TREE REGENERATION, DIVERSITY AND CARBON STOCK IN TWO COMMUNITY MANAGED FORESTS OF TANAHUN DISTRICT, NEPAL

A Dissertation Submitted for the Partial Fulfillment

of Master of Science in Botany

Institute of Science and Technology,

Tribhuvan University,

Kathmandu, Nepal

Submitted by:
PRAKASH GAIRHE
Batch: 2068/2069
Exam Roll Number: 18219
T.U. Registration Number: 5 -1-48-3002-2002

Central Department of Botany,
Tribhuvan University, Kritipur, Kathamandu

February, 2015

TRIBHUVAN UNIVERSITY
INSTITUTE OF SCIENCE AND TECHNOLOGY
CENTRAL DEPARTMENT OF BOTANY

Ref No:

KIRTIPUR, KATHMANDU
NEPAL

Tribhuvan University
Central Department of Botany
Kirtipur, Kathmandu

RECOMMENDATION

This is to certify that **Mr. Prakash Gairhe** has completed this dissertation work entitled "**Tree Regeneration, Diversity and Carbon Stock in Two Community Managed Forests of Tanahun District, Nepal**"as a partial fulfilment of Masters of science Degree in Botany under my supervision with special paper "Ecology and Resource Management". This is his original research work and has been carried out under my supervision. To the best of our knowledge, this thesis work has not been submitted for any other degree in any institution.

Devkota
....

Dr. Anjana Devkota
Supervisor
Lecturer
Central Department of Botany,
Tribhuvan University,
Kritipur, Kathmandu.

February, 2015

Phone: 4331322, 4332636, Fax: ++977-1-4333515, Post Box: 26429
E-mail: info@cdbtu.edu.np, Webpage: www.cdbtu.edu.np

TRIBHUVAN UNIVERSITY
INSTITUTE OF SCIENCE AND TECHNOLOGY
CENTRAL DEPARTMENT OF BOTANY
OFFICE OF THE HEAD OF DEPARTMENT

Ref. No.

KIRTIPUR, KATHMANDU
NEPAL

Tribhuvan University Central Department of Botany Kirtipur, Kathmandu

LETTER OF APPROVAL

The dissertation work entitled "**Tree Regeneration, Diversity and Carbon Stock in Two Community Managed forests of Tanahun District, Nepal**" submitted by **Mr. Prakash Gairhe** has been accepted as a partial fulfillment of the requirements for Masters of Science in Botany (Ecology and Resource Management).

EXPERT COMMITTEE

....

Supervisor
Dr. Anjana Devkota
Lecturer
Central Department of Botany
Tribhuvan University,
Kathamandu, Nepal.

....

Internal Examiner
Prof. Dr. Pramod Kumar Jha
Professor
Central Department of Botany
Tribhuvan University
Kathamandu, Nepal

....

External Examiner
Dr. Deepa Dhital
Senior Scientific officer
Nepal Academy of Science and Technology Khumaltar
Lalitpur, Nepal.

....

Head of Department
Prof. Dr. Pramod Kumar Jha
Professor
Central Department of Botany
Tribhuvan University
Kathmandu, Nepal.

Date of Examination: March 15, 2015

Phone: 4331322, 4333722 Fax: ++977-1-4332636, Post Box: 26429
E-mail: info@cdbtu.edu.np, Webpage: www.cdbtu.edu.np

ACKNOWLEDGEMENT

This study would not have been possible to complete without the kind and helpful co-operation of many individuals. It is my pleasure to example my special respect, gratitude and appreciation to Prof. Dr. Pramod Kumar Jha, Head of the central Department of Botany for granting me an opportunity to conduct the research for the partial fulfillment of the Master Degree in Botany.

I express my gratitude to my supervisor Dr. Anjana Devkota, Lecturer, Central Department of Botany ,Tribhuvan University who showed great interest and provided excellent guidance to complete this dissertation. I am indebted for her valuable suggestion and supervision.

I am very much indebted to Cornell Nepal study Program (CNSP) for providing me the necessary financial support for this research work.

I would also like to extend my special thanks to Prof. Dr. Mohon Siwakoti for his help in species identification and equally to Dr. B. B. Shrestha, Dr. R.K.P.Yadav, Dr. S.K. Ghimire, Dr. C.B. Baniya and all the faculty members of Central Department of Botany, T.U, for their guidance in respective fields. Thanks are due to administration of Central Department of Botany for providing me necessary Instruments during field study.

I would like to thank my Father; Benu Prasad Gairhe, Mother; Mina Gairhe, Brothers; Laxman Gairhe, Bishnu Bastola, Pushpa Raj Pudasaini, Bishal Bhandari, Sisters; Jamuna Gairhe, Manisha Sharma, Deepa Gairhe and all of my friends for their continuous support during study.

Special thanks goes to authorities of Taldanda community forest and Fulbari community forest, district forest office, Range post of Bhimad VDC and Dulegauda Tanahun for providing me place to conduct research. I want to thank Department of Hydrology and Metrology Babarmahal, FRA Office and REDD+ office of department of Climate change kathmandu for providing me necessary data.

February 2015

Prakash Gairhe

ABSTRACT

Studied community forests lie in low elevation (500m to 620 m) of western Hill in Tanahun district of Nepal. Taldanda Community forest (TF) of Dulegauda VDC is regenerating forest and being managed by communities since twenty years, while Fulbari Community forest (FF) of Chang VDC is older and growing.

Carbon stock of tree species of both forest were determined by allometric regression model and species diversity by Simpsons and Shannon –weaver index. Fulbari CF found to have lower value of tree carbon stock (71.11 per ha) as well as tree diversity (H1=0.9978) than the carbon stock (109.82 ton per ha) and diversity (H1=1.1835) of Taldanda CF. Statistical analysis through T- test did not show significant difference for mean values of their carbon stock and density but significant different in mean value of diversity, DBH and basal area of two forest types.

ANOVA- Test showed significant difference between the mean values of carbon stock and diversity among the strata of Fulbari CF (log carbon, *P=0.00* and log H1, *p=0.001*) while test did not show significant difference in mean values carbon stock (*p=0.001*) but significant difference in diversity (*p=0.0045*) among the strata of Taldanda CF. There was no significant difference in other stand attributes like density, basal area and DBH among the strata of both forest types.

Two way ANOVA showed Proximity of strata from road or settlement had significant effect on carbon stock among the strata in Fulbari CF (*p=0.003*) but there was no significant effect of recent disturbance (*p=0.882* in Fulbari CF and *p=0.18*1 in Taldanda CF) and combined effect of both proximity and disturbance (*p=0.226* in Taldanda CF and *p=0.138* in Fulbari CF) on tree carbon stock in both forest types. *Shorea robusta* was found the single dominant species in Fulbari CF (higher value of Simpsons index and basal area) and contribute about 64% of carbon stock while in Taldanda CF *Shorea* contribute 44% of carbon stock . *Shorea* along with *Schima* also have comparable dominancy in Taldanda CF.There was Significant positive correlation and relationship of carbon stock with diversity (R^2=0.371, *p=0.0023*) in Fulbari CF, while density showed significant positive relationship with carbon stock and tree diversity of Taldanda CF.

