wood was estimated to be 0.01 m^3 and 0.08 m^3

respectively, based on a population of 90 million as in 1980 (Chowdhury, 2006). The figure would be less if the present forest production and population considered. The gap between demand and supply has increased with the raising population. This gap could be reduced through the establishment of plantations of fast growing trees in the denuded forest areas, wastelands as well as homestead areas. However declaration of some new in-situ conservation areas in Bangladesh is definitely a light of hope against forest destruction and genetic depletion. There are 14 wildlife sanctuaries and game reserves with total 120011 ha areas and four national parks with total 15239 ha areas in Bangladesh. Most of the conservation areas are adjacent to densely populated areas where people are apparently more dependent on forest or natural sources for their livelihood. This gives a high potential for conflicts between natural reserves and people. In such a situation selecting the best conservation strategy facing people's interests and nature conservation is hard to determine, but would give the chance for highest success in conservation effort as well as in striking peoples' demands . So, the present study aims to achieve the following objectives as one of the several efforts in identifying the best conservation strategy for Bangladesh.

Objectives:

To compare different conservation strategies in the context of maintaining biodiversity and the livelihood of people by means of three study areas: Chunati wildlife sanctuary, Dulahazara safari park and Sitakunda eco-park.

Sub objectives:

- To survey the conditions of flora and tree species.
- To identify the current and previous employment opportunities for local people.
- To analyze the programmes taken so far - to conserve, manage and develop the protected study area during time of establishment and in 2010.
- To identify the best option for conservation practices by putting priority on the livelihood of local people.
- To give recommendations for the implementation of conservation strategies.

2. LITERATURE REVIEW

2.1 Forest management

Sustainable forest management has become the salient cross-cutting theme in forestry throughout the world today. This paradigm recognizes that forests are managed for a wide variety of ecological, economic, and social benefits. This explicit recognition of many outputs and services as management objectives has recast the economic analyses on the values of forests. The history of scientific forest management in Bangladesh dates back to the nineteenth century with defined forest policies and laws. Due to various socio-economic and socio-political factors, forest cover of the country was reduced drastically and all policy initiatives to stop the decline proved ineffective. Although traditional forest management objectives covered a wide range from economic benefit to ecological stability, these have never been attained fully. Huge population and increase limited land area compelled policy makers to think about alternatives to traditional forest management. One alternative, social forestry was introduced in Bangladesh in early 1980s and has proved to be extremely successful. While traditional forest management resulted in a net loss of forest resource cover, social forestry on the other hand, is playing a vital role in the expansion of forest cover (40, 387 ha of new forest cover and 48, 420 km new strip plantation since the mid-1980s) benefiting thousands of poor people. Results show that during the last four years (2000-2003) more than 23 000 individuals benefited from the final felling of different social forestry plantations (woodlot, agroforestry and strip plantation) (Muhammed, N., et al., 2005).

At present, encroachment rate is too high and increasing alarmingly that causes environmental degradation as well as low forest cover and productivity in Bangladesh. Rural poverty accelerates the encroachment in meeting the demand of dwelling place and forest products. Ali, M. (2002) studied the changes in the major attitudes of forest users towards forest and land use issues, such as illegal harvesting, encroachment and shifting cultivation, indicates that scientific forestry introduced during the British regime had a strong influence on the people of Bangladesh. Restrictions to rights and tenure of

forest use and the alienation of people from forest lands, force forest users to change their attitudes. Subsequent changes in the socio-economic environment and subsistence needs of users created a desperate situation leading to the exhaustive use of forests. The continuation of the forest policy after independence ensured those changes became socially embedded. However, encroachment has been a comparatively recent phenomenon that has been exacerbated by population increase and changes in socio-political circumstances in Bangladesh.

The natural encroached and degraded forest is under public management regime while a substantial amount of marginal land belongs to other semi-public agencies such as Roads and Highways or Water Development board. Due to lack of initiatives and proper management these lands have been left unused and underutilized. In contrast, non-governmental organizations (NGOs) are with appropriate management structure and technologies to utilize these lands in reducing poverty and enhance rural livelihood. In order to rehabilitate these encroached forests non-governmental organizations have been found to be very active and successful. They have added a new dimension in the forest management, which has ensured participation of the community people and protection of the forest. By following a framework of common partnership between public and private management systems, the issue ‘property right conflicts’ has been resolved by the involvement of several NGO’s and enhanced rural life. As an outcome of this common partnership 33,472 km roadside plantation and 53,430 ha reforestation activities have been carried out in last two decades. The achievement of NGOs’ partnership in managing forest resource seems to be effective towards poverty irradiation and better livelihood (Safa, M. S. 2005).

2.2 Studies on Biodiversity

The process of forest fragmentation, a common phenomenon occurring in tropical forests, not only results into continuously forest getting fragmented but also brings about several physical and biological changes in the environment of forests. Consequently, there is a loss of biodiversity due to change in habitat conditions. These remnant

fragments provide the last hope for biodiversity conservation. Jha et al. (2005) studied the impact of decreasing patch size of a fragmented forest on the diversity of the tropical dry deciduous forests in Vindhyan highlands, India. Remotely sensed data has been used to describe the changes brought about in vegetated areas over a period of 10 years as a result of fragmentation and its impact on biodiversity was assessed. Further, in order to assess the loss of species with respect to the reduction in patch size, species area curves for various change areas were analyzed. It was observed that the rate of decrease in the number of species is faster in the case of negative change areas as compared to the positive change areas of the region. Various diversity indices also support this observation. The recommend that such an analysis would help in formulating appropriate conservation measures for the region. Pande (2001) made a quantitative vegetation analysis as per aspect and altitude and regeneration behaviour of tree species in Garhwal Himalayan Forest, India using quadrat method (size of quadrat, 10m × 10m for trees; 5m × 5m for shrubs and 1m × 1m for herbs). Horkar and Totey (2001) studied on floristic diversity and soil in Navegaon National Park (Maharshtra), India.

Belem, B., et al., (2007) proposed a combination of ethno-botanical surveys and botanical inventories in the “Parc National Kaboré Tambi” in Burkina Faso. They analyzed the importance of the park plant species, identified the constraints faced by local people to harvest the park plant products, analyzed the park vegetation structure and assessed the degree of regeneration of the main useful species. They concluded that conservation by domestication of the source species and improved harvest of Non Wood Forest Products could be combined for sustainable management of the park.

Rahman and Vacik (2009) examined the impact of picnic activities on forest diversity, structure, regeneration and vitality of tree species in the Bhawal National Park of Bangladesh. The study area was classified as a non-used, occasionally used and frequently used area on the basis of the intensity of the picnic activities. A total of 43 plant species were enumerated in the whole study area. The highest plant species richness (41 species) were observed in the non-used area whereas the lowest species

richness (11 species) in the frequently used area. The diversity index decreases with the increase of picnic intensity whereas the concentration of dominance increased. Nath et al. (1997) has investigated on the structural composition of a natural forest of Chittagong Hill Tracts (south) Forest Division based on diameter class distribution and found that different dbh classes were dominated by different tree species. Ahmed and Haque (1993) carried out a study on percentage distribution of species and diameter class in natural forest of Bangladesh. Nath et al. (1998) has done a work on diversity and composition of trees on Sitapahar Forest reserve of Chittagong Hill Tracts (South) Forest Division, Bangladesh by a stratified random quadrate method having diameter at breast height >10cm. Nath et al. (1999) has studied on basal area distribution of a tropical wet evergreen forest of Chittagong Hill Tracts (South) Forest Division, Bangladesh. Uddin et al. (1998) produced an annotated checklist of angiospermic flora of Sitapahar at Kaptai of Chittagong Hill Tracts. Jashimuddin et al. (1999) made a survey to know the status of Biro Sal forest in North-Western part of Bangladesh where Sal comprised 96% of the total tree population and mostly of coppice origin. Hossain et al. (1999) made an investigation on the natural regeneration status and distribution pattern in a mixed tropical forest at Kaptai of Chittagong Hill Tracts (South) Forest Division by lying quadrate of 3m × 3m and reported that percentage distribution of each individuals of different species in different height classes decreased as the height increased. Das (1977) made a quantative stand structure of the Tropical Moist Deciduous Sal forests of Madhupur Garh, Bangladesh using ten plots of 66×66 feet area each were taken from an area covering about 5000 acres. Alam and Pasha (1999) conducted a quantitative survey in Chittagong University Campus named a floristic account of Chittagong University Campus and a total of 665 species under 404 genera and 126 families were recorded.

2.3 Forest conservation and local people participation

Many rural people in developing countries are dependent on local natural resources, and the conservation rules put into place in many protected areas frequently forbade all extraction and in many cases all entry except for tourism or research. This created a climate of increasing park-people conflicts that in many cases compromised

conservation goals and led to a refocus in protected areas management and research in the social sciences worldwide. Here Heinen, J. T. 2010 described survey and non-survey based protocols developed to study the effectiveness of protected areas in the societal realm. Such studies can allow managers to plan for interventions where needed and can aid in designing appropriate local development projects in an effort to ameliorate park-people conflicts.

A total of 19 protected areas (PAs) have been established in Bangladesh representing all the four forest types of the country. Apart from being the repository of biological diversity, these PAs serve as the source of subsistence livelihoods to the local communities. While all the PAs are managed by the state Forest Department (FD), with a view to ensure sustainability, a recent approach of co-management has been initiated in five PAs as a pilot project with an aid of development partners incorporating stakeholders' participation. Along with demonstrating a number of upbeat impacts, the initiatives exert some constraints which need to be addressed properly to ensure the success of participatory approach and enhance the ongoing conservation scheme (Chowdhury and Koike 2010). Mukul et al., (2008) concluded that effective co-management, between PA managers and local forest user groups, which ensures clearly defined rights of various stakeholders on PAs and their active participation in decision-making processes, is necessary to secure the future of PAs in Bangladesh. Rasheed, K. B. S. (1995) presented a strategy, not merely of halting deforestation, but of reforestation on a national scale and through people's participation in the process. In response to the crisis in the forestry sector, traditional government forest management programs have been replaced by participatory forestry in recent years as the principal strategy for reforestation. This change in strategy has two goals (1) encourage new plantations, and (2) generate income and create jobs for the rural poor. Participatory forestry is a benefit sharing scheme in which the landless and the marginal farmers are employed in tree plantation work.

2.4 Options for income generation

National parks have complex relationships with local communities that impact both conservation success and community well-being. Integrated conservation and development projects have been a key approach to managing these relationships, although their effectiveness has been increasingly questioned. Nature based tourism is increasing throughout the world. Most is based in national parks and restricted areas. UNESCO has declared 28% of the world's largest continuous mangrove forest, the Sundarbans, as a world heritage site in 1987. But having the world's densest population, it is difficult to protect the flora and fauna unless there are economic benefits to the country as well as to the local people. Salam M. A., et al., (2000) suggested that nature oriented tourism can be one means to help achieve sustainability in the reserve forest as well as protecting the important world heritage site. Well-planned tourism could provide economic and political incentives for proper management and for conservation and could bring additional benefit to local communities and regional economies.

Also the relationships of park and people were studied in the Armando Bermudez National Park in the Dominican Republic, focusing on forests, aquatic resources, community well-being and development, and ecotourism. Hiking and trekking opportunities attract both national and international tourists to the park, and community members benefit from employment as tour guides and providing mule rentals. At the same time, tourism activities also present continuing challenges related to: (1) the distribution of tourism benefits between local people and outsiders, and within the local community, (2) maintaining the local economic benefits of tourism while protecting park resources, and (3) developing park- or conservation-related economic opportunities to complement tourism. The results highlight the need to develop site-specific strategies to manage park-people relationships through interdisciplinary analysis (Schelhas, J., et al. 2002).

Pandit, B. H., et al., (2009) examined the effective practices and constraints of community-based forest management enterprises (CBFEs) in Nepal in providing income

benefits to the poor. The tenure reform clarity and strengthening of tenure rights at community level through various CBFM programs in Nepal in the last few decades has enhanced opportunities for the rural people to benefit from forest-based enterprises. However, a key concern as these programs have advanced over the years has been whether the poor benefit from them given their high dependence on the forests. The effective practices of the CBFEs in increasing income benefits were found to include representation of the poor and marginalized groups in executive committees in the FUGs based enterprises, targeted employment of the poorest in the collection of non-timber forest products and in processing units in networks, and enabling the poor to own share capital in cooperatives and companies. Community forestry in Nepal vests rights of access, use, exclusion, and management of national forestland to local user groups. There is strong potential for community forests to serve as the basis for improving the quality of life and the status of livelihoods in rural Nepal while conserving forest resources. Frequently, community forest user groups are dominated by local elites who choose to close access to community forestland for several years. As a result, forest conditions are improving, but the poorest households bear the cost of strict protection. Thoms, C. A. (2008) argued that community forestry is thus having rather limited success at improving rural livelihoods. Although community forestry is fairly successful at conservation, there remain huge wealth disparities between community forest member households, limited access to vital forest products, and significant power disparities within community forest user groups. Such conditions of inequity, reinforced by current community forestry policy and practice, severely challenge the development potential of community controlled natural resources.

3. DESCRIPTION OF THE STUDY AREAS

3.1 Selection of the study sites

The study was planned to be carried out in the following conservation areas of Bangladesh (fig 1):

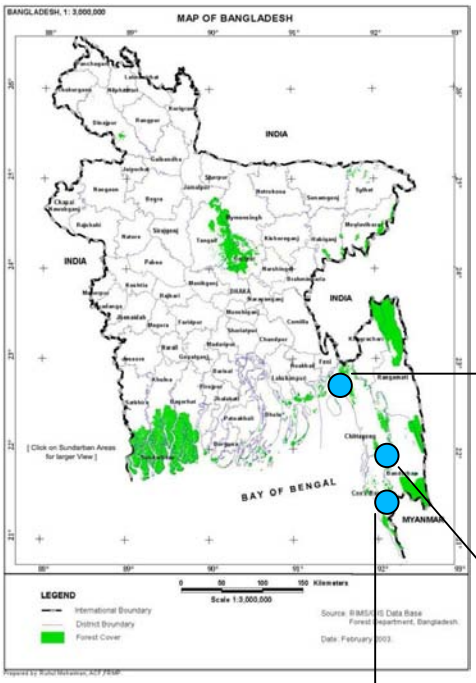
1. Chunati Wildlife Sanctuary (Chittagong, 7761 ha, est. yr. 1986)
2. Sitakunda Botanical Garden and Eco-park (Chittagong, 808 ha, est. yr. 1998)
3. Dulahazara Safari Parks (Cox's Bazar, 600 ha, est. Yr. 1999)

They have been selected, because those three areas are well-known for their good natural forest condition, biodiversity conservation activities, the role of tourism and that rural people's poverty is mitigated by NWFPs and income sources by different management strategies.

3.2 General description of the Chunati wildlife sanctuary, Dulahazara safari park and Sitakunda eco-park

3.2.1 Chunati wildlife sanctuary

The wildlife sanctuary was formally established through gazette notification under the Wildlife Act in 1986. It is one of the protected areas in which Non Government Organizations (NGOs) are actively involved in programs for its protection. The Chunati wildlife sanctuary includes 7764 ha of natural evergreen forest and grassland. The Asian elephant, wild boar, Rhesus monkey, barking deer still roam this huge tract of open land. During the mid 1980s, the sanctuary was covered by dense forest of garjan and other hardwood species. Demand for wood of boat building and commercial enterprises contributed to a rapid loss of forest in the late 1980s. In 2004, the sanctuary was selected as one of the five pilot sites for co-management under the Forest Department's Nishorogo Program.



Map of Bangladesh

Sitakunda eco-park

Dulahazara safari park

Chunati wildlife sanctuary

(Source: Forest Department)

Figure 1: Maps showing the study areas (Chunati wildlife sanctuary, Dulahazara safari park and Sitakunda eco-park)

Location: The Chunati wildlife sanctuary is located at 21°40´ north latitude and 92°07´ west longitude, located about 70 km in the south of Chittagong city on the west side of Chittagong. Originally it is a part of Chittagong (south) Forest Division, but now it is part of the Wildlife and Nature Conservation Division.

Geology: The sanctuary area has four main geological formations: Pleistocene, Pliocene, Miopliocene and Miocene.

Rock and soil: According to reconnaissance soil survey carried out 1971-1973 by the directorate of soil survey, the soils on the alluvial plains and valleys in the Chunati wildlife sanctuary are silty loam to silty clay loam, moderately to strongly structured and neutral to medium acidic subsoil (Khan 1990).

Topography and landform: The Chunati wildlife sanctuary area is generally hilly with shallow to deep gullies and gentle to steep slopes. In some sections there are narrow valleys winding around hills blocked by ridges connecting the hills.

Water and river system: The Chunati wildlife sanctuary is clear with gravely and stony beds traverse the area. They provide a good drainage to the area and clean water to the wild animals and the people as well as for irrigation in the surrounding areas. It also serves a habitat to a great number of amphibians (Source: Bangladesh Meteorological Department).

Climate: The variations on rainfall, temperature, humidity, sunshine, winds, storms or cyclones during the various seasons are of primarily importance for the tree species, their growth and development and also for proper management of biodiversity. Rain showers are frequent and heavy during the monsoon season (May to October) and sporadic rainfall occurs during the whole year. In summer the temperatures ranges from average daily lows of 24.9°C to 32.5°C average maximums and in winter from 14.2°C to 29.5°C. In monsoon the humidity ranges from average 100 % maximum to 41 %

minimum and in the dry season from average 98.2 % maximum to 28.6 % minimum (Source: Bangladesh Meteorological Department).

3.2.2 Dulahazara safari park:

At the initial stage 300 ha of area were taken for the Dulahazra safari park. Now it is 600 ha big and covered with tropical semi evergreen forest with a permanent boundary. The total area will be 900 ha in the future. It is a reserved forest. The project activities were started in 1999 in that area (Source: Safari park office).

Location: Dulahazra safari park is located between $20^{o}50´$ and $21^{o}50´$ north latitude and between $92^{o}0´$ and $92^{o}15´$ east longitude, located on the most southeast region of Bangladesh. It is under the Cox's Bazar forest division. This park is 50 km northern from Cox's Bazar district.

Geology: Dulahazra safari park is covered with small hills. Geologically this region was created during the Pliocene era of the tertiary period, which was up 25 million years ago. It was under the 'Dupitilla series' that was built up by sandstone and shale (Source: Dulahazara safari park office).

Climate: The climate of this park is moist tropical maritime. Heavy rainshowers occur from June to September. Mean rainfall is about 740.8 mm during the month of June. Relative humidity is 70 %-85 %. Mean annual temperature of this area is 26.6^{o} C (average 32^{0} C maximum and 14.70^{0} C minimum).