TABLE OF CONTENTS **PAGE NO:**

LIST OF FIGURES **PAGE NO:**

LIST OF TABLES

ABBREVIATIONS AND ACRONYMS

°C	Degree celcius
%	Percentage
AGB	Above ground biomass
ANOVA	Analysis of variance
BA	Basal area
C	Carbon stock
CF	Community forest
CFMs	Community managed Forests
CFUG	Community forest User Group
Cm	centimeter
COP	Conference of parties
DBH	diameter at breast height
DFO	District Forest Office
DOF	Department of Forest
DNPWC	Department of National Park and Wildlife Conservation
et al.	and others
FAO	Forest Agriculture Organization
FF	Fulbari Community Forest
FRA	Forest Resource Assessment
GHGs	green house gases
GoN	Government of Nepal
Ha	hectare
HH	house hold
IPCC	Intergovernmental panel on climate change
KATH	National Herbarium and Plant laboratory
km	kilometer
$m^2 .ha^{-1}$	meter square per hectare
m^2	meter square
ml	Milliliter
MoPE	Ministry of Population and Environment
MoFSC	Ministry of Forest and Soil Conservation
ppm	parts per million
REDD	Reducing Emissions from Deforestation and Degradation
SOC	soil organic carbon
TUCH	Tribhuvan University Central Herbarium
TF	Taldanda community Forest
$t\ ha^{-1}$	Ton per hectare
UNFCCC	United Nations Framework Convention on Climate Change

1. INTRODUCTION

1.1 Background

Forest store large quantity of carbon in the living biomass, soil and litter and exchange the carbon with atmosphere through respiration and photosynthesis. Significant quantity of carbon can be sequestered in land and vegetation layers by regeneration of disturbed forest and conservation of forest (Brown *et al.* 1996). Carbon stock in forest ecosystem refers to the amount of carbon stored in forest ecosystem, mainly in living biomass and soil, but to a lesser extent also in dead wood and litter. So determination of carbon stored in living biomass is essential to know that present amount of carbon stored as well as make suitable measure for the future.

Carbon emission from deforestation account for an estimated 20% of global carbon emission (IPCC 2007), second only to that produced by fossil fuel combustion (Campbell *et al.* 2008). Growing trees and other vegetation capture Carbon dioxide (CO_2) from atmosphere and combine it with water to produce sugar and carbohydrates. A ton of carbon in trees as a result of removal of 3.87 tons of CO_2 from the atmosphere (Hunt 2009).

Climate change will affect the carbon cycle in a way that will result in an excess amount Carbon dioxide (CO_2) in the atmosphere (IPCC 2013).

Carbon dioxide is major green house gas and its concentration in the atmosphere has been increasing steadily since 1958 (Keeling *et al.* 1959). According to IPCC the level of CO_2 in today's atmosphere is 31% higher than it was in the industrial revolution about 250 years ago. Today's level of atmospheric CO_2 has risen to 375 ppm from the past level of 280 ppm of preindustrial period (Ramchandaran *et al.* 2007).

Terrestrial ecosystems store almost three times as much carbon it is in the atmosphere. Forest vegetation and soil share about 60% of the world's terrestrial carbon (Singh *et al.* 2006). The sink capacity of the forest increases when tree density and area expand. In an average 50% of the dry weight of the biomass is carbon (Mac Dicken 1997).

Species diversity is the measure of diversity within an ecological community that incorporates both species richness and the evenness of species abundances. Diversity is measured for three main reasons: to measure a stability to determine if an environment is degrading, to compare two or more environments and to eliminate the need for extensive lists.

Diversity indices provide important information about the composition of community. Species diversity can be expressed in a single index number. Ecologist have developed many indices of species diversity among which Simpsons index (Simpsons 1949) and Shannon-wiener Index, H^1 (Shannon and Weaver 1949) are the most commonly used indices.

Simpsons index (C) reflects dominance while Shannon-wiener Index ($H^{1)}$ is thought to represent uncertainty or a information of a community. The value of diversity index is higher in rich forest and lower in forest dominated by single species.

Convention on Climate Change (UNFCCC) recognized forest degradation as an important contributor to global carbon emissions by incorporating it into the Reducing Emissions from Deforestation and Forest Degradation (REDD+) mechanism (UNFCCC 2008).

Few works has been made in quantifying carbon losses due to human disturbances (Parrotta *et al.* 2012). The degree of degradation of carbon stocks in tropical forest depends on disturbance types (e.g. logging, understory fires, edge effects) as well as the intensity and frequency of disturbance events (Laurance *et al.* 2006, Barlow *et al.* 2012 and Arag~ao *et al.* 2014).

Due to the limitation of existing studies on alterations of individual components of the total forest stocks or the effects of single types of disturbance in relatively small areas (Barlow *et al.* 2003, Feld paunch *et al.* 2005 and Paula *et al.* 2011) we still have a limited *understanding* of the combined effects of multiple forms of disturbance on different carbon pools, which constrains our ability to identify management (Erika *et al.* 2014).

1.1.1 Forest and Land Use Areas of Nepal

Total forest area of Nepal is 1287000 thousands ha in Terai while forest and shrub land in the Mountain is about 3960000 thousands ha which cover non cultivated inclusions (NCI) of 517 thousands ha and cultivated inclusions of 211 thousands ha (DOF 2012).

Demand and supply of wood products

The supply of Fuel wood was estimated to be 2.58 million tons, 5.44 million tons and 0.94 Million tons for Terai, Hills and Mountains respectively in 2011. The supply would increase to 3.72 million ton, 6.96 million ton and 1.33 million tons in 2020 and 5.07 million tons, 9.60 million tons and 1.51 million tons in 2030 for Terai, Hills and Mountains respectively. Remarkable change in collection and gathering activities are affecting the demand and supply of forest products in Nepal. Forest of Terai is vulnerable to illegal harvesting and population growth while transportation of wood to urban areas is common in hills (DOF 2012).

Current demand of fuel wood in Nepal is about 10.5 million ton per year. The demand would increase to 11.7 million tons in 2020 and to about 13 million tons by 2030. For hilly region total demand would raise from 4.4 to 5.5 million ton in 2020 (MoFSC, 2013). Increase in population growth and households would demand more constructional materials for houses and harvesting of forest products.

1.1.2 Community Forest

Forest act of Nepal -1993 defines two primary kind of forest (National and private forest) and five secondary kind of forest under national forest (Government managed, community managed, protected forest, leasehold forest, religious and private forest).

Community forestry is one of the renowned participatory forest management schemes in Nepal. AS of 2011 a total 2.1 million households 40% of total population, through 17,685 user groups are managing about 1.6 million hectare (27.4 %) of country total of national forest as community forest (community forestry division department of forest (www.dof.gov.np).

There are about 15 CMS in 8 Terai districts of Nepal which covers area of 39,457 hectares. Recent study by MFSC in 20 Terai district, revealed that rate of forest cover was increasing with annual rate of 0.06% during 1990/91 to 2000/2001. Micro level study and visual interpretation revealed that Nepal's forest coverage and condition is significantly improving due to community forestry intervention (DOF 2012).

Sustainable management of forest in Nepal could not only increase and stabilize the supply of forest products, but it would also help in contributing the Livelihood of the 17,685 CFS and CFUGS 2.18 million households involved in community forest management (DOF 2012).

1. 2 Rationale of the study

Community forests hold large stocks of carbon. Government of Nepal is handing over more than 90 percent of national forest of hills to communities for conservation and improving the livelihood of local people using forest resources. Community forest are important contributor of carbon sequestration projects like REDD and $REDD^+$ mechanisms, which are currently supported under international agreements such as the Kyoto Protocol's clean development mechanism.

Carbon (C) storage and sequestration could have important implications for the management of C-sink projects, not only for reforestation and a forestation type projects, but also for emissions reductions projects that focus on forest conservation and management (UNFCCC 1997, 2005).

Comparative study on regenerated and old growth community forest is useful to know the effectiveness of managers for the conservation of forest biomass and diversity since community management or the effectiveness of management system for conservation.

Study of effect of disturbance and settlements and road on carbon stock and diversity is most essential as degree of degradation of carbon mostly depends upon the type of disturbance and time elapsed during disturbance (Laurance *et al.* 2006).

Understanding the relationship of tree-species diversity to carbon storage will be critical to maintaining C stocks of protected forests over the long term and our understanding on species level management (Balvanera *et al.* 2006).

Studying the regeneration status, species contribution on carbon stock is helpful for choosing the suitable species with high value of carbon stock and for planning about the future level of carbon stock.

1.3 Objective of the study

Objectives:

- To study the effects of settlements and road proximity on carbon stock and diversity of trees in old growth (Fulbari CF) and regenerated (Taldanda CF) forests.
- To compare the regeneration status, density, basal area of tree species and species contribution on carbon stock in two forest types.
- To know the relationship of tree carbon stock of with diversity of trees and their relationship with density, DBH and Basal area of tree species in two community forests.

1.4 Research questions

- Is there any significant difference in mean value of carbon stock and tree diversity between and among the strata of old growth and regenerated Community forest?
- Is there any significant relationship between tree carbon stock, diversity and other forest attributes like tree density?
- Is there any significant impact of disturbance or edge effect to bring variation in carbon stock, diversity and other attributes of trees among the strata of forest?

1.5 Limitations

- Seedlings and herbaceous as well as shrub species were not harvested as CF authority did not allow it.
- Soil carbon was not determined due to the lack of time.

2. LITERATURE REWIEW

2.1 Carbon Stock

Shrestha and Singh (2007) have studied soil-vegetation Carbon pool at four types of forest (managed dense *Shorea* (DS), degraded forest (DF), pine mixed (PS), and *Schima–Castanopsis* (SC) forest) and two types of cultivated land (irrigated low land (Khet) and rain-fed upland (Bari)) in the Pokhare Khola watershed (400 -1100m asl) of Nepal. They determined the vegetation carbon pool was largest in DS forest (219 ± 34 Mg ha^{-1}) and least in SC forest (36±5 Mg ha^{-1}), while its order among forest types was DS>DF>PS>SC. The soil organic carbon (SOC) pool was largest in Bari land (15.7 ± 1.5 kg Cm^{-2}) and least in PS forest (6.2 ± 0.5 kg Cm–2) but the overall order among land uses was Bari> DF>Khet>SC>DS>PS.

Shrestha (2008) studied the impact of vegetation types on Carbon stock in two community Forests of Palpa ,Nepal and concluded that the forest types play an important role on total carbon sequestration. He found the total biomass carbon in *Shorea robusta* and *Schima-Castanopsis* forest were 101.66 t ha^{-1} and 44.43 t ha^{-1} respectively. Soil carbon sequestration in *Schima-Castanopsis* and *Shorea robusta* forest was found 130.76 and 126.07 t ha^{-1} respectively. According to his study the total carbon sequestration in *Shorea* forest was found 1.29 times higher than *Schima-Castanopsis* forest.

Oli and Shrestha (2009) studied carbon storage in different forest of Nepal and research found that forests cover nearly 40% of the total land area of the country. Carbon storage in the above-ground and below-ground biomass, deadwood and litter and forest soil was 897 million metric tons in the year 2005. Community managed forest cover about 1.2 million ha and contribute 183.3937 million tons of carbon while Government managed forest cover about 3.9 million ha with contribution of 596.0296 million tons of carbon and protected forest cover and 0.71 million ha with contribution of 108.508 million tons of carbon but other types of National forest i.e. Leasehold and Religious forest and private forest has low contribution to carbon as compared to above mentioned forest types.

Baral *et al.* (2009) assessed the study on above-ground carbon stock in the five major forest types, representing two physiographic regions and four districts of Nepal and found that the rate of carbon sequestration by different forest types depended on the growing nature of the forest stands. Tropical riverine and *Alnus nepalensis* forest types demonstrated the highest carbon sequestration rates in Nepal. Results indicated variation in age of the stand (18-75 years), above-ground carbon stock per hectare (34.30-97.86 dry wt. t ha^{-1}) and rate of carbon sequestration (1.30-3.21 t $ha\text{-}^{1}yr\text{-}^{1}$), according to different forest types.

Khayamali (2010) estimated the above ground biomass of two community forests namely Neelbarahi Community Forest and Gauradevi Community Forest of Bhaktapur district were 67.663t ha^{-1} and 28.435 t ha^{-1} respectively whereas the soil organic carbon were found 19.61 t ha^{-1} and 28.948 t ha^{-1}. According to his calculation the total soil carbon contents in these two communities were 69.146 t ha^{-1} and 47.732 t ha^{-1} respectively.

Thakuri (2010) calculated the carbon sequestrated in *Shorea robusta* (Sal) dominant community forest (CF). He has found 168.992 t ha^{-1} of C was sequestrated in which above ground, below ground (root) and undergrowth biomass organic carbon were found 61.958, 18.587 and 5.736 t ha^{-1} respectively. In his study also SOC was gradually decreasing with respect to soil depth with mean SOC of 82.706 t ha^{-1}.

Thapa (2010) estimated the total carbon stock of Hasantar community forest, Seuchatar, Kathmandu (including SOC-pool and tree biomass carbon) was substantial even in a small forest area of 64 ha which was estimated to be 7562.85 ton C. His study also showed that the carbon stored in the forest soil was four times more than that in tree biomass (dry matter). It also suggests that more carbon could be sequestered and stored in cultivated soil, forest soil and above ground tree biomass with efficient management.

Bhattarai *et al.* (2012) examined the carbon sequestration potential of community-based forest management in four community forests in Nepal. They have selected four different watersheds with a total area of 630 ha in three physiographic regions. Forest carbon pools were measured in two successive years using the standard ground based inventory techniques. They measured a stock of approximately 478,000 ton CO_2 at the end of 2009, and through the CF practices, are able to sequester an additional 4700 ton CO_2 every year.

Madal *et al.* (2014) studied the effect of drivers of deforestation on forest carbon stock in three different collaborative forest dominated by *Shorea robusta* species in Mahottari District of Nepal. Three collaborative forests namely Gadhanta-Bardibas, Tuteshwarnath and Banke- Maraha Collaborative Forests (CFMs) were selected for research site. Highest carbon stock was found to be 269.36 t ha^{-1} in Gadhanta-Bardibash CFM. The findings showed that the levels of carbon stocks in the three studied CFMs were different depending on how the drivers and management units influence them.

Neupane and Sharma (2014) studied the effect of vegetation size, type and altitude on above ground biomass and carbon stock in Jalbire Mahila CF and Laxmi Mahila CF of Gorkha district, Nepal. The above ground carbon pools in Jalbire Mahila CF was 131.54 t ha^{-1}, while in Laxmi Mahila CF was 52.90 t ha^{-1}. The carbon pool of Jalbire Mahila CF was higher than that of Laxmi Mahila CF due to greater density of the larger sized trees. The species Sal (*Shorea robusta)* sequestrated more carbon pool in both CFs.

Burenguer *et al.* (2014) studied a large scale field assessment of carbon stock in human modified tropical forest results of the largest field study to date on the impacts of human disturbances on above and belowground carbon stocks in tropical forests. There was positive correlation between biodiversity and C storage across land use but no evidence for a positive relationship between tree-species diversity and above-ground biomass or soil carbon in either forests or agro forests. However, results highlighted the disproportionate contribution of a small number of species to stand-level carbon stocks.

Live vegetation, the largest carbon pool, was extremely sensitive to disturbance: forests that experienced both selective logging and understory fires stored, on average, 40% less aboveground carbon than undisturbed forests and were structurally similar to secondary forests. Edge effects also played an important role in explaining variability in aboveground carbon stocks of disturbed forests.

2.2 Carbon Stock and Diversity Relationship

Szwagrzyk and Gazda (2007) found that a negative relationship exists between aboveground biomass and tree species diversity in natural forests of Central Europe.

Fornara and Tilman (2008) suggested that there was a positive impact of plant diversity on soil carbon accumulation in agriculturally degraded soils at Cedar Creek, Minnesota,USA.

Nakakaawa *et al.* (2009) studied changes in carbon stocks and tree diversity on carbon and non-carbon farmers' plots in a pilot carbon offset project implemented by smallholder farmers in south western Uganda. There were strong positive correlations between carbon stock and tree diversity. Carbon densities in farmland were significantly (t = -2.38; *P = 0.023*) higher than those in grasslands. There were no significant differences in tree diversity on farmlands but significant differences (species richness t = 2.18; P = 0.04; Shannon Index t = 2.92; P value = 0.0077) in grasslands.