Management of the park: The Divisional Forest Officer (DFO) of the Nature and Wildlife Management Division in Chittagong is responsible for managing the safari park. There are two Assistant Conservators of Forest (ACF), two forest rangers (FR), six wildlife protectors (WP) and six wildlife scouts (WS) working for the park management.

3.2.3 Sitakunda eco-park: This eco-park was established (fig. 1) under Bangladesh wildlife preservation (Amendment) act 1974. Considering the long stretched evergreen forests in the hills, man made mangrove forests in the coastal belt, diversified wild animals and outstanding scenic beauty of the area an eco-park was established at Sitakunda under Chittagong districts in 1998. The area covers natural evergreen forests with 808 ha areas and possesses high diversity in plant and animal composition.

Location: This eco-park is situated at the northwestern part of Chittagong district, between $22^{o}36´$ and $22^{o}39´$ north latitude and $91^{o}40´$and $91^{o}42´$ east longitudes. It is under the southern Sitakunda Reserved Forest of Chittagong Forest Division.

Soil: The soil developed on the unconsolidated and compact rocks of Dupitila formation is usually moderately well to excessively drain. It is created by fallen rotten leaves and therefore often shows a thin layer of soil containing many worms and strong populations of composting micro organisms, quite over the surface. The soil is deep and probably the oldest in that area. Top soils are dark grayish brown to dark brown, consisting of sandy loam to loam, are moderately granular on crumbly neutral to strongly acidic layers if moist and medium to very strongly acidic when dry. Sub-soils are yellowish brown to yellowish red in color, consist of sandy loam to silty clay loam and are of moderate to strong blocky structure. Some soils contain a hard concretionary or indurate lateritic layer at variable depths. Substratum is often weak to strong mottled grey and brown to red, containing quartz gravel (BBS, 2010).

Topography: This eco-park is constituted with medium high to low hill ranges with altitude of 352 meters above sea level. These hills are made of sandstone and shale (BBS, 2008).

Climate: The climate of the study area is moist tropical. Maximum rainfall occurs from June to September. The area remains dry for about four to five months. From December

to February it remains cool. In the winter time and at the end of the monsoon the whole study area becomes hazy (BBS, 2008).

The mean annual temperature of the study area is 26.6^{o}C. Normally, rainfall occurs during the month of May to September for five months. Maximum rainfall is in the month of July and the amount is 596.6 mm on an average. The humidity remains less in the month of February (72.2 %) and maximum in the months between July and August (85.5 %) (BBS, 2008).

Wind is an important climatic factor in terms of aiding ecologic and physiographic processes in those forests, particularly the natural seed or fruit dispersal for natural regeneration in the forest areas. But strong wind is very destructive, destroys infra-structures and hampers outdoor recreational activities. Based on record of storm frequency that affected Bangladesh from 1978 to 2010, there have been as many as 12 severe storms that affected the forest areas and occurred mainly during the monsoon months (Source: Bangladesh Meteorological Department).

Habitat type and habitat quality: There are four habitat types namely, high forest, low forest, grass land and water body. The high forests and low forests are the major habitat types in terms of extent or size. The remaining natural forest habitat became very poor in quality during the time of 1980-1994 which is now in process to recover it. Unfortunately the gathering of forest products such as fire wood and others by the people residing inside and around the areas and more so the clearing for the cultivation of agriculture crops had been adversely affecting the quality of the wildlife habitats.

3.3 Three study sites at a glance

Table 1 shows that all the three study areas have more or less same objectives. Only the Chunati wildlife sanctuary has co-management system. Overall all the three study areas have same problems like hijacking, robbery and pick-pocketing in the remote forest

areas. These problems happen because of too many people and too less employment opportunities, poverty and malnutrition, more free time, frustration and less education.

Table 1: Information about three study areas

Study area 1 **Chunati wildlife sanctuary**	**Study area 2** **Dulhazara safari park**	**Study area 3** **Sitakunda eco-park**
Establishment year: 1986	**Establishment year:** 1999	**Establishment year:** 1998
Area: 7764 ha	**Area:** 600 ha	**Area:** 808 ha
Objectives: To create a co-management model with local people and forest department, to increase the income of local people, to develop tourism, to increase and implement biodiversity development work and research work	**Objectives:** To conserve the naturally grown tree species and help breeding animals and birds in Bangladesh, to conserve the endangered species of Bangladesh, to create a natural habitat for birds and animals, to increase awareness of tourists and research about conserve wildlife	**Objectives:** Genetic conservation and development, to plant and manage different kinds of bamboo, cane, timber species and medicinal plants, to conserve endangered species, to conserve biodiversity, to create habitats for animals, eco-tourism and research
Forest management: 29 local people involved as forest guards for forest protection to establish co-management work	**Forest management:** No local people involved in forest management	**Forest management:** No local people involved in forest management
Co-management work	No co-management work, forest managed by government	No co-management work, forest managed by government
Benefits of the local people: After rotation period, local people will get the benefit sharing by selling the trees, local people will take care the trees as a top down policy	**Benefits of the local people:** After plantation, now natural regeneration occurs, no tree cutting, biodiversity conservation going on, after life time the tree will die and rotten but no one will collect it.	**Benefits of the local people:** After rotation period government will sell the tree and save the money in a governmental fund, there will be plantation every year but local people never get any benefit sharing from the timber tree
Local people will get the benefit by collecting NWFPs, they will have work in that area as a daily labor for plantation, as forest guards or other works	No entrance for local people	Local people will get the benefit by collecting NWFPs, they will have work in the eco-park as a daily labor for plantation or other works

4. METHODOLOGY

The investigation was made for data collection by physical measurement directly from the study sites, expanded by a survey among the local people as well as data analysis.

4.1 Secondary information

The informations and relevant literature required for conducting this thesis paper were collected from different books, journals, seminar proceedings and published papers of the library of the Institute of Forestry and Environmental Sciences, University of Chittagong, Bangladesh, Forest Research Institute (BFRI) and Dhaka Ban Bhaban (Dhaka Forest Office). Related informations and literature were collected from internet sources as well. Informations about the study areas were collected from the concerned authorities of Chunati wildlife sanctuary forest office, NGOs office and co-management office, Dulahazara safari park office, Sitakunda eco-park office and Chittagong forest department.

4.2 Reconnaissance survey

To have an idea of species composition prior to sampling procedure for floristic composition and diversity, undergrowth and regeneration study, a number of field visits were conducted. At this stage, a formal discussion was held with the concerned officials of the investigated areas, related NGOs, local people and related forest departments. Two transect walks (one from north to south and from east to west) across each study area were made with the help of the field assistants according to Chattergy et al., (2000). The objectives of this walk were to get familiarized with the vegetative community and to get and idea about the species in the study areas.

4.3 Field data collection procedures

Fig 2 shows how the working procedure during field data collection period was done. Twenty five questionnaire surveys of the local people from each study site were conducted from there who living in the study area and partly or fully dependent on the

forest for their livelihood. Twenty five survey plots were taken to observe soil color, soil properties, humidity, tree species and their regeneration from each conservation area.

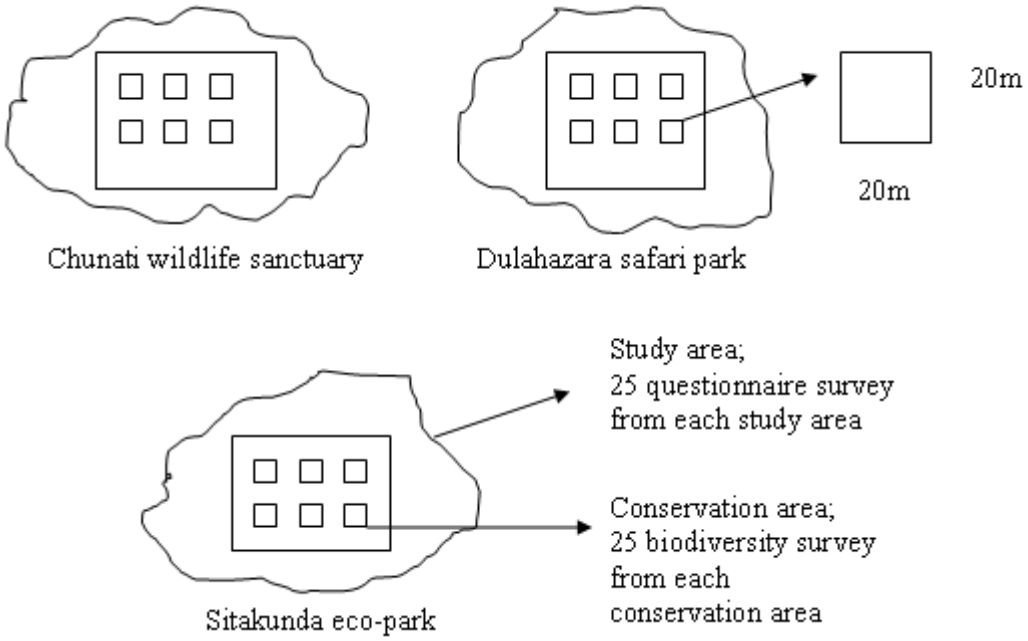


Figure 2: Working procedure during field data collection period

4.3.1 Measurement of tree species structure, composition and diversity

To examine the species structure, composition and diversity of the study areas, firstly a field visit was done. Maps of the areas were collected indicating forested area, agricultural land, encroached areas for cultivation and habitation, woodlot plantation and different development structures. From the map the forest area was demarcated and a group of three members was formed to conduct the field study. Systematic sampling was carried out for proper representation of the areas with a total of 75 sample plots. From each study area 25 plots comprising 20 m × 20 m in size were investigated (fig 3). Species diversity, composition and density at each site were evaluated. All timber and medicinal trees ≥ 10 cm in DBH and > 1.6 m in height were identified and measured.

Figure 3: Measurement procedure of tree species composition and regeneration at Dulahazara safari park.

On each plot, disturbance levels (natural or human disturbance) were evaluated. The history of disturbances was assessed as past, present and continuous.

4.3.2 Methods for regeneration study

Under tropic conditions forest vegetation, anyway by sexual or vegetative means, has a rapid growth and is completed within a few months leading to high species diversity. However clear felling of natural forests results not only in a loss of seedlings and saplings, but also causes disturbance of the natural forest condition and hence the whole ecosystem (Haque and Alam, 1988).

For the regeneration survey was therefore one subsample plot was selected from each main plot laid out for tree species measurement. Thus data investigation on a total of 75 sample plots (25 for each) conservation area of 2 m × 2 m in size was done. Seedlings and shoots from sprouting were identified, counted and recorded in the data measurement sheet.

4.3.3 Methods for shrubs, herbs and climbers estimation

The diversity of ground flora species on each site was studied on each main plot by estimating the percentage of the coverage of the ground.

4.3.4 Identification of plant species

The common species were identified directly in the field. Local people working in the field and forest officials also helped in identifying some species. For unknown species, plant samples were collected and preserved in herbarium sheets and then identified by the taxonomists of Bangladesh Forest Research Institution (BFRI) and Institute of Forestry and Environmental Sciences and Department of Botany, Chittagong University.

4.3.5 Equipment used in the field study

The following equipment and materials were used during the field studies and preparation of the herbarium:

- Measuring tape: 50 m metal tape for measuring plots.
- Dia tape: 2 m fiberglass tape for measuring diameter at breast height (DBH).
- Suunto clinometer: height measuring instrument for measuring height of an individual tree.
- Red tape: used to measure plants.
- Long knife and scissor: used to severe twinges and branches and to provide suitable shape of the respective herbarium.
- Sharp small knife: used to provide suitable shape of the respective herbarium.
- Pegs: used to measure plot areas.
- News paper and art paper: used to wrap and convey the specimen.
- Large poly bag: used to collect plant samples for herbarium.
- Plant press: used to press the herbarium sheet.
- Pencil: used to write down the date and information about plants and local people.
- Notebook: used to write down the information about plants and local people.
- Data measurement sheet: to note the height and DBH of plants and local people.
- Identification card: for writing down the local name during herbarium collection.

4.4 Data analysis

After the collection of field data the information were processed and compiled by MS Excel and SPSS. For describing the diameter distribution, six DBH classes were set at interval of DBH 10 cm considering number of individuals in that classes. For the height class distribution six height classes were prepared to study structural compositions of the area.

For 20 dominant species of each study area the basal area, relative density, relative dominance, relative frequency, relative abundance and Importance Value Index (IVI) were calculated (Moore and Chapman, 1986; Shukla and Chandel, 1980) as well as the Family Importance Value. Species richness was measured using Margalef's diversity index. Species diversity was assessed with Simpons's concentration index and Shannon's information index. Similarity index and Pielou's evenness were also measured.

Calculation of stem basal area following Chaturvedi and Khanna (1982) were calculated by the following equation:

$a = 0.7854 \times (DBH)^2$

where, a is the basal area of each tree in m^2 and 0.7854 an empiric constant

The basal area/ha is calculated according to the formula (Shukla and Chandel, 1980):

$$\text{Ba/ha} = \frac{\sum \frac{\Pi}{4} D^2}{\sum area\ \ of\ \ all\ \ quadrats} X \qquad 10000$$

Basal area = $\Pi D^2/4$.

Where, Ba = Basal area in m^2

D = Diameter at breast height in meter

$\Pi = 3.14$

Following the formulas of Moore and Chapman (1986), Shukla and Chandel (1980), and Dallmeier et al., (1992) quantitative structure parameters of investigated trees were calculated:

1. Density of one species = $\frac{\text{Total No. of individuals of one species in all the quadrates}}{\text{Total No. of quadrates studied}}$

2. Relative density of one species = $\frac{\text{Total No. of individuals of one species in all the quadrates}}{\text{Total No. of individual of all species}} \times 100$

3. Frequency of one species = $\frac{\text{Total No. of quadrates in which the species occurs}}{\text{Total No. of quadrates studied}} \times 100$

4. Relative frequency of one species = $\frac{\text{Frequency of one species}}{\text{Sum of all frequencies}} \times 100$

5. Abundance of one species = $\frac{\text{Total No. of individuals of one species in all the quadrates}}{\text{Total No. of quadrates in which the species occurs}}$

6. Relative abundance of one species = $\frac{\text{Abundance of the species}}{\text{Total abundance of all the species}} \times 100$

7. Relative dominance of one species = $\frac{\text{Total basal area of one species in all quadrates}}{\text{Total basal area of all species in all quadrates}} \times 100$

8. Importance Value Index = Relative density + Relative frequency + Relative dominance

According to Martinez (1966), functional diversity is defined as “the variety of interactions with ecological processes” and can be quantified by determining the nature and extent to which functional groups are represented in an ecological system. Functional diversity, evenness and richness were measured using different methods.

Shannon-Wiener Index $(\overline{H})$

This diversity index is computed by using the Shannon-Wiener information index (Shannon-Wiener, 1963) which is:

$$\overline{H} = -\sum Pi \ln Pi$$

Where quantity P_i is the proportion of individuals found for the i^{th} species and is estimated using the maximum likelihood estimator:

$$P_{i} = n_i / N$$

Where n_i is the number of individuals of the i^{th} species. And N is the total number of individuals of all species. The index becomes a maximum when the probabilities (number of individuals) for all species are equal. The result is zero if there is only one possibility.

Simpson's Index

Concentration of dominance is measured by using the calculation of the Simpson's Index, which is calculated according to Simpson (1949):

$$ID = \sum_{i=1}^{S} (ni / N)^2$$

Where,

ID = Index of dominance

S = Number of species

ni = Number of individuals of the i^{th} species

N = Total number of individuals of all species

Similarity Index

Similarity index was calculated according to **Sørensen's** (1957):

IS = (3×D) / (A+B+C)

Where,

IS = Index of Similarity

D = Common species in three sites.

A = Species present in site A.

B = Species present in site B.

C = Species present in site C.

Pielou's Measure of Evenness

Pielou's measure of evenness is calculated according to Pielou (1984):

$E = \overline{H} / \ln S$

Where,

E = Species evenness index

H = Shannon-Wiener Index of diversity

S = Total No. of species

Measurement of species richness

Margalef's Index was used as a simple measure of species richness (Margalef, 1958):

Margalef's index, SR = (S – 1) / ln(N)

Where,

SR = Species richness index

S = Total number of species

N = Total number of individuals in the sample

4.5 Social survey:

Three goals of sustainable development were observed by a socio-economic survey of local people which included the aspects of I) economic well-being II) social and human development and III) environmental sustainability and regeneration.

Social surveys were carried out by a semi-structured questionnaire which covered aspects related to plants, plant diversity, conservation and livelihood. For that survey 25 local people per study area were asked who were at least partly dependent on forest resources for supporting their livelihood (fig 4 and fig 5). In total 75 local peoples' information's were collected from the three different study sites.

Figure 4: Social survey at Sitakunda eco-park

Figure 5: Social survey at Chunati wildlife sanctuary co-management office.

Education of the respondents: Mostly were literate but some were illiterate. 77 % of the children of the respondents were literate, among them 74 % females and 82 % males.

Age of the respondents: In Chunati wildlife sanctuary respondents were aged between 30 and 59, in Dulahazara safari park between 28 and 55 and in Sitakunda eco-park between 26 and 60, getting benefits from the forest and the forest area by different occupations and also collecting NWFPs. Table 2 shows the information of the respondents.

Table 2: Respondents' information of the three study areas.

	Chunati wildlife sanctuary	**Dulahazara safari park**	**Sitakunda eco-park**
Total respondents	25	25	25
Female respondents	10	0	2
Male respondents	15	25	23
Average age	42	40	42
Average family size	6.24	6	6.16
Children information of the respondents			
Female	76	73	76
Male	55	53	53
Literate female	59 1 Graduate, 3 High school pass & 55 Literate	55 2 Graduate, 3 High school pass, 7 School pass & 43 Literate	54 1 High school pass, 1 School pass & 52 Literate
Illiterate female	17	18	22
Literate male	52 2 High school pass, 1 School pass & 49 Literate	36 13 Graduate, 1 High school pass, 2 School pass & 20 Literate	44 2 School pass & 42 Literate
Illiterate male	3	17	9

5. RESULTS

5.1 Ecological characterisation

5.1.1 Soil properties

Fig. 6 shows that sandy loam and sandy loam to clay loam soil properties were dominant. These soil types indicate high fertility for plants and a good habitat for different insects and microorganisms. The average soil humidity was on average 50 %-60 % on all the three study areas.