Wang *et al.* (2011) studied Positive Relationship between Above Ground Carbon stock and Tree Structural diversity in Spurce dominated forest in New Bronswick Canada. Tree species, size, and height diversity indices as well as a combination of these diversity indices were used to correlate aboveground C stocks. . Results showed stand structural diversity has a significant positive effect on aboveground C stocks even though the relationship was weak overall. Positive relationships observed between the diversity indices and above ground C stocks support the hypothesis that increased structural diversity enhances aboveground C storage capacity.

2.3 Diversity and stand structure

Kunwar and Sharma (2004) selected two community forests, Amaldapani and Juphal from Dolpa district, for the study of quantitative analysis of tree flora. A total of 419 individual trees representing 16 species, 16 genera and 11 families were recorded. Total stand density and basal area were, 2100 trees ha^{-1} and 90 m^2 ha^{-1} respectively, in Amaldapani and 2090 tree $ha\text{-}^1$ and 152 $m^2/ha\text{-}^1$ in Juphal.

Shrestha (2005) studied the Impact of Forest Resource Management and Practices on community structure and regeneration of locally managed *Shorea robusta* forest in Mid hills of Central Nepal (Namajung Village of Gorkha and Khari Village of Dhading district. He found the diversity values H1=1.09 and H1= 1.30 respectively in Namajung and Khari community forest. Sustainable regeneration of *Shorea robusta* in Both community Forests.

Shau *et al.* (2008) also documented that tree density, diversity, and structure at forty – two sites in the Anchanakmar-Amarknatak Biosphere Reserve of Central India responded to anthropogenic disturbance. The number of species and indices of species diversity were positively associated with coppicing and also with total disturbance which included foot trails and dung piles as evidence of livestock grazing

Sapkota *et al.* (2009) studied spatial distribution; advanced regeneration and stand structure of in seasonally deciduous *Shorea robusta* forest of Nawalparasi district of Nepal and found that most disturbed forest had less trees species richness, in the more disturbed plots greater density of saplings and no significant difference in stem basal area. The overall stand density changed quadratically along the disturbance gradient.

Anitha *et al.* (2009) compared forest composition in Annikhhaty hills of Western Ghats where the low disturbance was from past logging and present grazing and high disturbance was due to human .they found that higher species richness and diversity index (98 and 3.9) for low disturbance forest and lower for high disturbance forest stands (48 and 2.7).They also found significant difference in mean value of basal area of trees, density of seedlings and number of species.

2.4 Community Forestry in Nepal

The forest act 1993 defined the ‘community forestry’ and recognized user groups as legal entities that should develop, protect and manage forests for collective benefits (Sharma 2000).

The forest conditions were gradually improved after handing over forests to communities with positive impacts on biodiversity conservation (Jackson and Ingles, and increased production of firewood, timber, fodder, forest litter and grass and other non-timber forest products (NTFP) which have supported subsistence livelihoods (Kanel 2004, Acharya and Sharma 2004).

This was turned around by implementing CFM and handing over forests to local communities in the 90's.and deforestation rates were considerably reduced, particularly in the hills (Acharya and Sharma 2004, Banskota 2000).

Numerous degrading ecosystems have improved due to decentralized and participatory forest policies. The impact of this policy in the forestry sector has undoubtedly been positive in reducing deforestation and forest degradation in Nepal Himalaya. From a climatic perspective, community forest has contributed to enhancing the capacity of natural sinks (Banskota 2000).

Community forests over was 1.1 million ha, or about one quarter of the country's forest (Kanel, 2004), was being managed by communities with 93% of this is in the hills and 7% in the Terai (Springate-Baginski *et al.* 2007).

It is supposed that the establishment of community forest by restricting uses increase the biodiversity. But there is lack of information obtained through systematic research on the effect of community forest on the biodiversity (Ingels 1994, Shrestha *et al.* 2010).

The community forestry has given high priority to commercially important plant species and less prioritized species have faced the problem of population decline and lack of regeneration (Ingels 1994). Several forests have been developing into mono dominant forests and species diversity of such forests have been reduced (Kandel 2007, Acharya *et al.* 2007).

As of 2011 a total 2.1 million households 40% of total population, through 17,685 user groups are managing about 1.6 million hectare (27.4 %) of country total of national forest as community forest (community forestry division department of forest (www.dof.gov.np).

Micro level study and visual interpretation revealed that Nepal’s forest coverage and condition is significantly improving due to community forestry intervention (DOF 2012).

3. STUDY AREA

3.1 Description of the Study Area

3.1.1 Forest in Tanahun district

The total forest area of this district is 78,111.22 ha. Community forest covers 35791 ha while leasehold forest covers 1964.35 ha of the total forest area. Private forest, religious forest and national forest cover 15.28 ha, 4.47 ha and 40350.73 ha respectively. There are 511 CFUGs consisting of 50177 households. Each CFUG get an average of 73.95 ha forest area with an average of 98 HH per CFUG. Forest area per HH averages to be 0.71 ha. Until now, only 45.82 % of the total probable CF area has been handed over to CFUGs (DFO 2012).

3. 2 Description of the Community Forest Area

Selected community forests area lie in Dulegauda and Chang VDC of Tanahun District. Nearest city Pokhara is about 20 km North West from the Taldanda community forest and about 28 km North West from the Fulbari community forest. Both community forest are similar in topography within a hill slope of about 26 degree and have settlement on top hill and downhill side of forest with variation of altitude of 500 to 620 meter.

3.2.2 Taldanda Community Forest

It lies in the Northern east part of the Tanahun district in ward no.8 of Dulegauda VDC of Tanahun. The forest lies in the hill about 2 km north from the Prithivi highway section of Dulegauda Tanahun. The forest covers an area of 84 ha .It is natural regenerated or secondary forest managed by community since 20 years. Forest is dominated by *Shorea robusta* species. It is divided into 5 blocks.

Aspect: Forest lies in south facing slope with 20-30 degree of sloppiness.

Socioeconomic conditions: A total household of 325 with 1620 people of different caste are the user group of this forest. Major castes are Magar, Gurung, Brahmins, Chhetries, Muslims, Newar and Dalits.

Altitudinal range: Forest has an altitudinal range of 520 m to 560 m.

3.2.3 Fulbari Community Forest

It lies in the Chang VDC ward no.7 of Tanahun district of Nepal. It covers an area of 112 ha. It is a natural and primary forest dominated by *Shorea robusta* species. The forest is divided into four blocks southern boundary of the forest is formed by Seti River. The forest is about 5 km south from the Tharpu Bajar and about 6 km south eastwards from Dulegauda Tanahun.

Socioeconomic conditions: Total household of 72 with population of 466 are the user group of this community forest. Major castes of this forest user are Gurung with few households of Newar and Dalits.

Aspect: South facing slope with 5-35 degree of sloppiness.

Altitudinal range: Forest has an altitudinal range of 490 m to the 530 m.

3.2.1Climate

Climate of the study area is subtropical. Average monthly temperature recorded in Kairenitar substation from 2008-2013 AD was 23.27$°C$. Average Maximum and minimum monthly temperature of the area were 29.73$°c$ and 17.12 $°C$ respectively. Average Monthly rainfall recorded was 195.37 mm. and average annual rainfall was 2344.5mm (Fig.1). Average maximum and minimum rainfall recorded were 595.3 mm in June and 3mm in December respectively. July and August recorded highest temperature (27.9 $°C$ and 28.1$°C$ respectively) and December recorded minimum temperature ie.15.3$°C$ (DHM 2014).

Geographical Locations: $27^{0}57^{'}08.32^{''}$N, $84^{0}07^{'}10.45^{''}$E

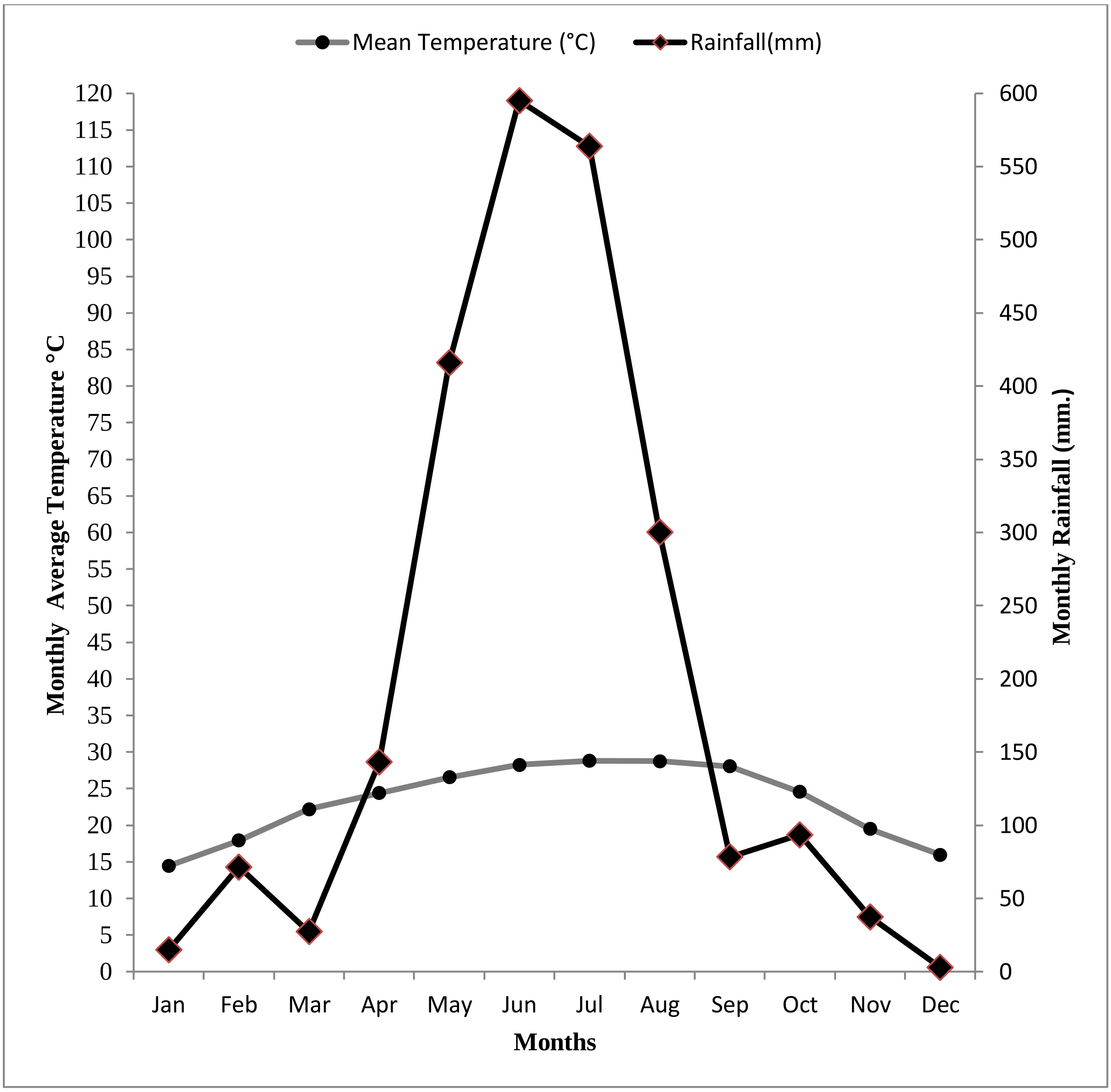


Fig1. Climatic graph showing Average monthly temperature and Rainfall from 2008-2013 at Kharenitar weather station, Dulegauda Tanahun.
Source: Department of Hydrology and Meteorology Kathmandu Nepal (DHM 2014).

3.2.4 Map of the Study Area

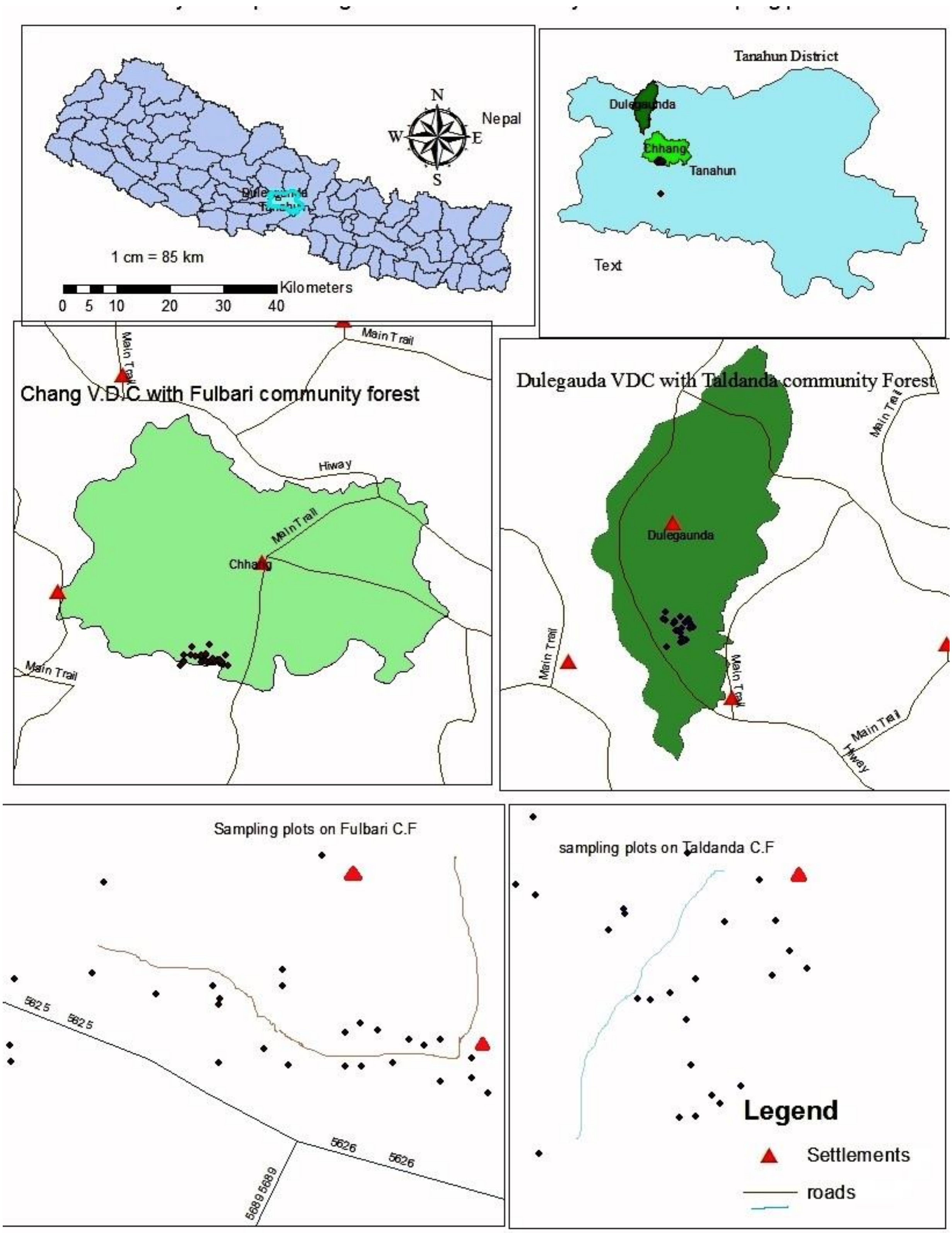


Fig.2 Layout map of the study area showing road connectivity and settlements.