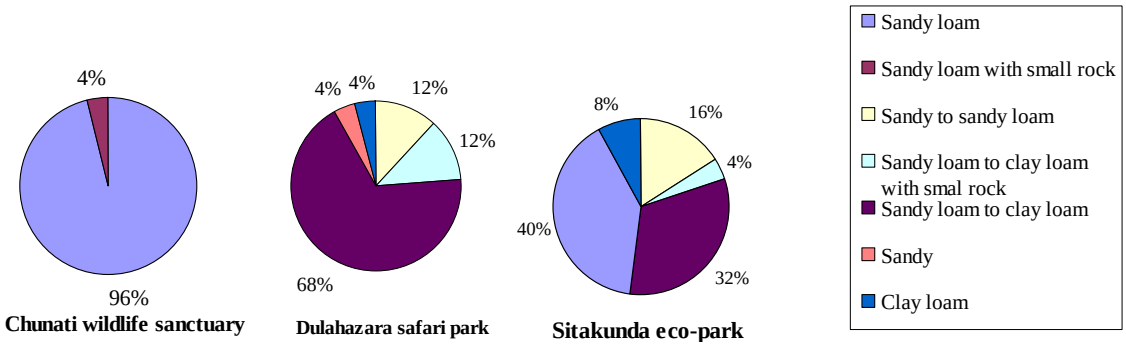


Figure 6: Differences of soil properties in percentages at three different study areas

5.1.2 Soil color

Fig. 7 shows that in the three different study areas, brownish soil color was most dominant, followed by brownish to blackish, blackish and brownish to reddish. Some of the plots of the Dulhazara safari park and Sitakunda eco-park showed reddish soil color with small rocks, which limits the growth and survival of plants, insects and microorganisms, and it is indicated by very little ground vegetation. Some waterlogged areas had clay loam soil with blackish color.

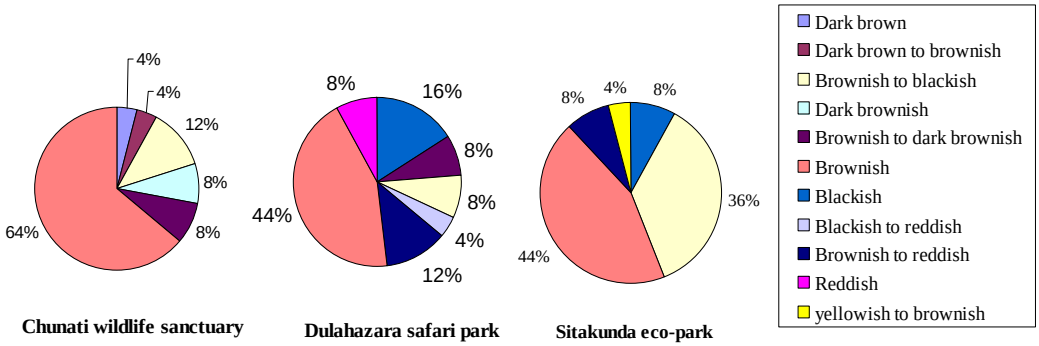


Figure 7: Differences of soil colors in percentages at three different study areas

5.1.3 Crown and vegetation coverage

Crown coverage and vegetation coverage were studied at all three study areas. Fig. 8 shows that the highest average crown coverage was 69 % at Sitakunda eco-park, 48 % for Chunati wildlife sanctuary and 39 % for Dulahazara Safari park.

On the other hand, Dulahazara Safari park had the highest average vegetation coverage (72 %), Chunati wildlife sanctuary and Sitakunda eco-park had more or less the same average vegetation coverage with 65 % and 63 % respectively. For the vegetation coverage the quantity of herbs, shrubs and climbers were estimated.

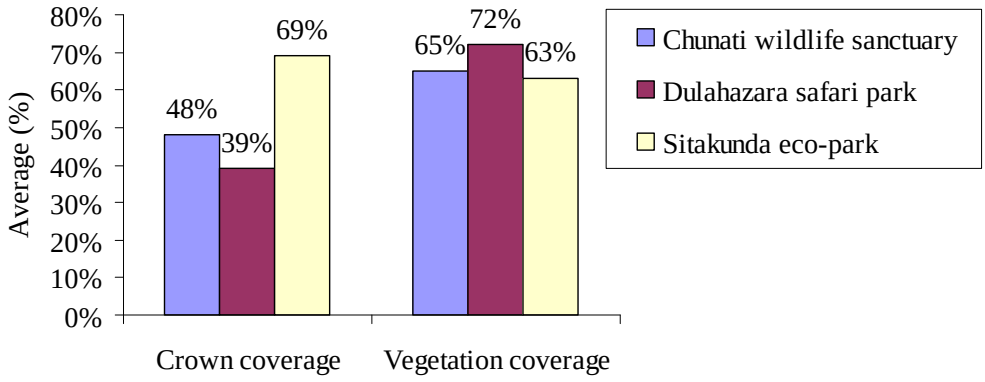


Figure 8: Average percentages of crown coverage and vegetation coverage at the three study areas

5.1.4 Average herb, shrub and climber percentage

Fig 9 shows that more shrubs were available at Chunati wildlife sanctuary (46 %), a lot of herbs (30 %) were found at Sitakunda eco-park and at Dulahazara safari park the highest climber percentage (16 %) in comparison to the other study areas was observed.

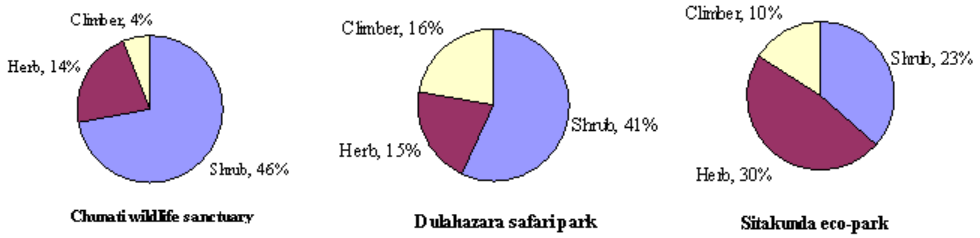


Figure 9: Average herb, shrub and climber percentages at the three study areas

5.2 Biodiversity analysis

5.2.1 Species richness

Regeneration (height < 160 cm) was counted on all 2 x 2 m^2 area plots in all 75 plots. Fig 10 shows that in Chunati wildlife sanctuary 33 different tree species were found in regeneration, Dulahazara safari park had 36 and Sitakunda eco-park had the highest number with 54 different tree species. On the other hand mature trees (height > 160 cm) were counted on 20 x 20 m^2 area plots in all 75 plots. In Chunati wildlife sanctuary 78 different tree species were found. Dulahazara safari park had 55 and Sitakunda eco-park had the highest number of different mature tree species with 146 in the selected sampling areas.

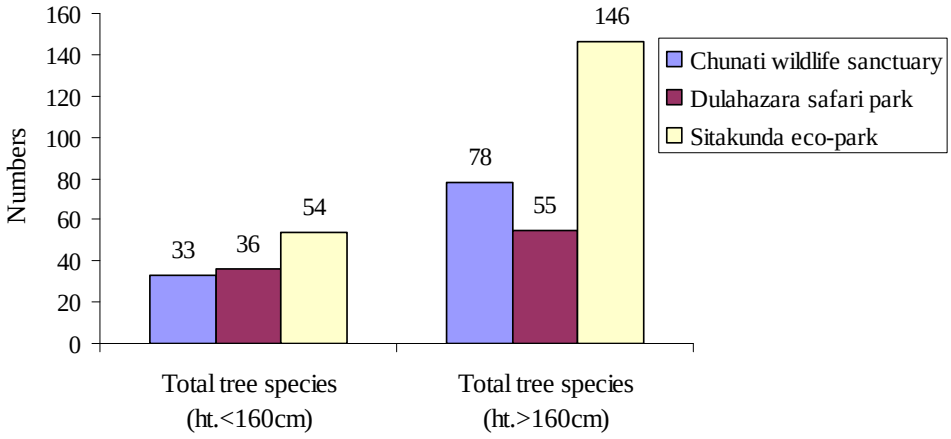


Figure 10: Total tree species counted at the height of < 160 cm and > 160 cm at the selected areas of the three study sites

5.2.2 Trees abundance

In Chunati wildlife sanctuary 25900 n/ha of tree seedlings were counted during the regeneration survey, which is the highest amount of regeneration in all three areas. Dulahazara safari park had 23400 n/ha of tree seedlings and Sitakunda eco-park the lowest numbers (18900 n/ha) of tree seedlings. On the other hand 466 n/ha of mature trees were found in Chunati wildlife sanctuary, 399 n/ha at Dulahazara safari park and 634 n/ha of mature trees were counted at Sitakunda eco-park.

Fig 11 shows that in Chunati wildlife sanctuary 11000 n/ha (42 %) were *Dipterocarpus turbinatus* of the Dipterocarpaceae family, which were most dominant in that area (fig 12), followed by *Acacia auricoliformis* of the Mimosaceae family with 3100 n/ha (12 %), *Holarrhena pabescens* of the Apocynaceae family with 1200 n/ha (5 %), *Syzygium cerasoideum* of the Myrtaceae family with 1100 n/ha (4 %), *Syzygium grande* of the Myrtaceae family and *Vitex peduncularis* of the Verbenaceae family with 1000 n/ha (4 %) each. Beside the above mentioned more 27 species in less quantity were also present in that area.

In Dulahazara safari park 8300 n/ha (35 %) were *Dipterocarpus turbinatus* of the Dipterocarpaceae family, which were also most the dominant in that area (fig 12),

followed by *Aporusa aurea* of the Euphorbiaceae family with 2600 n/ha (11 %), *Syzygium cerasoideum* of the Myrtaceae family with 1600 n/ha (7 %), *Vitex peduncularis* of the Verbenaceae family and *Lagerstroemia speciosa* of the Lythraceae family with 1500 n/ha (6 %) each. Beside those some 31 species were found additionally in that area but in less quantity.

In Sitakunda eco-park, within 189 individuals, 4400 n/ha (24 %) were *Acacia auricoliformis* of the Mimosaceae family, which was the most dominant species regeneration in that area, then *Syzygium cerasoideum* of the Myrtaceae family with 1900 n/ha (11 %), *Albizia lebbeck* and *Albizia procera*, both from the Mimosaceae family with 900 n/ha (5 %) each. Apart those 50 species were found additionally with less quantity in that area.

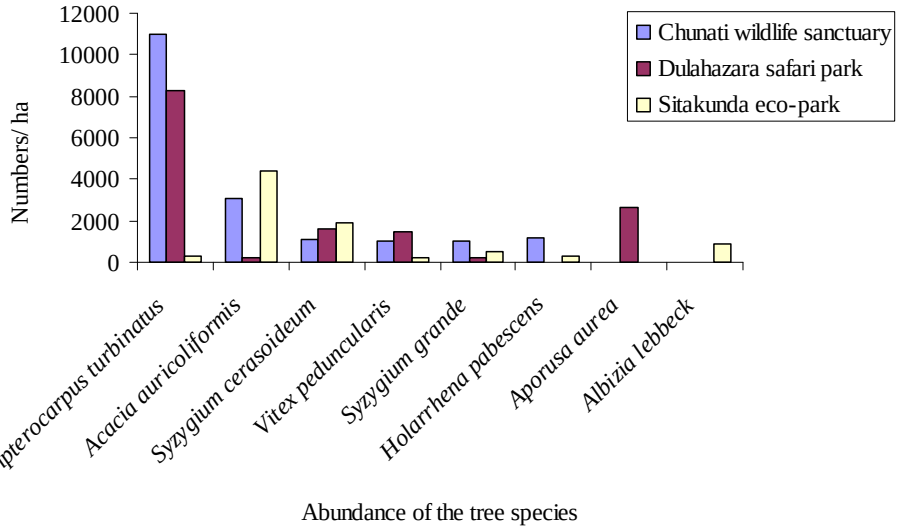


Figure 11: Most dominant tree species regeneration (height < 160 cm) at the three study areas.

Figure 12: Dulahazara safari park area, forest dominated by *Dipterocarpus turbinatus*

There were 25 plots of each study area with 20 x 20 m^2 areas taken to observe the height and diameter at breast height (DBH) of individuals in the three different study areas. Only species with more than 160 cm in height were considered. Fig 13 shows, that in Chunati wildlife sanctuary *Dipterocarpus turbinatus* with 87 n/ha and *Acacia auricoliformis* with 80 n/ha were the most dominant species, followed by *Dipterocarpus alatus* with 33 n/ha and with low occurrence *Dipterocarpus costatus*, *Gmelina arborea*, *Lagerstroemia speciosa*, *Protium serratum*, *Syzygium grande*, and many more. Dulahazara safari park was dominated by *Dipterocarpus turbinatus* with 99 n/ha, followed by *Grewia tiliaefolia* with 23 n/ha, *Castanopsis tribuloides* with 18 n/ha, *Syzygium grande* and *Xylia dolabriformis* with 17 n/ha, *Syzygium cerasoideum*, *Terminalia belerica* and many more.

Sitakunda eco-park was dominated by *Acacia auricoliformis* with 44 n/ha, *Mangifera indica* with 27 n/ha, *Artocarpus heterophyllus*, *Callicarpa arborea* and *Holarrhena pabescens* with 16 n/ha each, *Psidium guajava*, *Eucalyptus camaldulensis*, *Bombax ceiba* and many more with low occurrence.

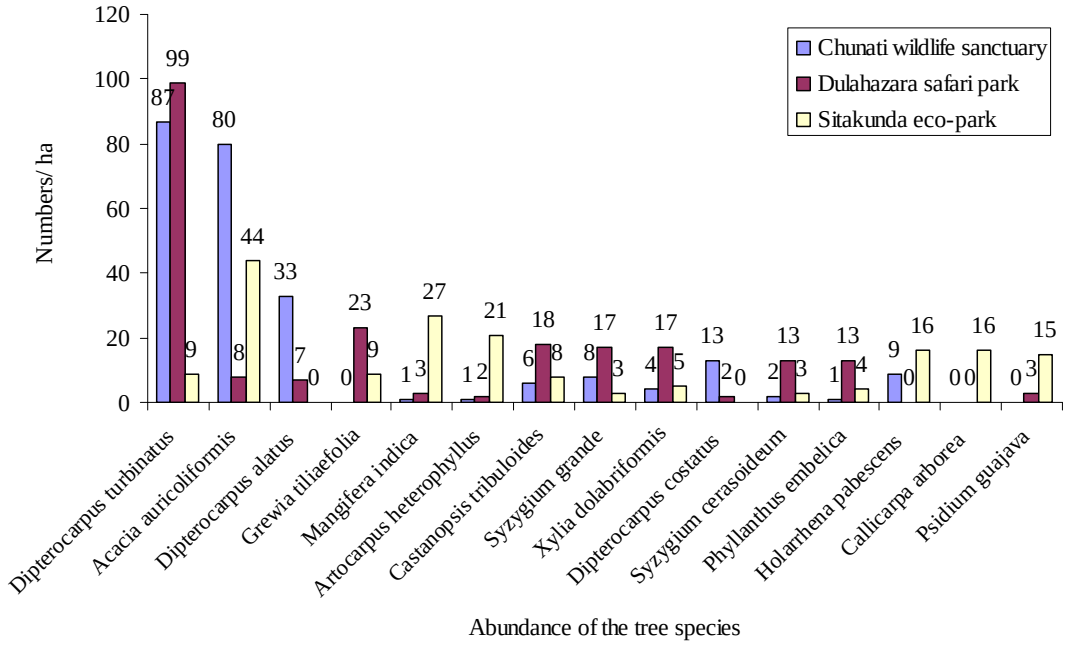


Figure 13: Most dominant mature tree species (height > 160 cm) at the three different study areas.

5.2.3 Abundance of tree families

There were in total 46 families found at the three study areas (fig 14). 30 tree families were found at the Chunati wildlife sanctuary, 26 families at the Dulahazara safari park and the highest number (45) was observed at the Sitakunda eco-park.

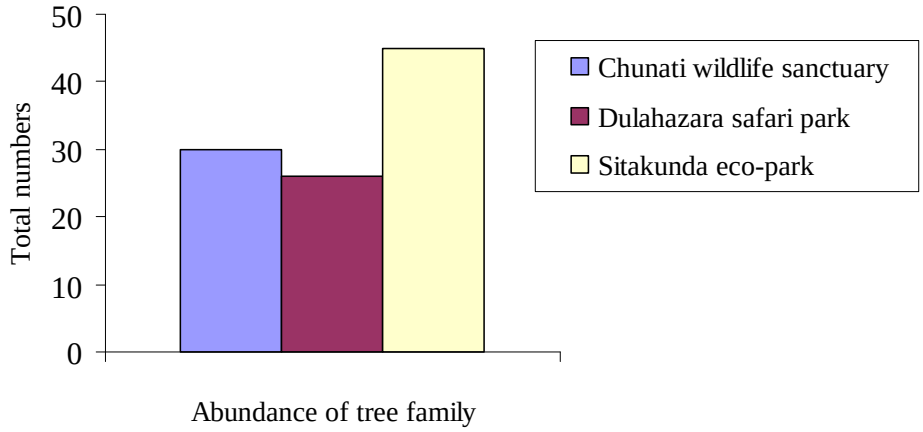


Figure 14: Abundance of tree families at the three different study sites

5.2.4 Structural diversity

Table 3 shows that the highest amount of tree individuals was found at heights below 1.60 m and the lowest stem number at > 32 m height at Dulahazara safari park and Sitakunda eco-park. Chunati wildlife sanctuary had the lowest stem number at 16-24 m height interval.

Table 3: Tree individuals' distribution in different height classes (in m) at the three different study areas.

Height class (in m)	Chunati wildlife sanctuary (n/ha)	Dulahazara safari park (n/ha)	Sitakunda eco-park (n/ha)
< 1.60 m	25900	23400	18900
(1.6 - 8) m	173	109	148
(8 - 16) m	118	156	338
(16 - 24) m	49	44	124
(24 - 32) m	55	55	24
>32 m	71	35	0

Table 4 shows that the highest amounts of tree individuals were available at the DBH of below 10 cm and the lowest amount of tree individuals were > 100 cm DBH at the three study sites.

Table 4: Tree individuals' distribution in different DBH (Diameter at breast height) in centimeter classes at the three study areas.

DBH (cm) class	Chunati wildlife sanctuary	Dulahazara safari park	Sitakunda eco-park
<10 cm	25900	23400	18900
10 - 20 cm	283	250	492
20 - 30 cm	47	44	112
30 - 40 cm	20	24	22
40 - 50 cm	26	9	0
50 - 60 cm	22	15	3
60 - 70 cm	18	19	1
70 - 80 cm	15	15	3
80 - 90 cm	25	20	1
90 - 100 cm	8	2	0
> 100 cm	2	1	0

5.2.5 Dominant tree species composition

Table 5, 6 and 7 show the relative density, relative frequency, relative abundance, relative dominance and importance value index of 20 dominant tree species. It becomes evident that only five tree species (*Dipterocarpus turbinatus, Acacia auricoliformis, Lagerstroemia speciosa, Protium serratum* and *Castanopsis tribuloides*) are occurring at all three study sites within the dominant tree species.

Table 5: The relative density (RD %), relative frequency (RF %), relative abundance (RA %), relative dominance (RDo %) and importance value index (IVI) of 20 dominant tree species at Chunati wildlife sanctuary are listed.

Botanical name	Local name	No	Relative density (RD %)	Relative frequency (RF %)	Relative abundance (RA %)	Relative dominance (RDo %)	Importance value index (IVI)
Dipterocarpus turbinatus	Teli gorjan	87	18.67	15.38	8.71	51.55	85.60
Acacia auricoliformis	Akashmoni	80	17.17	4.62	26.69	1.69	23.47
Dipterocarpus alatus	Dhuli gorjan	33	7.08	13.85	3.67	18.75	39.67
Dipterocarpus costatus	Baytta gorjan	13	2.79	2.31	8.67	11.40	16.50
Gmelina arborea	Gamar	11	2.36	4.62	3.67	0.53	7.50
Lagerstroemia speciosa	Jarul	10	2.15	2.31	6.67	0.20	4.66
Protium serratum	Gutgutia / Chagol nadi	9	1.93	3.08	4.50	0.16	5.17
Holarrhena pabescens	Kurchi	9	1.93	4.62	3.00	0.13	6.67
Madhuca indica	Mahuya	9	1.93	5.38	2.57	0.22	7.54
Syzygium grande	Dhaki jam	8	1.72	6.15	2.00	0.21	8.08
Vitex peduncularis	Goda	8	1.72	5.38	2.29	0.17	7.27
Shorea robusta	Sal	8	1.72	2.31	5.34	0.24	4.26
Aphania danura	Goda horina	7	1.50	4.62	2.34	0.14	6.26
Acacia mangium	Manjium	7	1.50	2.31	4.67	0.43	4.24
Castanopsis tribuloides	Batna	6	1.29	4.62	2.00	0.15	6.06
Anisoptera scaphula	Boilum	6	1.29	4.62	2.00	0.09	5.99
Artocarpus chaplasha	Chapalish	6	1.29	3.85	2.40	0.29	5.42
Swintonia	Civit	6	1.29	3.85	2.40	1.42	6.55

floribunda							
Aphanamixis polystachya	Pitraj / Royna	6	1.29	3.85	2.40	0.18	5.32
Tectona grandis	Segun	6	1.29	2.31	4.00	1.32	4.91

Table 6: The relative density (RD %), relative frequency (RF %), relative abundance (RA %), relative dominance (RDo %) and importance value index (IVI) of 20 dominant tree species' at Dulahazara safari park.

Botanical name	Local name	No	Relative density (RD %)	Relative frequency (RF %)	Relative abundance (RA %)	Relative dominance (RDo %)	Importance value index (IVI)
Dipterocarpus turbinatus	Teli gorjan	99	24.81	18.46	8.54	70.27	113.54
Grewia tiliaefolia	Asar	23	5.76	7.69	4.76	0.51	13.96
Castanopsis tribuloides.	Batna	18	4.51	8.46	3.39	0.37	13.34
Syzygium grande	Dhaki jam	17	4.26	6.15	4.40	1.00	11.42
Xylia dolabriformis	Lohakat	17	4.26	1.54	17.59	2.33	8.13
Phyllanthus embelica	Amloki	13	3.26	4.62	4.48	0.29	8.17
Syzygium cerasoideum	Puti jam	13	3.26	6.92	2.99	0.46	10.65
Terminalia belerica	Bohera	10	2.51	4.62	3.45	0.73	7.85
Protium serratum	Gutgutia / Chagol-nadi	9	2.26	4.62	3.10	0.17	7.04
Lagerstroemia speciosa	Jarul	9	2.26	3.85	3.73	0.96	7.06
Acacia auricoliformis	Akash-moni	8	2.01	3.08	4.14	1.04	6.12
Swintonia floribunda	Civit	8	2.01	3.08	4.14	1.70	6.78
Artocarpus chaplasha	Chapalish	7	1.75	3.08	3.62	0.71	5.54
Dipterocarpus alatus.	Dhuli gorjan	7	1.75	5.38	2.07	5.31	12.45
Vitex peduncularis	Goda	7	1.75	3.85	2.90	0.07	5.67
Terminalia chebula	Haritaki	7	1.75	3.85	2.90	1.21	6.81
Duabanga grandiflora.	Bandor-hola	6	1.50	2.31	4.14	0.12	3.93
Michelia champaca	Champa	6	1.50	1.54	6.21	0.16	3.20
Garcinia cowa	Kao	6	1.50	3.08	3.10	0.32	4.90

Swietenia mahagoni	Meho-goni	6	1.50	1.54	6.21	0.36	3.41

Table 7: The relative density (RD %), relative frequency (RF %), relative abundance (RA %), relative dominance (RDo %) and importance value index (IVI) of 20 dominant tree species' at Sitakunda eco-park are listed below.

Botanical name	Local name	No	Relative density (RD %)	Relative frequency (RF %)	Relative abundance (RA %)	Relative dominance (RDo %)	Importance value index (IVI)
Acacia auricoliformis	Akash-moni	44	6.94	11.83	6.03	11.33	30.10
Mangifera indica	Am	27	4.26	5.92	7.40	7.59	17.76
Artocarpus heterophyllus	Kanthal	21	3.31	4.73	7.19	8.00	16.05
Callicarpa arborea	Bormala	16	2.52	4.14	6.26	1.42	8.09
Holarrhena pabescens	Kurchi	16	2.52	4.14	6.26	1.24	7.91
Psidium guajava	Peyara	15	2.37	2.96	8.22	2.22	7.54
Eucalyptus camaldulensis	Eucalyp-tus	12	1.89	7.10	2.74	4.72	13.71
Bombax ceiba	Shimul	11	1.74	5.33	3.35	6.98	14.04
Acacia mangium Willd.	Manjium	10	1.58	2.96	5.48	1.67	6.21
Grewia tiliaefolia	Asar	9	1.42	4.14	3.52	0.81	6.38
Lagerstroemia speciosa	Jarul	9	1.42	2.37	6.16	1.25	5.04
Calophyllum inophyllum	Pipul / Punial	9	1.42	4.73	3.08	0.95	7.10
Albizia procera	Sada Koroi	9	1.42	4.14	3.52	3.11	8.67
Dipterocarpus turbinatus	Teli gorjan	9	1.42	4.73	3.08	1.30	7.46
Castanopsis tribuloides	Batna	8	1.26	4.14	3.13	0.51	5.91
Protium serratum	Gutgutia / Chagol-nadi	8	1.26	4.73	2.74	0.53	6.52
Adina cordifolia	Holdu	8	1.26	4.14	3.13	0.64	6.04
Albizia lebbeck	Kala koroi	8	1.26	4.73	2.74	2.42	8.42
Euphorbia javanica	Kanjan	8	1.26	3.55	3.65	0.80	5.62
Terminalia catappa	Kat-badam	7	1.10	4.14	2.74	1.08	6.33
Madhuca indica	Mahuya	7	1.10	3.55	3.20	0.68	5.33

Tectona grandis	Segun	7	1.10	1.78	6.39	1.62	4.49

5.2.6 Diversity indices

Basal area (m^2/ha), diversity index, dominance index, evenness index and similarity index were calculated for the three different study areas. The basal area (m^2/ha) was calculated for the trees > 10 cm DBH and Table 8 shows that Chunati wildlife sanctuary had the highest basal area with 53.93 m^2/ha, followed by Dulahazara safari park with 39.06 m^2/ha and Sitakunda eco-park with 16.64 m^2/ha. But species diversity was highest in Sitakunda eco-park with 5.847 followed by Chunati wildlife sanctuary with 3.43 and Dulahazara safari park with 2.985 respectively. At Sitakunda eco-park the dominance index was higher than the Dulahazara safari park and Chunati wildlife sanctuary. And the similarity index of the three study areas was 0.398, which means that species observed at the study areas are almost 40 % similar compare to each other. Comparing the most dominant species, the study areas are 25% similar (table 5, 6 and7).

Table 8: Indices of the three different study areas for all trees > 160 cm height and > 10 cm DBH

	Chunati wildlife sanctuary	**Dulahazara safari park**	**Sitakunda eco-park**
> 10 cm DBH (Basal area m^2/ha)	53.93	39.06	16.64
Diversity Index	3.43	2.985	5.8471
Dominance Index	-0.0764	-0.0584	-0.02928
Evenness Index	0.7873	0.7449	1.1732
Species Richness Index	12.5321	9.0166	22.4735
Similarity Index	0.3978	0.3978	0.3978

5.3 Socio-economic conditions

5.3.1 Utilization of natural resources

The local people of the two different forest sites Chunati wildlife sanctuary and Sitakunda eco-park utilize different forest resources like fire wood, fodder, litter, wild animals, timber and NTWPs.

In Chunati wildlife sanctuary people use mostly the forest trees for producing fire wood and use the forest for fodder and for litter collection. They also depend on the forest for cattle grazing, agricultural activities, timber and NWFPs. Interested people are involved in the co-management system. By this system they get money from selling the wood. In Dulahazara safari park people have no chance to use different resources from the forest, because it is a strictly reserved area. But it is a very famous tourist location. So, the local people earn money by different kinds of tourist recreation activities like constructing hotels, restaurants, parking lots, supplying animals food, taking care of the sick animals, running cosmetic, toy and traditional clothes shops, or different kinds of foods and drinks shops, flower and card shops. In Sitakunda eco-park people use forest resources mostly for fire wood, fodder, litter collection, and very less cattle grazing. Agriculture is located close to the borders of the forest area. They are also allowed to collect NWFPs like bamboos, canes, grasses, mushrooms, fruits and honey from the forest areas.

5.3.2 Tree species preferred by the local people

The local people prefer special tree species for planting them in the forest areas, depended on the management strategies for their personal benefit.

Fig 15 shows that people from Chunati wildlife sanctuary preferred timber trees like *Dipterocarpus turbinatus* and *Acacia auriculiformis.* In the co-management system they can share benefits from the timber species. They also choose some multi-purpose tree species like *Mangifera indica*, *Phyllanthus embelica*, *Terminalia arjuna*, *Protium serratum*, *Terminalia chebula* and *Garcinia cowa*. From those tree species they get firewood, fodder, timber, fruits, medicines and much more at the same time. The people from Dulahazara safari park area have no choice about selecting tree species, because they don’t have the right to collect forest products from the forest areas. The people from Sitakunda eco-park don’t show interest in planting timber trees, because they don’t get benefits from the timber production, but just from NWFPs. So they are interested much more about fruit trees and medicinal trees like *Mangifera indica*,

Phyllanthus embelica, Terminalia arjuna, Terminalia belerica, Protium serratum, Terminalia chebula, Elaeocarpus floribundas or *Garcinia cowa* etc.

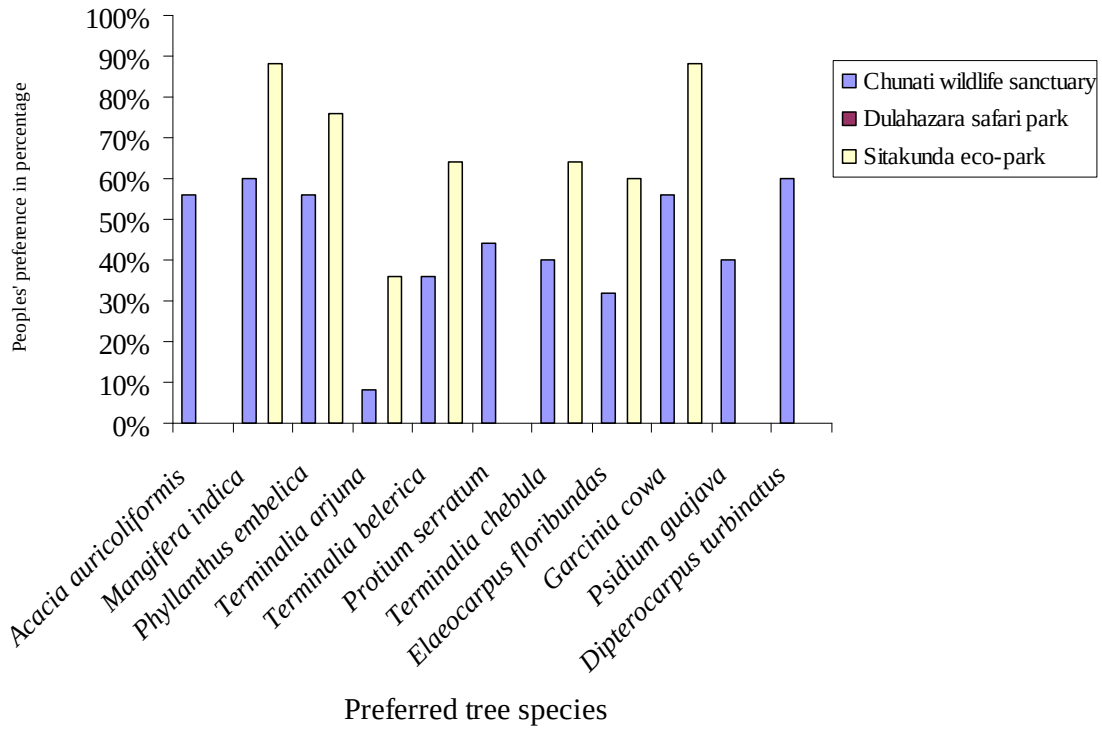


Figure 15: Preferred tree species of the local people at three different study sites

5.3.3 Peoples' perception about forests and its biodiversity

This survey was initiated to find out the basic knowledge about different forest types of local people at the three different forest sites. Fig 16 shows that 100 % of the local people in Dulahazara safari park define forests by naturally grown trees to provide food and habitation. In Chunati wildlife sanctuary and Sitakunda eco-park, 84 % and 92 % people define forests are more related to tourism, timber trees with a mixture of fruit trees and medicinal trees or a natural habitat for wild animals.

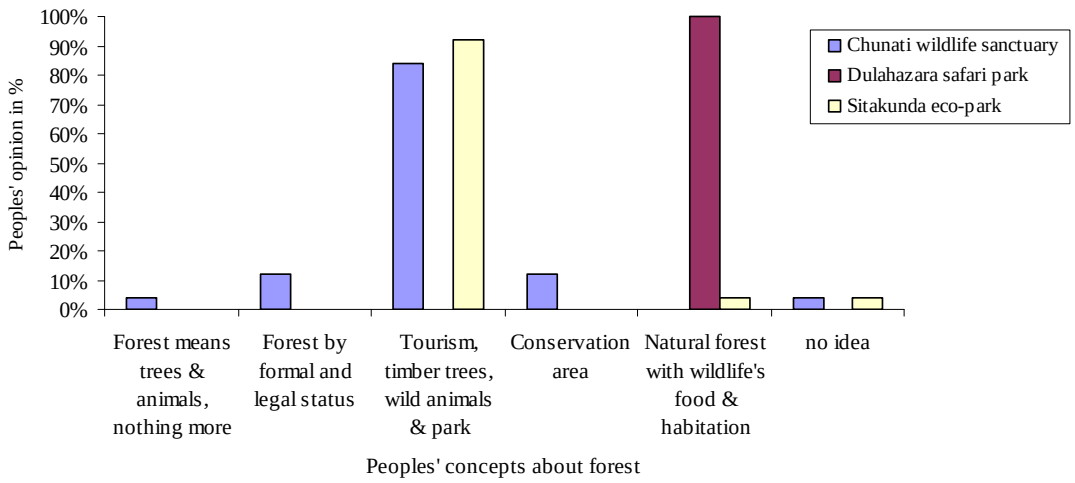


Figure 16: Basic knowledge about different forest types of the local people at the three forest sites.

Fig 16 shows that in Chunati wildlife sanctuary 4 % of peoples' opinion about forests means trees and animals, 12 % of peoples' opinions comprise forests that indicate an organization according to formal and legal rights, 84 % mean that forests are related to tourism, timber trees, wild animals and parks wherever 4 % had no idea about forest. 4 % in Sitakunda eco-park said that forest means naturally grow up trees to provide wildlife's food and habitation and 4 % of all people had no idea about forest.

Local peoples' opinion was additionally observed to examine their understanding about biodiversity. There were three concepts of biodiversity presented. Those were: I) diversity of living organisms and their interactions with each other II) natural wealth, where everything exists to live III) surrounding nature and its variety additionally the respondents could choose from the options IV) something else and V) don't know the concept at all.

Fig 17 shows that the highest percentages (84 % and 56 %) were found in the Chunati wildlife sanctuary and Dulahazara safari park on behalf of the concept of biodiversity I, 56 % of the people in the Sitakunda eco-park had no idea about biodiversity in general.

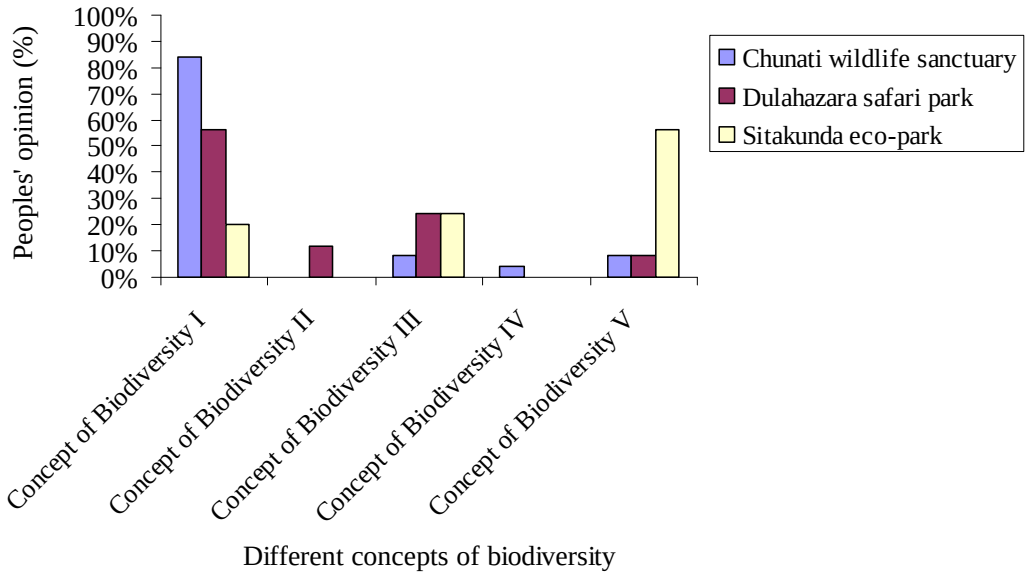


Figure 17: Local peoples' basic knowledge about diversity at the three different study sites

Table 9 shows the relationship between the perception of people about forests and their opinion about biodiversity concept. All 75 respondents were combined in that survey from the three different conservation areas. A high relation (17) was found for the combination of the concepts of "Biodiversity I" and "Forest seen as a combination of tourism, timber trees, wild animals & park" as well as "Forests seen as natural forest with wildlife's food & habitation" (14).