4. METHODOLOGY

4.1 Sampling Design

From the community forest management authority and with their manuals management year of Taldanda community forest and Fulbari community forest was known to be twenty year and five years respectively. Taldanda CF is secondary or regenerated forest after complete clearance by fire while FF is old primary forest. So forest was classified as regenerated or secondary and primary or old growth (IPCC 2006, management regime could be taken for making comparison between forest types).

4.1.1 Sampling Design Methods

Stratified random sampling method was used for sampling of tree species of both forests. Each forest was divided into different blocks by community forest authority (CF manuals) based upon the geographical location and species composition. Map of CF manual was taken as the reference manual for the study.

Required number of plots in each forest types and blocks were determined to be at least 1% (Rana *et al.* 2008) of the total area of forest (total area of the forest and each blocks was referred from CF manuals of respective forest groups) and proportional number of plots were established in each blocks of the forests.

Sampling plot size of $10 \times 10 m^2$ was determined to be appropriate for the sampling the stand with large number of stems small in diameter (Mac Dicken 1997). Altogether 72 plots were established with 36 plots on each forest types. Meanwhile distance of each plot from nearest settlement or road was noted.

According to objective of study and for statistical analysis, forest was reclassified into 4 strata with 9 plots on each strata based upon the proximity to settlement, roadside or riverside, topography (MacDicken1997, Pearson *et al.* 2007). This method was only used for regrouping of strata after the data collection and did not affect the earlier designated sampling plots.

4.1.2 Sampling Design within Plots

Each plot of size of 10×10 m^2 was established with the help of rope and aspect of the plot was maintained with the help of clinometers so that each corner of the plot is 90 degree to each other or plot is perfect square in shape. Distance between each plot was maintained to be 100 m. Within each plot, diameter of each tree was measured at the breast height (1.37m) with the help of DBH tape, angle between observer and tree was measured with the help of clinometers and distance between tree and observer was measured with the help of measuring tape. Tree with DBH less than 5cm was excluded for carbon stock measurement (Chave *et al.* 2005). Height of the observer was taken with the help of altimeter and slope and aspect was taken with the help of clinometers.

Slope was taken with the help of clinometers, geographical position of the each plot (Latitude and longitude) was taken with the help of Geographical positioning system (GPS) and altitude was taken with the help of altimeter.

Other information of plots such as disturbance activities like fodder collection, timber harvesting, human encroachment, grazing, fire etc were included in data sheet (yes/no) and accordingly level of disturbance was determined.

To study the regeneration, nested plot of size 5×5 m^2 was established within each plot. Saplings and seedlings were counted in each nested plot which have DBH < 5 cm, (Subedi *et al.* 2010).

4.2 Plant Collection, Herbarium Preparation and Identification

Plant specimens were collected, tagged and pressed with the help of Herbarium presser in the field. The local names of most of the specimens were recorded by consulting local villagers. The specimens were identified in Tribhuvan University Central Herbarium (TUCH) in consultation with Prof. Dr. Mohan Siwakoti, Central Department of Botany. Those herbarium not identified in TUCH were identified in National Herbarium and Plant laboratory (KATH).

4.3 Data Analysis Method

First the normality of the data was tested with the help of SPSS 16.0 version of the software (Shapiro test).Normality of data tested with the help of Shapiro -Wilk test was done, non normal data was transformed and normality was mentioned.

- T-test (Independent sample) and Wilcox on-signed test was applied to compare mean values of the variables of two forest types.
- Mean values among the strata of each forest were compared with ANOVA (post hoc test) and two way ANOVA.
- Pearson's correlation analysis was used to explore the correlation between variables. Regression analysis was used to examine the relationship.
- For mapping of sampling site and study area arc GIS software of 9.3 versions was used.

4.4 Calculation Methods

4.4.1 Carbon Stock

Allometric regression model is used to evaluate the above ground biomass (AGTB), yet it is seldom directly tested (Brown *et al.* 1989, Houghton *et al.* 2001and Chave *et al.*2001).

According to the fame work of the study, equation for dry, moist, wet climate with annual rainfall (1,500 – 3,000 mm) suggested by Chave *et al.* 2005 for subtropical forest was used. As average rainfall of study area from 2008 AD to 2012 A.D was 2344.5 mm (Department of Hydrology and Metrology).

$AGTB = 0.0509 \times \rho D^2 H$

Where,

AGTB= Above ground Tree biomass (kg)

ρ= Wood density (kg/m^{-3})

H= Height of tree (m)

D= diameter at breast height

For wood density of each tree species, the global data base presented by Zanne *et al.* (2009) was used.

Estimation Of Below Ground Biomass

The biomass of root system of tree was estimated by assuming that it constitutes 15% of the above ground biomass Root: Shoot ratio =0.10 or 0.15 (Mac Dicken 1997).

Estimation of Carbon Stock

Total biomass was obtained as the sum of biomass of tree. To estimate the carbon stock in tree biomass, the sum of biomass was multiplied by 0.47 which is the default carbon fraction in tree biomass. Estimated above ground biomass was converted into total biomass by adding below ground biomass. The below ground biomass was taken as15% of above ground biomass. Biomass calculated as before was converted into carbon stock by multiplying as above by 0.47 default value (IPCC2006).

The individual value of c obtained in kilogram was converted into ton per hectare by dividing it with area ($100\times100\ m^2$) and multiplied by 10, then Carbon stock value of each individuals of the plots was summed up to obtain the carbon stock value of tree biomass .

Carbon Stock of Species

Similarly carbon stock of individual tree species was determined by summing up density values of whole forest for that particular species.

Percentage of contribution carbon stock of each species of trees in a forest was calculated by taking the proportion of sum of carbon stock per ha of all species in forest to the sum of carbon stock of a particular species on the same forest.

$$\text{Carbon stock of a species (\%)} = \frac{\text{Sum of carbon stock of a species per ha} \times 100}{\text{Sum of carbon stock of all species per ha}}$$

4.4.2 Species Diversity

Common measures of diversity include counts of number of species (species richness) and use of indices such as Shannon–Wiener's index (Shannon and Weaver 1949) or the Gini–Simpson index (Simpson 1949), which further on are referred to as Shannon's and Simpson's diversity indices, respectively.

The explanatory power of Shannon's diversity index based on basal area is superior to a measure based on species count. Basal area provides a better indication of the degree to which each species occupies a particular site and is a good measure of potential biomass growth (Nakakaawa *et al.* 2014).

Species diversity was calculated based on Shannon diversity index using the general formula:

$H0 = \sum pi \times lnpi$

Where H0 = Shannon's diversity index,

p_i = species proportion (based either on species

Count or species basal area) and ln = natural logarithm.

Using species basal area, the

Shannon index was calculated as:

$H0 = = \sum_{i=0\text{-}n}^{n} BAi/BAt/ \ln BAi/BAt$

Where BAi = basal area of a particular species i in a plot, and Bat= total basal area of all species in a plot.

Simpson's (1949), diversity index gives the probability that two individuals selected at random will belong to the same species.

It was calculated as $D = 1/pi^2$

Where pi is the proportion of individuals in species community

4.4.3 Basal area and Density

Basal area: Basal area is regarded as an index of dominance of a species. Higher the basal area, greater is the dominance. Basal area of a tree species was determined by measuring either the diameter or circumstance of the average tree at the breast height (1.37 m) and was calculated with the following formula.

Basal area (m^2) $= \frac{\Pi d^2}{4}$

Where Π=3.14, d= diameter at breast height

Density

Density shows the number of individual trees per unit area and it indicates the numerical strength of a species in a community. Density of at different developmental phases was also determined of each tree species.

Density of a plot was calculated as number of a individuals in a plot

Density of particular species in a forest was calculated as;

Density(no. per ha) $= \frac{\text{Total number of any plant species} \times 1000}{\text{Area of sampling plot} \times \text{Total number of plot studied}}$

4.4.4 Disturbance Level Ranking

Disturbance factors in the forest were determined by direct observation in the sample plots. Altogether six disturbance factors: timber harvesting, firewood collection, soil erosion, human encroachment, fire and grazing were taken into consideration. Depending upon the severity and occurrence of those factors disturbance was ranked into 4 groups. Ranking value 1 was given for the case no occurrence of any disturbance factors, 2 for low disturbance, 3 for medium disturbance and 4 for severe disturbance.