Table 9: Relation between people perception on biodiversity concept

Basic Knowledge about different forest types	Concept of Biodiversity I	Concept of Biodiversity II	Concept of Biodiversity III	Concept of Biodiversity IV	Concept of Biodiversity V
Forest means trees & animals, nothing more	2	1	1		
Forest by formal and legal status	2	1	1		
Tourism, timber trees, wild animals & park	17		5		10
Conservation area	4			1	
Natural forest with wildlife's food & habitation	14	3	7		4
no idea					2

The survey was performed to discover the activeness of local people for forest protection. Fig 18 shows that in Chunati wildlife sanctuary 44 % of all people were active to create awareness and importance about the forest, 64 % of the people protect forest as forest guards, 96 % were involved in tree planting programs as plantation worker. In the area of Dulahazara safari park 4 % were active to create awareness about forests and the importance of forests, 28 % were involved in tree planting programmes and took care of seedlings as a daily labor, 4 % were involved for construction works inside the forest area for tourism and building up protection boundaries around the forest area, 8 % of the surveyed people took care of wild animals inside the forest area and 60 % were not active at all. In Sitakunda eco-park, 52 % of all people were active to create awareness about forests and its importance, 48 % were involved in tree planting programmes as plantation worker.

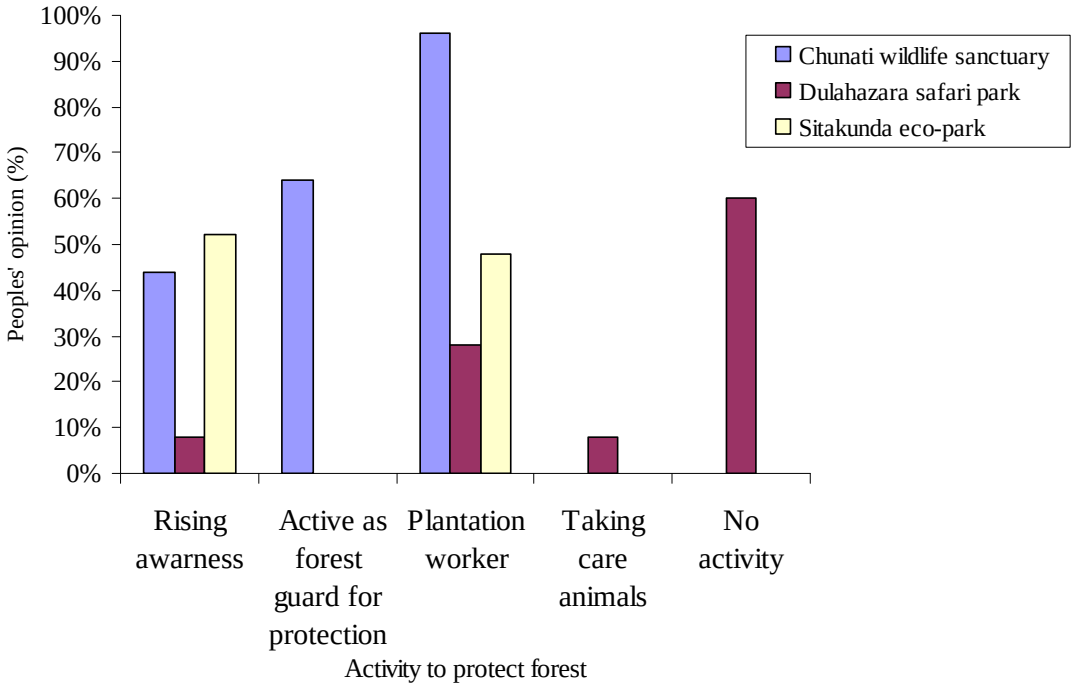


Figure 18: Peoples' opinion about their activeness to protect forests at the three different study sites.

5.3.4 Employment opportunities and income sources

The people who are fully dependent on the forest resources for their livelihood were 26 to 60 years old. Most of the times their children and wives joined them as helping hands

for litter, fire wood and fodder collection. Some of them prefer male descendants to get help for cattle grazing and agricultural activities. In general they had about 6 – 10 family members in total who were partly involved in the activities. Fig 19 shows that in all of the three study areas, on average the people with an age between 30 - 49 years are more involved in different employment activities to earn money for their livelihood.

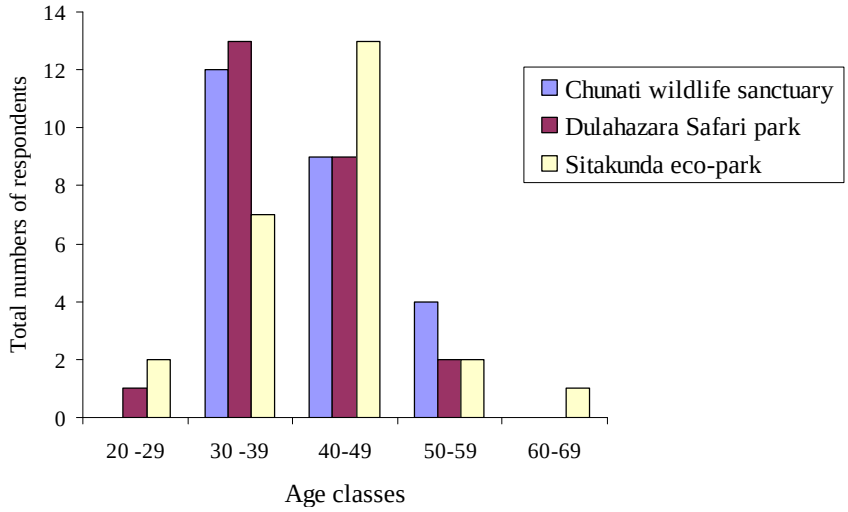


Figure 19: The total number of respondents involved in employment activities to earn money

Fig 20 shows that the local people of the three study sites have different kinds of occupations. Farmer and businessman, farmer and daily labor as well as farmer and service holder were the most common occupations in all the three study sites. In Chunati wildlife sanctuary area farmer and service holder (36 %) and farmer and daily labor (24 %) were most abundant. In Dulahazara safari park area farmer and businessman (52 %) and farmer and daily labor (24 %) were most abundant. In Sitakunda eco-park area farmer and businessman (40 %) and farmer and daily labor (32 %) were the most abundant. Beside these possibilities tourist vehicle driver was a very specific employment opportunity for those living inside of the forest area in Sitakunda eco-park.

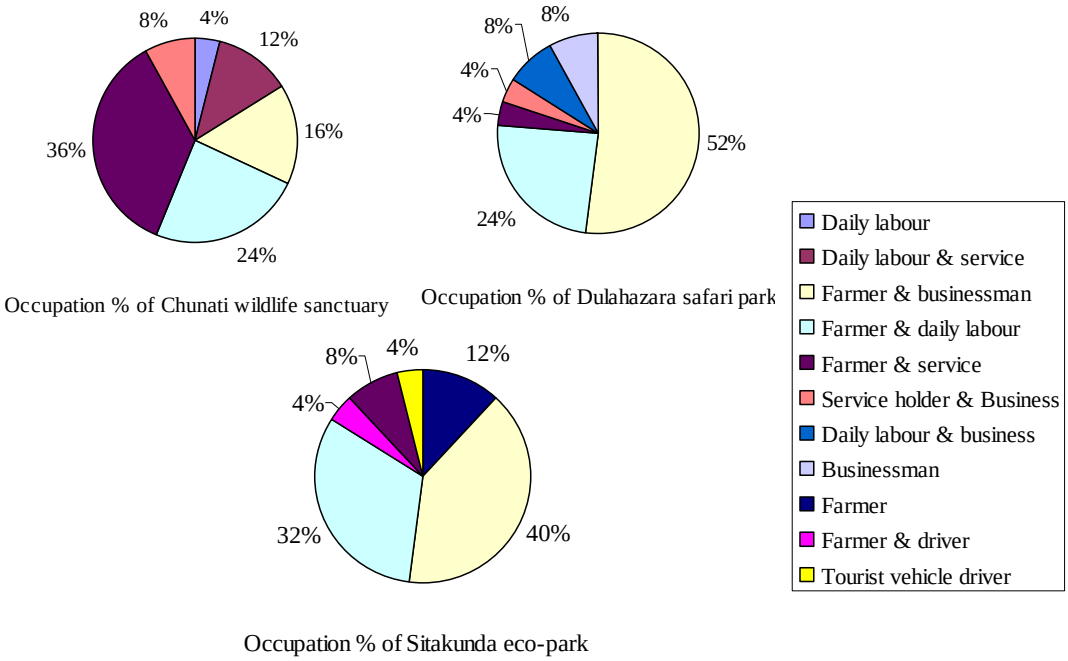


Figure 20: Percentages of different kinds of occupation of the local people

Fig 21 shows that some people had two different occupations to earn money and the average turnover of farmer and businessman combinations were higher than of other employment options. Here, the turnover for every occupation is shown as an average turnover. Usually October to January is the peak time for tourism and the rest of the year is dedicated to agriculture. The people from the Dulahazara safari park area earn more money by tourism (parking lots, selling tickets, food shops, restaurants, hotels, motels, clothes/toys shops, car washing etc.) than in the other two regions. In general they had the highest average turnover about 27,160 Taka per month. The income of the people from Chunati wildlife sanctuary is earned by co-management work, tree planting, tree caring and other forestry services and was on average turnover 15,180 Taka per month. The average turnover of the people from Sitakunda eco-park was about 12,240 Taka per month. 15 years ago small scale farming was the main employment opportunity for all studied areas, but nowadays tourist activity has increased and the local people find at least six different types of income sources in each area.

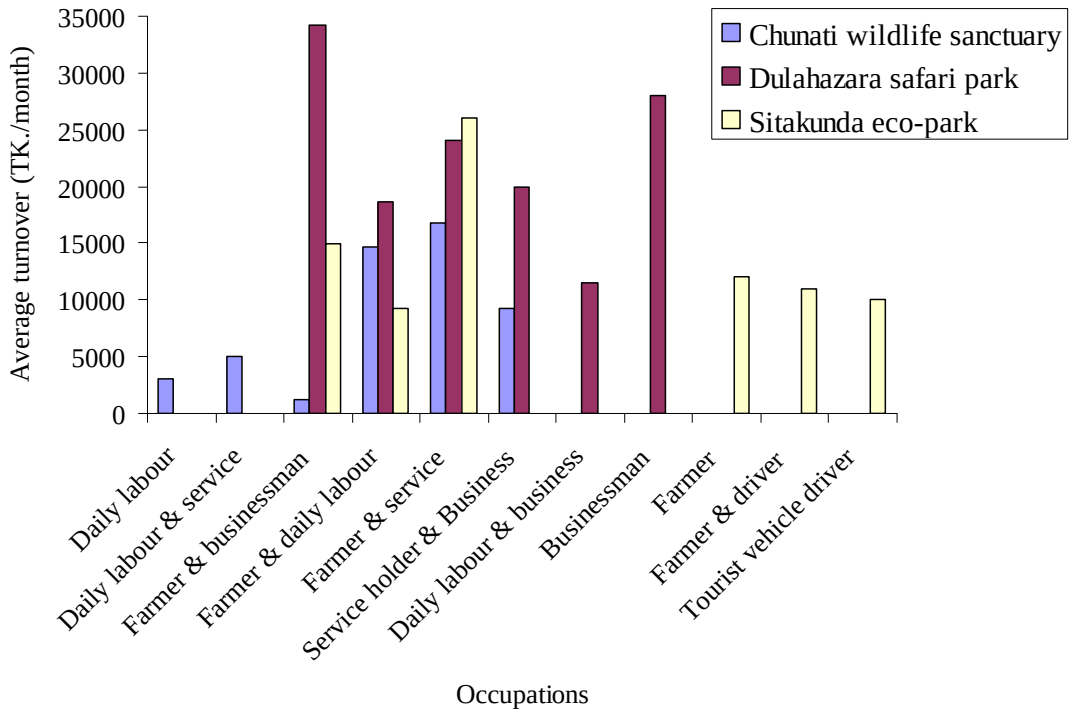


Figure 21: Different income sources and average turnover of the local people

Fig 22 shows that family size has to be considered in calculating the turnover average. In Sitakunda eco-park the turnover per capita (Taka/month) is higher than in Chunati wildlife sanctuary, and Chunati wildlife sanctuary people has more turnover per capita (Taka/month) than Sitakunda eco-park. Farming and forest service combined occupations show the strongest difference in turnover per capita and turnover.

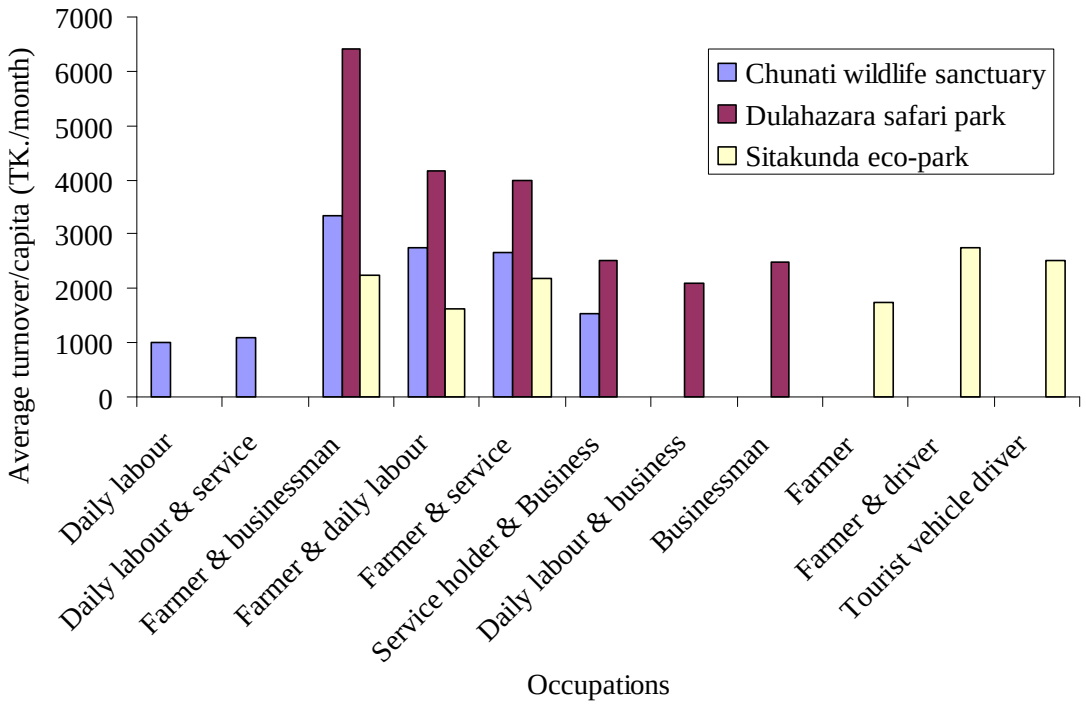


Figure 22: Different income sources and average turnover per capita of the local people

5.4 Planning phase of the three study sites

The survey was done to get to know how people become involved in the planning phase of the three different conservation strategies. At almost all study areas people have been officially involved in the forest improvement planning phase by Divisional Forest Officer (DFO). Fig 23 shows that about 92 % in Chunati wildlife sanctuary, 52 % in Dulahazara safari park and 44 % in Sitakunda eco-park were involved in the planning processes by the DFO. In Chunati wildlife sanctuary some NGOs, financed by United States Agency for International Development's (USAID's), like Integrated Protected Area Co-management (IPAC) and Nisorgo were working with biodiversity co-management projects with local communities and local government. There 52 % and 28 % of the local people were engaged, 12 % of all people were engaged by the local peoples' voting from co-management community and 8 % of the people had no contact to anyone. Also in Dulahazara safari park and Sitakunda eco-park 48 % and 56 % of the

people respectively had no contact to officials. This indicates that the involvement of local people in the planning of activities in general were very low.

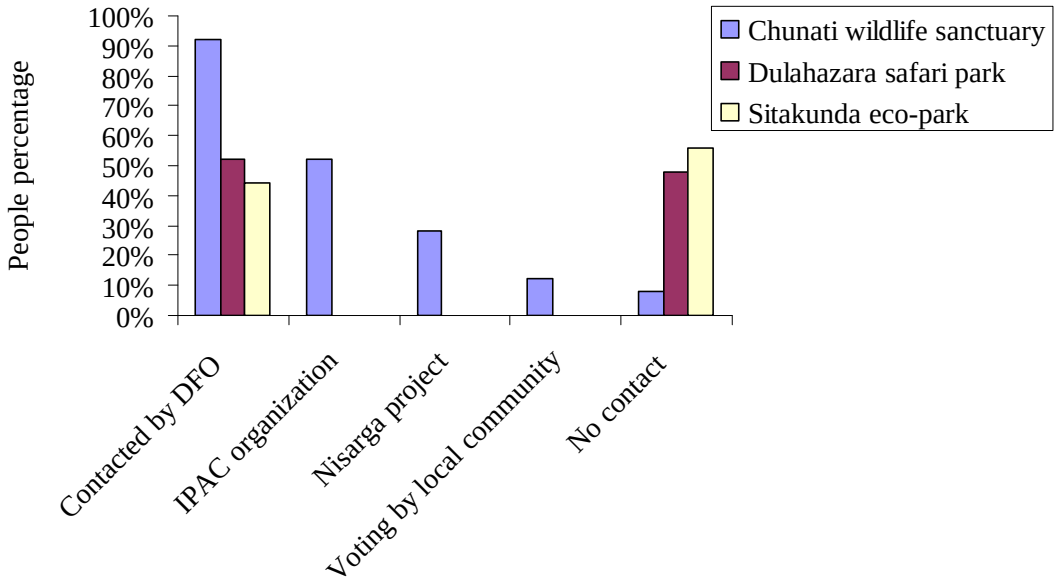


Figure 23: Local peoples' involvement in the planning phase of the three different conservation strategies

5.5 Local peoples' perception about conservation strategy

5.5.1 Improvement of the socio-economical situation

After establishing the Chunati wildlife sanctuary the relationship between local people and the Forest Department (FD) has increased significantly. By declaring as a sanctuary, implementing co-management with benefit-sharing, open discussion of forest problems and initiatives for forest protection and returning encroached agricultural areas, the FD has turned enemies into partners for forest protection and utilization.