5. RESULT

5.1. Properties of Species

5.1.1Density Diameter Relationship

The density of individuals at different D.B.H class was found to be different in two community forest types. The distribution curve for tree species (>5cm diameter) showed subsequent increase in number of individuals from upper DBH class to lower DBH class in both forest types (Fig 2). There was variation in DBH of trees between Taldanda CF and Fulbari CF. In Fulbari CF, there were old stock of trees with maximum diameter 75cm (Fig 2 b) while in Taldanda CF trees were comparatively younger with maximum diameter 45cm (Fig 2 a).

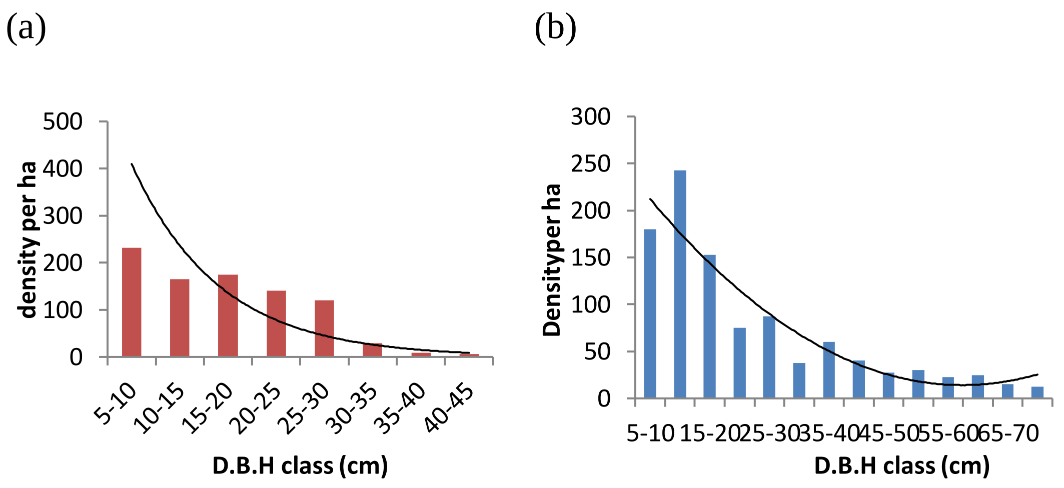


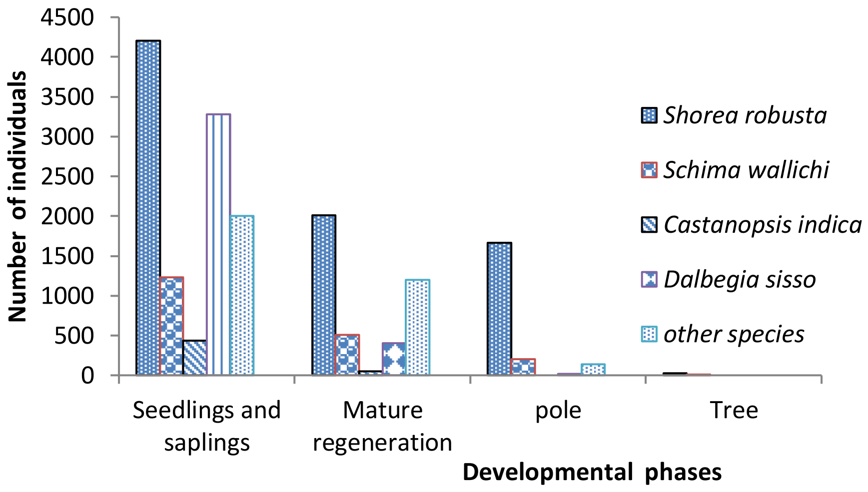
Fig2. Density diameter curve of trees<5cm and taller than 137 cm (a) Taldanda CF and (b) Fulbari CF

5.1.2 Species Distribution at Different Phases

Number of seedlings and saplings were highest in both forest types in comparison to other successive development phases (Fig 3). The percentage of seedlings and saplings were 69.97% in Fulbari CF and 64.06% in Taldanda CF. There were 25.05% individuals at mature regeneration phase, 3.90% at pole stage and 1.108% tree phase of Taldanda CF and 24.10% individuals at mature regeneration phase, 11.69% individuals at pole stage and 0.223% of individuals in tree stage in Fulbari CF.

Contribution of *Shorea robutsta* to total density was highest in comparison to other species in all developmental stages of both forests. Number of *Shorea* was 51.19% in Fulbari CF and 45.28% in Taldanda CF. Contribution of *Schima wallichi* and *Dalbergia sisso* and *Castanopsis indica* to total density were 11.14% 21.19% and 2.78% respectively in TF. While, *Schima walichi* and *Acacia catecu* contributed 17.60% and 8.80% respectively in FF. Other species contributed 19.12% in TF and 22.23% in FF (Fig 3).

(a)



(b)

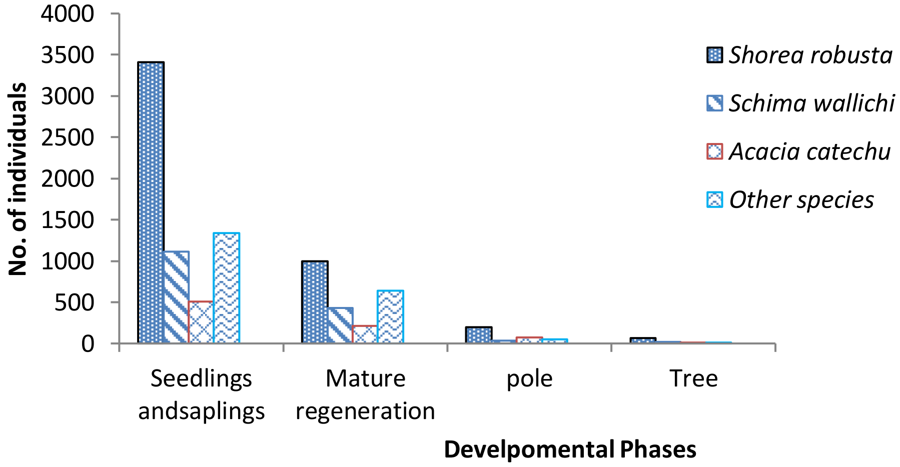
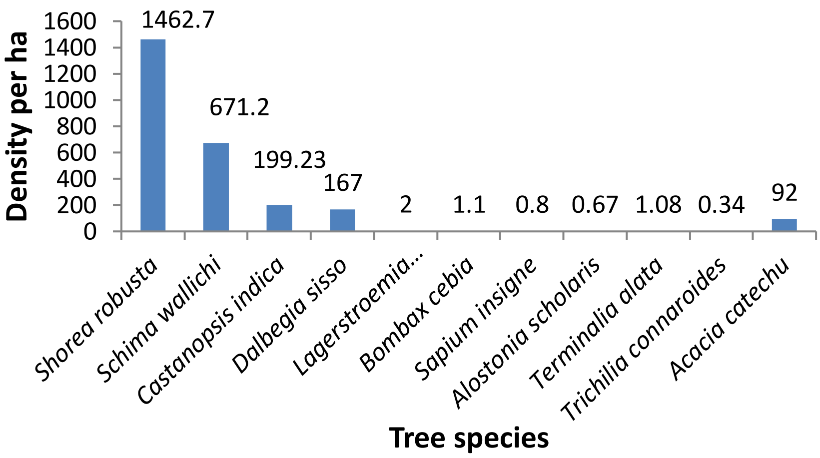


Fig.3 Number of Individuals at different developmental phases,(a)Taldanda CF,(b)Fulbari CF.Note: 1-3 cm DBH and height 30cm to 1.37m =seedlings and saplings 3-10 cm DBH and 1M to 1.37 M ht.=Mature regeneration phase,10-30 cm DBH and ht> 1.37 M= Pole and 30-90 cm DBH and Ht> 1.37 M=Tree.