At Dulahazara safari park, the local people have taken their chance for increased tourism activities and invested in tourism business as well as infrastructure projects like hotels, motels, hospitals, extended roads and markets.

After the establishment of Sitakunda eco-park the agricultural area decreased in size and led to an increase of the prize for daily things, while on the other hand the variety of indigenous fruits, timbers and medicinal plant species increased. More positive side effects were a hanging bridge over the lake, an increased income by NWFPs, new infrastructure (hotels, motels, and hospitals) and a higher security level inside the park at the main tourist trail.

Fig 24 shows the opinion of respondents about the changes after declaration as have protected land and reserved land. In Chunati wildlife sanctuary tree planting programmes increased by the opinion of 84 % of all people, occupation facility increased for 64 %, infra-structure and awareness for 48 %. In Dulahazara safari park area occupation facilities and infra-structure increased for 96 % compared to the other two study areas, literacy increased for 80 %, land price, animals and birds and awareness increased for 60 %. In Sitakunda eco-park occupation facilities increased for 92 % of the people, land price and infra-structure increased for 84 %, respectively 88 %, tree diversity and income increased for 64 %. At the same time local peoples' opinion on communication, cultural exchange, income, natural animals and birds' quantity in the forest area, tree diversity, land value, literacy among the local people and nursery increased measurably. That indicates that most of the daily life aspects have achieved an uplift of socio-economical conditions.

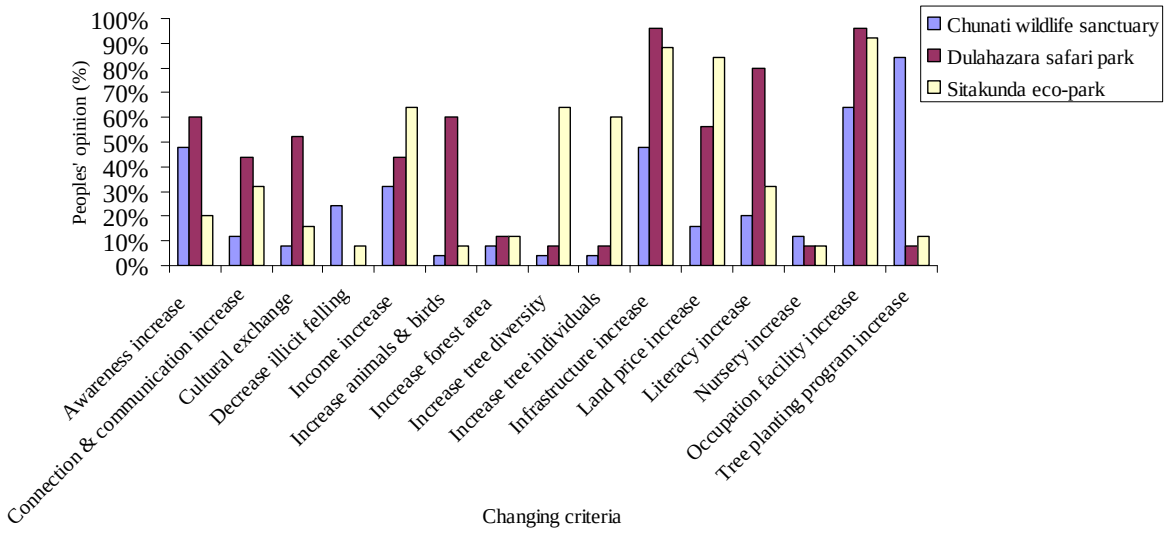


Figure 24: Peoples' opinion about the changes of the three study sites after declaration as protected land and reserved land

5.5.2 Peoples' satisfaction about conservation strategy

The survey was done to find out respondents' agreement about protection works at the three study sites. Fig 25 shows the peoples' opinions on the implemented about protection work in Chunati wildlife sanctuary: 96 % strongly agreed about protection activities and 4 % of the people agreed as well, but not so strong. In Dulahazara safari park 100 % of people strongly agreed and in Sitakunda eco-park 84 % strongly agreed, 12 % agreed and 4 % disagreed about the protection activities in that area.

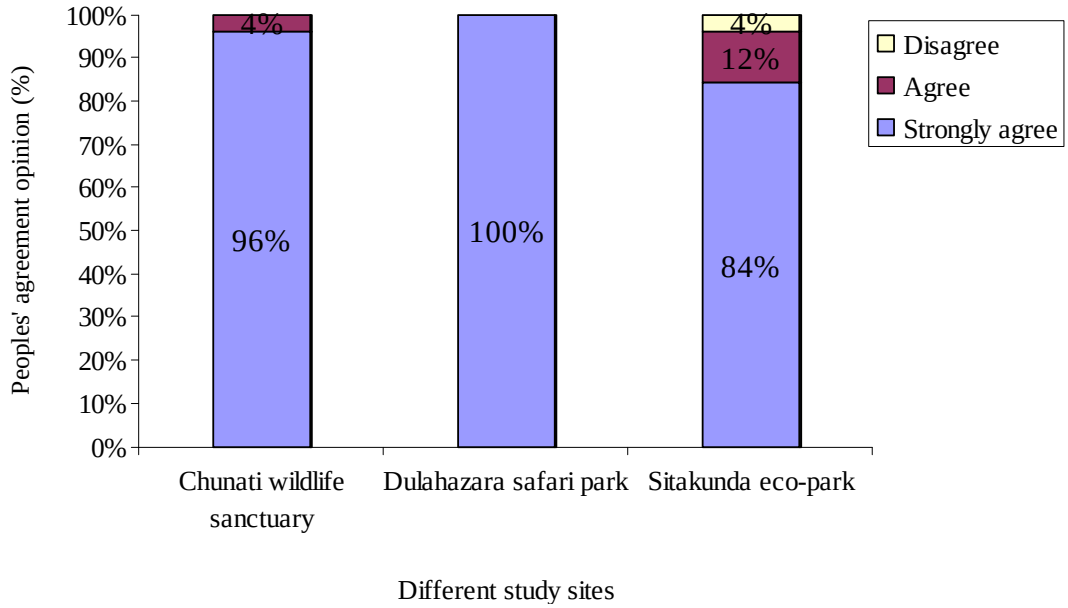


Figure 25: Peoples' agreement (in %) about protection works at the three study sites.

The survey was done to find out the satisfaction about conservation strategies for forest protection and the positive impacts on the forests at the three study sites. The satisfaction about protection procedures (Fig 26) indicates that, in Chunati wildlife sanctuary: 88 % of all people were strongly satisfied about the protection procedures in that area and 12 % were satisfied, but still there is the need for more intensive governmental care. In Dulahazara safari park 92 % of the interviewed people were strongly satisfied, 4 % were not satisfied with protection actions. In Sitakunda eco-park only 4 % were strongly satisfied, 84 % were satisfied. 16 % were not satisfied, because of increasing encroachment. The population pressure increased close to the forest borders.

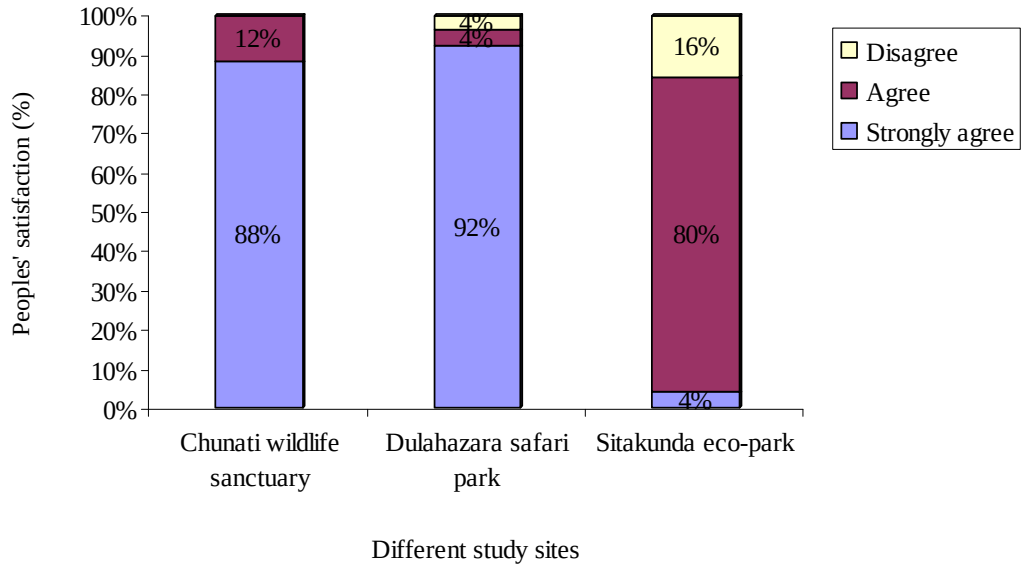


Figure 26: Peoples' satisfaction (in %) about management strategies for forest protection

Figure 27 shows the relationship between average turnover/capita and peoples' satisfaction about conservation strategies for forest protection. The answers of all 75 respondents were combined from the three study sites. The results indicate that the people who have higher income were generally more satisfied about the forest conservation management strategies implemented. 46 people were strongly satisfied with the implemented conservation strategy and their average turnover/capita is 3941 Taka/month. It was found, that some people have opted for "strongly agree" though they have low income per capita because they had no income before. So there is already an improvement for those poor people although only a minor one. Some people were disagreeing about the conservation strategy because they option did not have an impact on their income. Vice versa there were also observations that people, who have a low income, are still positive for the implemented conservation strategy. 22, 23 and 1 respondents were strongly agreed in Chunati wildlife sanctuary, Dulahazara safari park and Sitakunda eco-park area respectively.

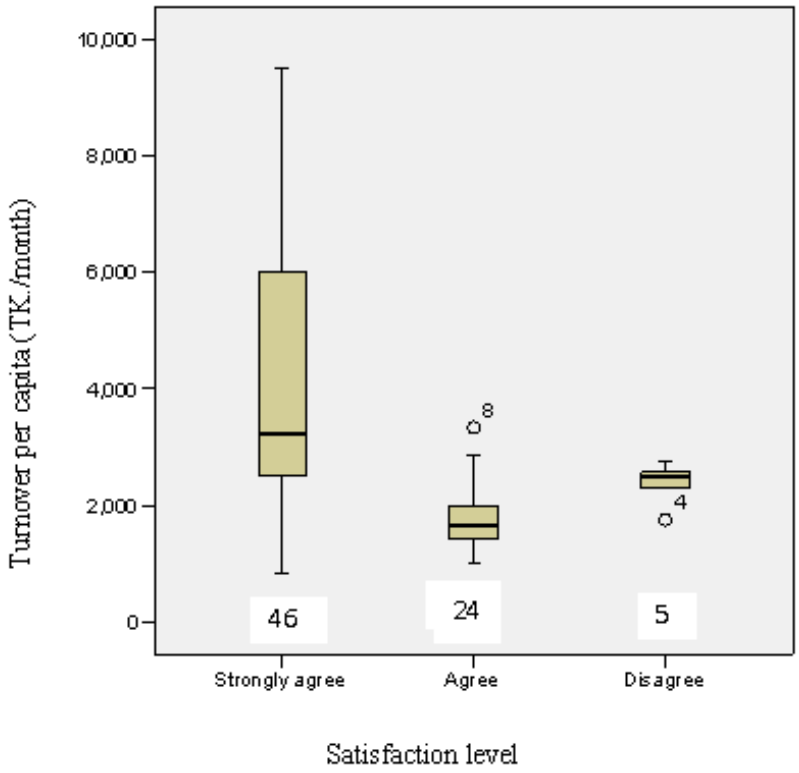


Figure 27: Relation between average turnover/capita and peoples' satisfaction level about conservation strategies for forest protection

Positive impacts from the forest after the declaration of wildlife sanctuary, safari park and eco-park at the three different study areas were the increase in awareness, tourist activity, occupation facility, meeting the firewood demand, increased literacy, NWFPs price, income, improved options for communication and connection, as well as a change of negative impacts retake to cultural exchange and cultural development. Modern infra-structure development led to an overall uplift of the socio-economic conditions in those areas.

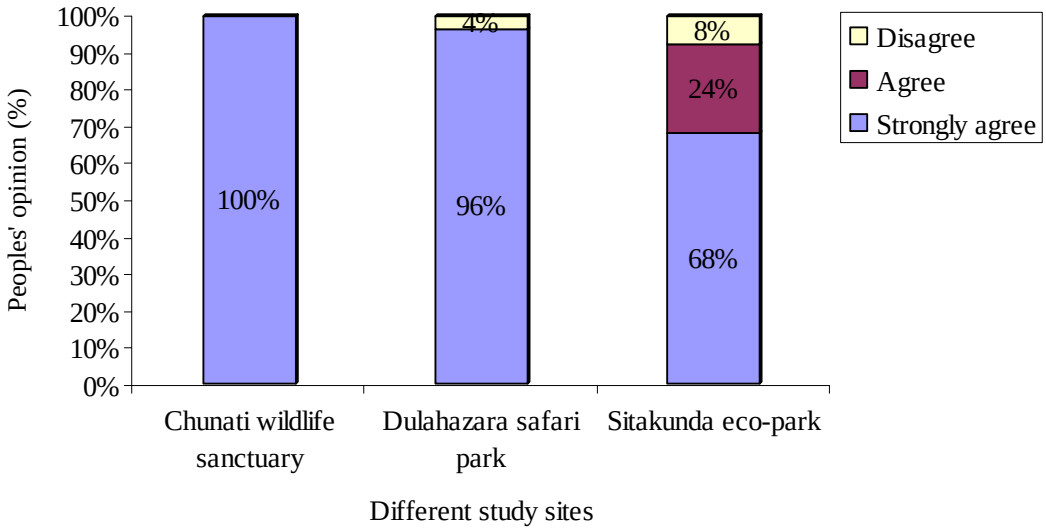


Figure 28: Peoples' opinion (in %) about positive impacts from the three study sites.

Fig 28 shows that in Chunati wildlife sanctuary 100 % of all people were the opinion, that they have experienced positive impacts from the conservation strategies. In Dulahazara safari park, 96 % of people were the strong opinion that they experienced positive impacts from the park and only 4 % disagreed. In Sitakunda eco-park 68 % strongly agreed about the positive impacts, 24 % agreed and 8 % disagreed. Mostly the reasons were no allowance for fire wood collection and cutting timber.

5.5.3 Impact on the social status of the local people

In this survey it was found that the social status of the local people has changed after declaring those areas as wildlife sanctuaries, safari parks and eco-parks. For that reason tree planting programmes or tourism activities increased and the local people found more occupation opportunities than before. Infra-structure, roads, markets, schools, hospitals, income and social facilities increased. This has modified the social status of the local people on the basis of income, education and leadership activity. Fig 29 shows that all people at the Chunati wildlife sanctuary felt that the conservation area changed their social status. 52 % experienced a good and 48 % poor social status. In Dulahazara safari park 28 % of all people had a very good, 32 % a good, 36 % a poor and 4 % a very poor social status. In Sitakunda eco-park 12 % of all people had a good, for 57 % the social

status changed from very poor to poor, 4 % indicates a very poor status and 8 % still no change in their social status.

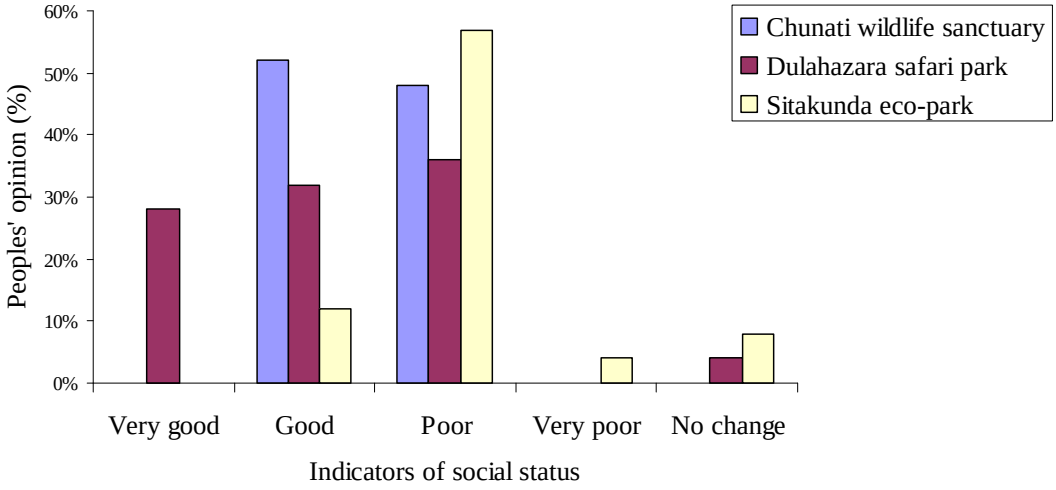


Figure 29: Opinions on a changed social status of the local people

5.6 Disturbances

There are two kinds of disturbances observed: 1) natural disturbance and 2) disturbance by human interventions. Here, the parameters of natural disturbances are soil erosion (in percentages per area), insects attack and wind broken trees (in No. of influenced trees in percentages), animal grazing and fire (in percentages per area). Sometimes animal grazing and fire are also caused by humans, because domestic animals are grazing inside the forest area and fire occurs for shifting cultivations. The parameters of disturbances by human interventions are illegal cutting/thinning (calculated by the No. of stumps), pruning (No. of trees), soil digging (area), tourism (garbage, fire, trampling, broken branches), litter collection (ground coverage) and shifting cultivation (area). Fig 30 indicates that more or less every study area has experienced some disturbances. Among all the disturbances illegal cutting or illegal thinning is highest. Dulahazara safari park has the highest score for illegal cutting followed by Chunati wildlife sanctuary and Sitakunda eco-park. Tourism disturbance was found in a higher rate at Sitakunda eco-park than in Dulahazara safari park followed by Chunati wildlife sanctuary. Soil diggings were found because of construction works for tourism facilities and of course

also some of the soil diggings are done by forest animals like foxes, wild boars, rabbits etc.

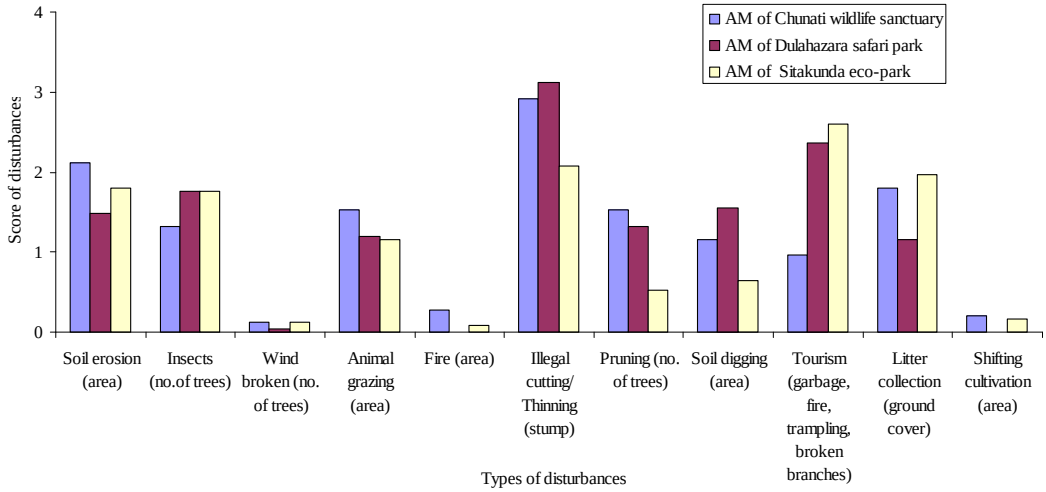


Figure 30: The average disturbance intensities of the three study areas

5.7 Improvement of the three study sites

Table 10 compares the improvement of the three study areas during the established time and 2010. It shows that forest area, crown coverage, biodiversity, peoples' life style, awareness about the forest, literacy, occupation source and income is increased. However, there is a scarcity of NWFPs and the populations at the three sites are also increasing.

Table 10: Comparison between establishing time and now of the three study areas:

	Chunati wildlife sanctuary		Dulahaza safari park		Sitakunda eco-park	
	1986	**2010**	**1999**	**2010**	**1998**	**2010**
Total forest area	7761 ha	7764 ha	300 ha	600 ha with plan of 900 ha	405 ha	808 ha
Total species Nos. (shrubs, herbs, grasses, orchids, epiphytes etc.)	310	107	No idea	↑	No idea	245
Total crown coverage	No data available	↑	No data available	↑	No data available	↑
Biodiversity (animal, bird and tree species)	↓	↑	↓	↑	↓	↑
Soil erosion	↑	↓	↑	↓	↑	↓
Awareness about forest trees	↓	↑	↓	↑	↓	↑
Population	No data available	↑	No data available	↑	No data available	↑
People involved by Co-management	15	29	no co-manage-ment	-	no co-managemen t	-
Occupation sources	↓	↑	↓	↑	↓	↑
Mean turnover	↓	↑	↓	↑	↓	↑
Social status	↓	↑	↓	↑	↓	↑
Literacy	↓	↑	↓	↑	↓	↑
NWFPs	↑	↓	↑	↓	↑	↓
Infra-structure development	↓	↑	↓	↑	↓	↑
Connection & communication	↓	↑	↓	↑	↓	↑
Cultural exchange	↓	↑	↓	↑	↓	↑
Tourism	No tourism	↑	No tourism	↑	No tourism	↑

5.8 Future perception of the local people

Local people were facing some problems during the extraction of forest products. They had some ideas to solve their problems related to the increased demands on forest resources.

In Chunati wildlife sanctuary the problems were related to forest laws and forest officers, to miss of clear rules and regulations, less maintenance and scarcity of forest products.

Their demands were converting some forest lands to agricultural lands; planting more fast-growing timber trees, expand benefit sharing or a co-management system, fruit trees and indigenous tree species plantation, increase of salaries of the forest guards, ownership of the encroached lands and proper silvicultural management. Their personal ideas to solve the problems were to create awareness about the importance of forestry and biodiversity and define clear rules and regulation about co-management and forestry. Additionally they want to decrease the corruption of forest departments, consider active governmental help and increase forest guards. By planting more indigenous and fast-growing tree species, the removal of brickfields from forest areas and stop wood burning in the brickfields would be possible to increase the productivity. Additionally they want to increase training about proper silvicultural management, increase tourist facilities and tourist accommodation and improve the security for tourists by engaging local people and video monitoring.

In Dulahazara safari park the problems were related to forest laws and forest officers. Local peoples' demands were collecting damaged trees as fire wood, more infra-structure to attract tourists, intensive care about tourism activity, secured natural habitat for wild animals, medical service for wild animals and a co-management system with benefit sharing procedure. Their personal ideas to solve the problems were increasing tourist visits in all ages, to build up a co-management system, create awareness about protection, an uncorrupted forest department, engage local people for construction works, flexibility of forest rules, intensive governmental care, more development work and infra-structure for tourism, natural habitat for wild animals and confirmed security for tourists by engaging local people and video monitoring.

In Sitakunda eco-park, the problems were related to forest laws to collect timber, scarcity of forest products and NWFPs. Their additional demands were implementing co-management with benefit sharing activities, more plantations of fruits, fodders and medicinal plants. Additionally they want to increase modern and attractive infra-structure for tourist attractions, increase the open space for NWFPs like bamboo, cane,

plant indigenous timber and fruit species and increase the security for tourists by engaging local people and video monitoring. Their personal ideas to solve the problems were starting up a co-management system with benefit sharing activities, developing a active governmental strategy with forest officials and local people. They want to engage more local people as forest workers and forest guards. They also want to increase modern infra-structure for tourists' attractions, to protect natural habitats for wild animals, stricter rules and regulations to take care of the forest as well as improve the security for tourists by engaging local people and video monitoring.

6. DISCUSSION

6.1 Biodiversity status

The establishment of different tree species is influenced by different factors. In this study 30 tree families were found at the Chunati wildlife sanctuary, 26 families at the Dulahazara safari park and 45 were at the Sitakunda eco-park. In Chunati wildlife sanctuary 33 different tree species were found in regeneration, Dulahazara safari park had 36 and Sitakunda eco-park the highest number with 54 different tree species. On the other hand from the mature trees in Chunati wildlife sanctuary 78 different tree species were found. Dulahazara safari park had 55 and Sitakunda eco-park had the highest number of different mature tree species with 146 in the selected sampling areas. Most dominant tree species and preferred tree species are *Dipterocarpus turbinatus*, *Protium serratum* and *Acacia auricoliformis*. Chunati wildlife sanctuary and Dulahazara safari park have the maximum trees in larger height class and DBH class. Ahmed and Bhuyian (1994) have conducted a regeneration study in the natural forest of Cox's Bazar Forest Division, Bangladesh by quadrates method of each quadrate size 3m × 4m. Twenty years ago Khan (1990) made an exploratory survey in Chunati wildlife sanctuary named "The flora of Chunati wildlife sanctuary" and recorded 477 plant species in this area. Das and Alam (2001) prepared a systematic annotation of 342 species occurring in forests, villages and home gardens, comprising of indigenous, naturalized aliens and exotics introduced in recent past. About 77 species was found in Baraitali forest of Chittagong forest division by Rahman (2002). Nath et.al. (1998) found 85 species (2-ha sampled area) in Sitapahar Forest Reserve of Chittagong Hill Tracts. About 66 species from a 2-ha sampled area in Idgaon Reserve of the Cox'sbazar North Forest Division recorded by Hossain (2001). So it becomes evident, that the number of families and tree species identified in the three study areas are comparable to other studies on species richness in Bangladesh. The figures are also in line with studies in the neighboring countries like India and Nepal. For instance Webb and Sah (2003) enlisted 152 species (49 trees, 45 shrubs, 16 climbers and 42 herbs) from the central Terai, whereas Timilsina et al. (2007) counted 131 species (28 trees, 10 shrubs, 6 climbers and 87 herbs) from the western

Terai of Nepal. Pandey and Shukla (2003) found 208 species (93 trees, 50 shrubs, 34 climbers and 31 herbs) in the eastern Terai and Shankar (2001) examined 87 species (>10cm DBH) in the Darjiling Terai of India. Swampy et al. (2000) listed 82 species (48 trees, 10 shrubs, 8 climbers and 16 herbs) from 250-400m altitude and moist deciduous forest in the Western Ghat of India.

6.2 Dependence on Forest Resources and livelihood's impacts

In Chunati wildlife sanctuary people use mostly the forest trees as fire wood, fodder and for litter. They also depend on the forest for cattle grazing, agriculture, timber and NWFPs. In Dulahazara safari park people earn money by different kinds of tourist recreation activities like constructing hotels, restaurants, parking lots, supplying animals food, taking care of the sick animals, cosmetic shops, toy shops, traditional clothes shops, different kinds of foods and drinks shops, flower and card shops. In Sitakunda eco-park people use forest resources mostly for fire wood, fodder, litter collection, and very less cattle grazing. Agriculture is located close to the borders of the forest area. They are also allowed to collect NWFPs like bamboos, canes, grasses, mushrooms, fruits and honey from the forest areas. Farmer and businessman, farmer and daily labor as well as farmer and service holder were the most common occupations for all over the three study sites. Conservation strategies create different kinds of employment opportunities as well as tourist business and plantation worker for tree planting activity.

Forestry is a productive sector with significant effects on meeting national socio-economic and environmental functions as well as the improvement of rural livelihoods (Mbuvi and Boon 2008). Modern forestry has been evolving towards multiple-use of forests and maintenance of biodiversity. Interest in integrating natural forest dynamics into management planning and silvicultural practices has increased as a result of concerns related to biodiversity values and maintaining ecological functions in managed forests. It is been well established that protection of any scarce natural resource e.g. forests, can not be viewed as a task separate from the people who depend on it for their livelihood. All protected forests should have a buffer zone management plan that

addresses resource management, community development, ecotourism and cooperation with other government and non-government agencies. Buffer zones provide not only an additional layer of protection to existing protected area but also give an opportunity of sustainable resource use to local people (Sharma, 1998). Bajracharya, B. S., et al., (2007) examined the socio-economic impacts of community-based conservation within the Annapurna Conservation Area (ACA), Nepal, through semi-structured interviews and a questionnaire survey with local residents, situated both within and outside the protected area. Results indicated that local communities have received a number of benefits from conservation, including improvements in access to forest resources, improved basic infrastructure such as drinking water, trails and bridges, and improvements in health, sanitation and social services. However, relatively few people (14.9%) within ACA receive direct financial income from tourism. Local communities also experience a number of costs of being involved in conservation, the most significant of which is increased crop damage by wildlife. These results indicated that the socio-economic benefits of community based approaches to conservation can outweigh the costs, even though the latter are significant. Despite some problems, including lack of suitable land for nursery establishment and inadequate level of technical knowledge for high quality seedling management, Ahmed, R., et al., (2008) found that production of tree seedlings is a promising profitable small-scale business.

So it becomes evident, that the income generation activities that have been started in the study areas are promising for the successful implementation of the conservation strategies. The local people are more satisfied and willing to support the idea of conservation management when they have opportunities to increase their livelihood.

6.3 Conservation strategies and co-management

In this study it is found that local peoples' employment opportunity has increased up to six different occupations and turnover/capita (TK. /month) has also increased than before. In Chunati wildlife sanctuary co-management system is already going on and people are aware to restore forest for their needs. Here, 64 % of the people protect forest

as forest guards, 96 % were involved in tree planting programs and took care of the seedlings as a daily labor. In the area of Dulahazara safari park, 28 % were involved in tree planting programmes and took care of seedlings as a daily labor, In Sitakunda eco-park, 48 % were involved in tree planting programmes and took care about seedlings as a daily labor. 88 %, 92 % and 4 % people are strongly satisfied, 12 %, 4 % and 80 % people are satisfied about conservation strategies and co-management system at the Chunati wildlife sanctuary, Dulahazara safari park and Sitakunda eco-park respectively. Their social status is also getting better than before. Uddin and Mukul, (2007) explored the role of NWFPs and home gardens in improving the livelihoods of forest dependent people and forest conservation in and around a newly declared protected area, Satchari National Park. Uddin and Mukul, (2007) found out that 27% of households in the Satchari area receive at least some cash income from NWFPs. Moreover collection, processing and selling of NWFPs constitutes the primary occupation of 18% of these households. They concluded that a co-management approach should be introduced to reduce local dependency on Satchari National Park in Bangladesh. Mukul and Quazi (2007) analysed participatory forestry, co-management of protected areas and highly motivated people who increasingly recognize the need for a healthy forest ecosystem that will provide future economic stability. Co-management strategy in pilot PAs has been demonstrating positive effects in Bangladesh in several studies conducted by the FD. These impacts are visible in a variety of aspects, e.g., preservation of biodiversity, reduction in dependency on forest resources, socio-economic upliftment of local communities, women's empowerment, and self-reliance. Subhani (2008) reported that a majority of female members of the left the profession of fuel wood collection after involvement in co-management activities in Satchari National Park, who feel that their participation helps increase their skills, decision-making power and respect in the eyes of the members of family and society. Nearly half of the women earn income independently in Lawachara. National Park since their participation in co-management, who categorized 'saving money' and 'preserving biodiversity' as the top two reasons for joining Forest User Group (FUG) (Shewly 2008). In Chunati Wildlife Sanctuary, Hoque

(2008) revealed that the socio-economic conditions of the FUG members improved after participation in co-management which made them socially empowered.

A good cooperation between forest departments and forest communities can effectively protect forestlands allowing them to regenerate successfully and thus create a reformation of a dense natural forest (Senbeta et al., 2002). In this study co-management system in Chunati wildlife sanctuary, forest guards, daily labors and plantation workers employment of Dulahazara safari park and Sitakunda eco-park show good cooperation between forest departments and forest communities to protect the conservation areas. Baskent, E.Z., (2008) explained the conceptual framework of an ecosystem-based multiple-use forest management planning focusing on biodiversity conservation and participation. Effective participation is evident only with the involvement of enthusiastic and skillful stakeholders. Therefore this conceptual framework could be seen as a good example for implementing conservation activities in Bangladesh in the future.

6.4 Disturbances in the conservation areas

In this study it was found that illegal cutting happens, because local people are too poor to survive in their life without utility of forest resources. Litter collection and pruning are also disturbances caused because of the need for fire wood. Tourism (garbage, fire, trampling, broken branches) happens, because of lack of garbage facilities and less awareness by not knowing about the future consequences of these illegal dumping. SALM, (2004) investigated patterns of forest structure and tree species diversity in an anthropogenic palm grove and undisturbed areas and found great heterogeneity in forest structure and composition, associated with biotic characteristics of the most important tree species. In general, the principal cause of forest loss in PAs is human-induced removal of woody biomass, in the form of timber and fuel wood. Against the interventions within the stipulated project period, the implementing agencies foresee a reduction in fuel wood removal and illegal logging, which will lead to a gradual re-establishment of forest habitats, especially natural regeneration of trees, shrubs and herb, and consequently support the biodiversity within the PAs (Aziz et al. 2004).

In the Sariska Tiger Project in north-eastern part of Rajasthan, NW India, Yadav and Gupta (2006) analyzed about species richness, diversity, basal cover and importance value index of the woody vegetation to find out the impact on the woody vegetation by anthropogenic disturbances. The study indicated that the original species composition of the undisturbed natural forest may not be restored once changed by human disturbance.

Ramirez-Marcial et al. (2001) studied the influence of anthropogenic disturbance on forest structure and composition in the highly populated Montane Rain Forests of Northern Chiapas, Mexico. They evaluated species richness, basal area and stem density along a categorical disturbance due to forest extraction, livestock grazing and fires and found drastically decreases floristic richness. The model allowed determining how elements such as roads or human settlements proximity, land tenure, shape of the forest patches, slope, soil type, and human population attributes have an impact on the deforestation process. Deforestation was more severe in opened, non flooded areas, with fertile soil, near roads and human settlements. Pasture lands encroachment was recognized as the main cause of forest clearing.

7. CONCLUSION

Forests are key suppliers of renewable resources. The provision of non-marketable goods and services, such as recreation, biodiversity and nature conservation become more and more important. However, the provision of industrial wood is worldwide still of highest importance and has led to overexploitation and destruction of natural forests.

Most of the people live surrounding forest areas are poor and the problem of unemployment is acute. Beside that these forest areas are the main source of fuel wood for local people. So from the last decades on these forests were experiencing severe human interferences. In order to maintain the complexity of the forest and its' species diversity, an economical management plan is desirable with a minimum in disturbance to the forest ecosystem. This conclusion is pointing to the necessity of protecting an entire forest, to conserve its' species composition and diversity. Therefore, a regular diameter and height distribution should be maintained on each site and a proper silvicultural management system needs to be followed. To regenerate the forest to its normal composition and natural environment, large scale reforestation should be undertaken in enrichment plantation areas with the help of local people by planting pre-dominantly native trees. Rehabilitation of degraded and encroached land is urgently needed in these areas. Whatever the options might be active community participation is a critical factor for long term success; the focus must be on participatory forestry by co-management and the implementation of in-situ conservation strategies.

The results indicate that the existing forests are rich in species diversity and co-management is an important alternative strategy for conserving the forest. By this co-management system local people and forest both are beneficial from each other, forest is managed by a sustainable way and people have some income sources.

8. RECOMMENDATION

The existing protection and conservation principles in managing natural resources follow the conventional strategies that do not include participation of local communities in planning and management which causes severe challenges. Some recommendations for a better protection and management of the forests can be given:

- New policies that promote conservation and the equitable use of biodiversity should be implemented. The policy should promote people's participation in nature conservation and sustainable management of resources. People living close to conservation areas should be able to require their demands but still avoiding to convert natural forest to manmade forest.
- The ongoing participatory forestry project of the forest departments should be revised to provide adequate funding to the participants and make provision for off farm employment activities. The coordination and collaborations between the participants, forest departments and NGOs should be strengthened in order to support the in-conservation of forests.
- A revision of the ongoing in-situ and ex-situ conservation strategies should be done in order to learn about the efficiency and effectiveness of the implemented programs.
- The effects of conservation strategies on different levels of biodiversity should be observed.
- Knowledge exchange of the findings from different case studies should be considered in order to improve in-conservation management on the long run.

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APPENDIX

Appendix 1: List of all tree species

Species code	Local name	Scientific name	Family	Family code
1	Agor	Aquilaria agallocha Roxb.	Thymelaeaceae	1
2	Akashmoni	Acacia auricoliformis Willd.	Mimosaceae	2
3	Akorma	Litsea monopetala	Lauraceae	
4	Am	Mangifera indica Linn.	Anacardiaceae	3
5	Amloki	Phyllanthus embelica Linn.	Euphorbiaceae	4
6	Amra	Spondias pinnata Kurtz.	Anacardiaceae	
7	Anargola/Ambarela	Myristica longifolia Wall.	Myristicaceae	5
8	Arjun	Terminalia arjuna Bedd W&A	Combretaceae	6
9	Arsol	Vitex peduncularis Wall	Verbenaceae	
10	Asar	Grewia tiliaefolia Vahl.	Tiliaceae	7
11	Ashoth	Ficus religiosa Linn.	Moraceae	8
12	Asok	Saraca indica	Caesalpiniaceae	
13	Ata	Anona squamosa	Anonaceae	
14	Aurocaria	Aurocaria excelsa	Coniferaceae	
15	Babul	Acacia nilotica	Mimosaceae	
16	Bakul	Mimusops elengi	Sapotaceae	
17	Bandor lathi	Cassia fistula Linn.	Caesalpiniaceae	
18	Bandorhola	Duabanga grandiflora Roxb.ex.Dc.	Sonneratiaceae	9
19	Banspata	Podocarpous nerifolia Wendl.	Podocarpaceae	10
20	Bara hariana	Erioglossum rubiginosum	Sapindaceae	
21	Batna	Castanopsis tribuloides A.Dc.	Fagaceae	11
22	Bauhinia	Bauhinia variegata	Caesalpiniaceae	
23	Baytta gorjan	Dipterocarpus costatus Gaertn.	Dipterocarpacea e	12
24	Bazna	Zanthoxylum budrunga	Rutaceae	
25	Bel	Aegle marmelos Linn.	Rutaceae	13
26	Bhora	Macaranga indica	Euphorbiaceae	
27	Bilati Amra	Spondias dulcis Solex Park	Anacardiaceae	
28	Bilati gab	Diospyros philippeninsus Desr.	Ebenaceae	
29	Bilimbi	Averrhoa bilimbi	Averrhoaceae	
30	Bish Gach	Cleistanthus collinus	Euphorbiaceae	
31	Bisoal	Acacia pennata (L) Wild.	Fabaceae	
32	Bohal	Cordia dichotoma	Boraginaceae	14
33	Bohera	Terminalia belerica Roxb.	Combretaceae	
34	Boilum	Anisoptera scaphula Roxb.	Dipterocarpacea	

			e	
35	Bokain	Melia sempervirens (Linn.) All	Meliaceae	15
36	Bormala	Callicarpa arborea	Verbenaceae	
37	Boroi	Zizyphus mauritiana	Rhamnaceae	16
38	Borta	Artocarpus lakoocha (Roxb.)	Moraceae	
39	Bot	Ficus benghalensis Linn.	Moraceae	
40	Chakua koroi	Albizia chinensis (Osb). Merr.	Mimosaceae	
41	Chalmorga	Hydnocarpus kurzii	Bixineae	
42	Chalta	Dillenia indica Linn.	Dilleniaceae	17
43	Champa	Michelia champaca Alba.	Magnoliaceae	18
44	Chapalish	Artocarpus chaplasha Roxb.	Moraceae	
45	Chatiyan	Alstonia scholaris Rbr.	Apocynaceae	19
46	Chickrassi	Chickrassia tabularis Juss.	Meliaceae	
47	Choi asol	Vitex pebescens	Verbenaceae	20
48	Civit	Swintonia floribunda Griff.	Anacardiaceae	
49	Debdaru/ Pendula	Polyalthia longifolia Benth & Hook	Anonaceae	21
50	Dhaki jam	Syzygium grande (Wt.) Wall.	Myrtaceae	22
51	Dhali Batna	Quercus velutina Lindl.	Fagaceae	
52	Dhamon	Grewia laevigata	Tiliaceae	
53	Dharmara	Stereospermum personatum	Bignoniaceae	
54	Dhoramara	Stereospermum chelonioides DC	Bignoniaceae	23
55	Dhuli gorjan	Dipterocarpus alatus Rox.ex.Don.	Dipterocarpacea e	
56	Dhup gach	Canarium resiniferum	Burseraceae	
57	Domor	Ficus roxburghii Wall.	Moraceae	
58	Eucalyptus	Eucalyptus camaldulensis Dehn.	Myrtaceae	
59	Gab	Diospyros embryopteris	Ebenaceae	24
60	Gamar	Gmelina arborea Roxb.	Verbenaceae	
61	Gelonium	Suregada multiflora	Euphorbiaceae	
62	Goda	Vitex peduncularis Wall.	Verbenaceae	
63	Goda horina	Aphania danura Roxb.	Sapindaceae	25
64	Gutgutia/ Chagol nadi	Protium serratum Engl.	Burseraceae	26
65	Halud Krishnachura	Peltophorum pterocarpum	Caesalpiniaceae	
66	Hargoja	Dillenia pentagyna Roxb.	Dilleniaceae	
67	Haritaki	Terminalia chebula Retz.	Combretaceae	
68	Hijal	Barringtonia acutangula	Lecythiadaceae	27
69	Holdu	Adina cordifolia	Rubiaceae	
70	Horina	Evioglossum edule Linn.	Sapindaceae	
71	Ichchori	Anogeissus acuminata Wall.	Combretaceae	
72	Ipil-ipil	Leucaena leucocephala	Mimosaceae	
73	Jacaranda	Jacaranda mimusifolia	Bignoniaceae	

74	Jambura	Citrus grandis Linn.	Rutaceae	
75	Jamrul	Syzygium samarangense	Myrtaceae	
76	Jangli Badam	Sterculia foetida L.	Sterculiaceae	
77	Jarul	Lagerstroemia speciosa (Linn.)	Lythraceae	28
78	Jhau	Casuarina equisetifolia	Casuarinaceae	29
79	Joga Domor	Ficus racemosa L	Moraceae	
80	Jolpai	Elaeocarpus floribundas	Elaeocarpaceae	30
81	Kadam	Anthocephalus chinensis	Rubiaceae	31
82	kaju badam	Anacardium occidentale	Anacardiaceae	
83	Kak domor	Ficus hispida Linn.f.	Moraceae	
84	Kala koroi	Albizia lebbeck	Mimosaceae	
85	Kali batna	Quercus acuminata	Fagaceae	
86	Kalo jam	Syzygium cuminii	Myrtaceae	
87	Kamranga	Averrhoa carambola Linn.	Averrhoaceae	32
88	Kanaidinga	Oroxylum indicum	Bignoniaceae	
89	Kanchol vadhi	Bischofia javanica Bl.	Euphorbiaceae	
90	Kanjan	Euphorbia javanica	Euphorbiaceae	
91	Kanthal	Artocarpus heterophyllus Lamk.	Moraceae	
92	Kao	Garcinia cowa Roxb.	Guttiferae	33
93	Katbadam	Terminalia catappa Linn.	Combretaceae	
94	Kechuya	Aporusa aurea Hook	Euphorbiaceae	
95	Keonra	Glochidion multiloculare	Euphorbiaceae	
96	Khudi jam	Syzygium fruticosum Roxb.	Myrtaceae	
97	Kodtbel	Feronia limonia Linn.	Rutaceae	
98	Kork plant	Quercus suber L.	Fagaceae	
99	Krishnachura	Delonix regia (Boj) Raf.	Caesalpiniaceae	34
100	Kurchi	Holarrhena pabescens Wall.	Apocynaceae	
101	Kusum	Schleichera oleosa	Sapindaceae	
102	Lambu	Chickrassia indica	Meliaceae	
103	Litchi	Litchi chinensis Sonner.	Sapindaceae	
104	Lohakat	Xylia dolabriformis Benth. (K. Kerrii)	Leguminosae	35
105	Lotkon	Bixa orellana Linn.	Bixaceae	36
106	Mahuya	Madhuca indica J.F.Gmel	Magnoliaceae	
107	Mandar	Erythrina fusca	Papilionaceae	37
108	Mandar	Erythrina ovalifolia	Papilionaceae	
109	Manjium	Acacia mangium Willd.	Mimosaceae	
110	Mehogoni	Swietenia macrophylla King.	Meliaceae	
111	Mehogoni	Swietenia mahagoni (Linn.) Jacq.	Meliaceae	
112	Menda	Litsea sebifera	Lauraceae	
113	Minjiri	Cassia siamea Lam.	Caesalpiniaceae	

114	Modon mosta	Dehasia kurzii King.	Lauraceae	38
115	Motor koroi	Albizia lucida Benth.	Mimosaceae	
116	Nageshor	Mesua nagassarium	Guttiferae	
117	Naglingom	Couroupita guianensis	Lecythiadaceae	
118	Nali jam	Syzygium claviflorum (Roxb.)	Myrtaceae	
119	Neem	Azadirachta indica A. Juss.	Meliaceae	
120	Nona	Anona reticulata	Anonaceae	
121	Nudusa	Cassia javanica	Caesalpiniaceae	
122	Pakur	Ficus infectoria Roxb.	Moraceae	
123	Petuk	Pterocarpus indicus Will.	Fabaceae	39
124	Peyara	Psidium guajava Linn.	Myrtaceae	
125	Pine	Pinus caribaea	Coniferaceae	40
126	Pipul/Punial	Calophyllum inophyllum Linn.	Guttiferae	
127	Pitraj/ Royna	Aphanamixis polystachya Wall.	Meliaceae	
128	Polash	Butea monosperma (Lam) Taub.	Leguminosae	
129	Puti jam	Syzygium cerasoideum (Roxb.) Raizada	Myrtaceae	
130	Putranjiba	*Drypetes roxburghii* (Wall.)	Putranjivaceae	41
131	Radhachura	Caesalpinia pulcherima Sweet.	Caesalpiniaceae	
132	Raintree	Samania saman (Jacq) Merr.	Leguminosae	
133	Raj koroi	Albizia richardiana	Mimosaceae	
134	Rakta kambal	Adenanthera pavonica	Mimosaceae	
135	Raktan	Lophopetalum fimbriatum	Celastraceae	42
136	Ritha	Sapindus mukorossi	Sapindaceae	
137	Sada Koroi	Albizia procera	Mimosaceae	
138	Safeda	Achras sapota	Sapotaceae	43
139	Sajina	Moringa oleifera	Moringaceae	44
140	Sal	Shorea robusta Gaertn.	Dipterocarpaceae	
141	Segun	Tectona grandis Linn.f.	Verbenaceae	
142	Sheora	Ficus heterophylla Linn.	Moraceae	
143	Shimul	Bombax ceiba (Linn.)	Bombacaceae	45
144	Shiuri	Anogeissus lanceolata Wall.	Combretaceae	
145	Sinduri	Mallotus phillippinensis	Euphorbiaceae	
146	Sonalu	Cassia nodosa Linn.	Caesalpiniaceae	
147	Tamal	Diospyros montana	Ebenaceae	
148	Tejbohal	Cinnamonum cicidodephne Meis	Lauraceae	
149	Tejbohal	Cinnamonum iners Reinw	Lauraceae	
150	Teli gorjan	Dipterocarpus turbinatus Gaertn.	Dipterocarpaceae	
151	Telsur	Hopea odorata Roxb.	Dipterocarpaceae	

152	Tetul	Tamarindus indica	Caesalpiniaceae	
153	Tetuya koroi	Albizia odoratissima (L.f.) Benth	Mimosaceae	
154	Toon/ Suruj	Toona ciliata	Meliaceae	
155	Tut gach	Morus indica Linn.	Moraceae	
156	Udol	Sterculia villosa Roxb.	Sterculiaceae	46
157	Uri am	Mangifera longipes Griff	Anacardiaceae	
158	Vadhi/ Jiga/ Jiol	Lannea coramandelica (Houtt.)	Anacardiaceae	
159	Vhadi	Garuga pinnata	Burseraceae	

Appendix 2: Tree species and disturbance survey

Plot no. Hill position
Plot size: 20 m * 20m Aspect (North/South):
Site description: (soil properties, soil type, color, humidity)

Vegetation coverage: % (Shrub: %, Herb: %, Climber: %, other: %)

Class of the tree
LT= Large tree >20m, ST= Small tree>10<20, P= Pole 5m – 10m, S= Sapling 160cm-5m

Tree species name	Class	DBH	Tree species name	Class	DBH

Regeneration of tree species: Plot size (2m * 2m) Plot No:
Vegetation coverage: % (Shrub: %, Herb: %, Climber: %, other: %)

Tree species	Height < 160 cm	Total nos.

Plot size: 20m * 20m Plot no:

1. Natural disturbances:

	V. high >75%	High %51-75%	Low 26-50%	V. low 0-25%	Recent/Past/M= recent + past
1.1: Soil Erosion (area)					

	V. high >75%	High %51-75%	Low 26-50%	V. low 0-25%	Recent/Past/M= recent + past
1.2 Insects (no. of trees)					

	V. high >75%	High %51-75%	Low 26-50%	V. low 0-25%	Recent/Past/M= recent + past
1.3 Wind broken (no. of trees)					

	V. high >75%	High %51-75%	Low 26-50%	V. low 0-25%	Recent/Past/M= recent + past
1.4 Animal grazing (area)					

	V. high >75%	High %51-75%	Low 26-50%	V. low 0-25%	Recent/Past/M= recent + past
1.5 Fire (area)					

2. Human interventions:

	V. high >75%	High %51-75%	Low 26-50%	V. low 0-25%	Recent/Past/M= recent + past
2.1 Illegal cutting/ Thinning (stump)					

	V. high >75%	High %51-75%	Low 26-50%	V. low 0-25%	Recent/Past/M= recent + past
2.2 Pruning (no. of trees + height)					

	V. high >75%	High %51-75%	Low 26-50%	V. low 0-25%	Recent/Past/M= recent + past
2.3 Soil digging (area)					

	V. high >75%	High %51-75%	Low 26-50%	V. low 0-25%	Recent/Past/M= recent + past
2.4 Tourism (garbage, fire, trampling, cutting branches)					

	V. high >75%	High %51-75%	Low 26-50%	V. low 0-25%	Recent/Past/M= recent + past
2.5 Litter Collection (ground cover)					

	V. high >75%	High %51-75%	Low 26-50%	V. low 0-25%	Recent/Past/M= recent + past
2.6 Shifting Cultivation (area)					

Appendix 3: Questionnaire

1. Name of the area:
2. Respondents information:

Name of respondents:

Age……, Vill……. Union:……..…., No of map unit:……..

3. Occupation: a) Farmer, b) Daily labor, c) Service, d) Businessmen

Source of income-a) Service, b) Business, c) Agriculture, d) Labor.

4. Income (monthly/yearly):

From which source?

5. What is the gain from forest area?

6. Average family size.

Sex	0-10yrs		10-20yrs		20-30yrs		30-50yrs		>50yrs	
		Education		Edu.		Edu.		Edu.		Edu.
Male										
Female										

Education: I= Illerate, B= Below S.S.C, S= S.S.C-H.S.C, G= Graduate

7. How do you get benefit from that area?

a) Fuelwood collection
b) Fodder collection
c) Litter collection
d) Hunting wild animals
e) Cattle grazing
f) Agriculture
g) Cutting timber
h) NTFP

8. Utilization of species

SI No	Species	Uses (*)									
		Fruit	Timber	Poles & rafts	Juice	Agri. Implements	Fuel	Fencing	Fodder	Handicrafts	Support To creepers

9. Which plant species are most important and why?

10. Which species you prefer for planting?

a) Fruit :
b) Timber :
c) Medicine :
d) Fodder :
e) Other :

11. Why?

12. Do you face any problem for forest product collection?

a) Forest officer
b) Forest laws
c) Distance
d) Scarcity of forest products

13. What is your additional demand from that forest land?

14. What is your comment to solve the problem?

15. Do you know what eco-park and national park is? Protected forest? In-situ conservation? The area where have you worked for which purpose?

16. What do you understand under the concept of biodiversity?

- diversity of living organisms and their interactions with each other
- natural wealth, where everything exists to live
- surrounding nature and its variety
- something else
- don't know the concept at all

17. How you been involved during the planning phase of the protected area?

- Contacted by DFO
- By governmental work processing
- Any other organization
- No contact

18. What changes occurred after the declaration this area as a protected land?

19. Social status:

Previous	Present	No change

1= very good, 2= Good, 3= poor, 4= very poor

20. Have you been involved in protection measure until now? By which activity?

21. Could you please give an answer to the following statements?

I think that is it really important to maintain tree species and animals in this area:

☐ strongly agree ☐ agree ☐ disagree ☐ strongly disagree

☐ I can´t answer

The way how this protected area is managed by government is appropriate:

☐ strongly agree ☐ agree ☐ disagree ☐ strongly disagree

☐ I can´t answer

The status of this area as protection zone (ecopark, wildlife Sanctuary, Safari Park) has a positive impact on the livelihood of myself / my family:

☐ strongly agree ☐ agree ☐ disagree ☐ strongly disagree

☐ I can´t answer

Appendix 4: Secondary Data from Forest Office

Reason for establishment:

Strategy for establishment:

Establishment data: Area, Total tree species, Species name, any endanger or threatened species, conservation purpose, Economic purpose, Environmental purpose

After 10 years of establishment: What changes occur?

Present data: Area, Total tree species, Species name, any endanger or threatened species, conservation purpose, Economic purpose, Environmental purpose

Expectation: What are the basic changes? What are the improvements and problems?

What does Forest Department think about peoples' benefit from that area?

Do Forest department has any conflict with local people?

Which tree species Forest department prefer to plant? Why? Is it related to local people benefit?

What do forest department think that about which activities most benefit for local people?

1. Fuel wood collection
2. Fodder collection
3. Litter collection
4. Hunting wild animals
5. Cattle grazing
6. Agriculture
7. Cutting timber
8. NTFP

PICTURES

1. Photographs of Chunati wildlife sanctuary

Pic 1: Crown coverage of Chunati wildlife sanctuary

Pic 2: Vegetation coverage of Chunati wildlife sanctuary

Pic 3: Fire wood collection by poor woman at Chunati wildlife sanctuary

Pic 4: Social survey at Chunati wildlife sanctuary

Pic 5: Co-management meeting at Chunati wildlife sanctuary

Pic 6: Tourism at Chunati wildlife sanctuary

2. Photographs of Dulahazara safari park

Pic 7: Crown coverage of Dulahazara safari park

Pic 8: Vegetation coverage of Dulahazara safari park

Pic 9: Disturbances at Dulahazara safari park

Pic 10: Tourism at Dulahazara safari park

3. Photographs of Sitakunda eco-park

Pic 11: NWFPs collection at Sitakunda eco-park

Pic 12: Fuel wood collection at Sitakunda eco-park

Pic 13: NWFPs collection at Sitakunda eco-park

Pic 14: NWFPs market at Sitakunda eco-park

Pic 15: Tourism at Sitakunda eco-park