5.1.3. Density and Relative Density of Species

Average density of tree species was 199.95 per ha and 120.71 per ha in Taldanda CF and Fulbari CF respectively. Density of *Shorea robusta* was highest of all in both community forest (1462.7 and 1166 trees per ha respectively TF and FF (Fig 4 a and 4 b). Other dominant species were *Schima wallichi* (671.2 and 398 trees per ha) *Castanopsis indica (*199.23 and 20 trees per ha) *Acacia catechu* (92 and 203.5 trees per ha) respectively in Taldanda CF and Fulbari CF (Fig 4).

(a)



(b)

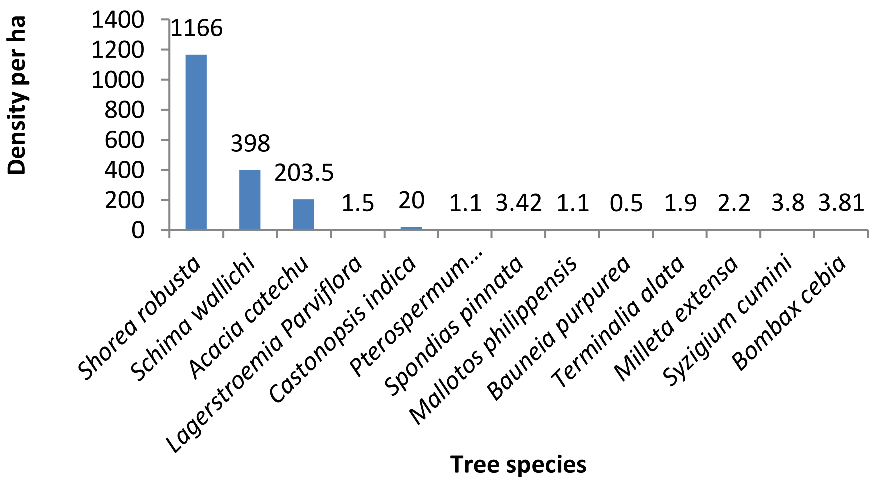
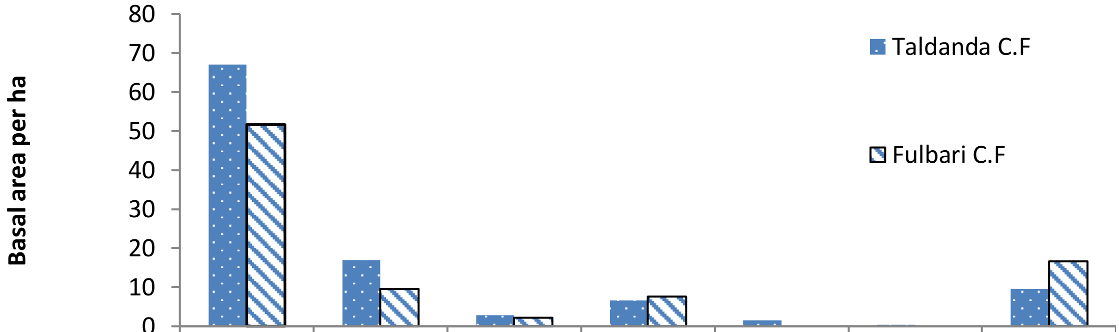


Fig.4 Density of trees per ha (a) Taldanda CF and (b) Fulbari CF

5.1.4. **Basal Area of Species**

In Taldanda CF, basal area of *Shorea robusta*, *Schima wallichi* and *Dalbergia sisso* measured 67.1 m^2 per ha, 16.89 m^2 per ha and 6.65m^2 per ha respectively (Fig 5). While in FF, basal area of *Shorea robusta*, *Acacia catechu* and *Schima wallichi* measured 51.67 m^2 per ha, 16.7 m^2 per ha 9.5 m^2 per ha respectively. Other major associated species were *Castanopsis indica*, *Lagerstroemia parvifolia* and *Bombax cebia*. Highest value of basal area of *Shorea robusta* in both CF indicated the forests were dominated by *Shorea robusta* species.



	Shorea robusta	*Schima wallichi*	*castonopsis indica*	*Dalbergia sisso*	*Lagerstroemia parvifolia*	*Bombax cebia*	*Acacia catechu*
Taldanda C.F	*67.1*	*16.89*	*2.89*	*6.65*	*1.58*	*0.315*	*9.56*
Fulbari C.F	*51.67*	*9.5*	*2.1*	*7.564*			*16.7*

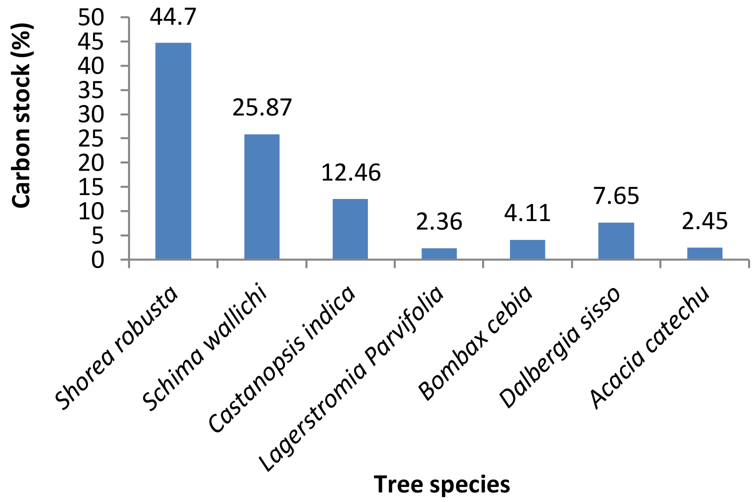
Name of tree species

Fig. 5 Basal area of trees in Fulbari CF and Taldanda CF.

5.1.5 Contribution of Species in Tree Carbon Stock

The value of Carbon stock were measured 109.82 t ha^{-1} in Taldanda CF and 71.11 t ha-[1] in Fulbari CF. Average contributions were highly skewed in Fulbari CF with maximum carbon stock (64.5%) on *Shorea robusta* and relatively low percentage of carbon stock on *Schima wallichi* (13.27%), *Acacia catechu* (19.82%) and other species (fig 6 b) but in Taldanda CF, carbon stock of *Shorea robusta* (44.7%) *Schima wallichi*, (25.87%) *Castanopsis indica* (12.46%) *and Dalbergia sisso* (7.65%) were almost proportional (Fig 6.b)

(a)



(b)

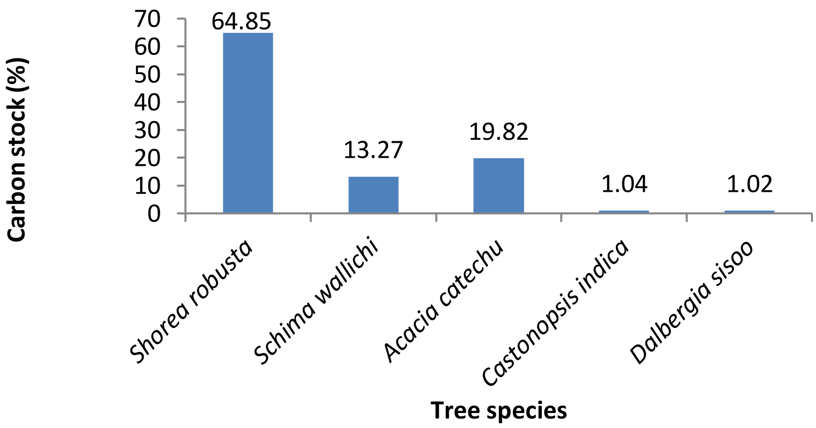
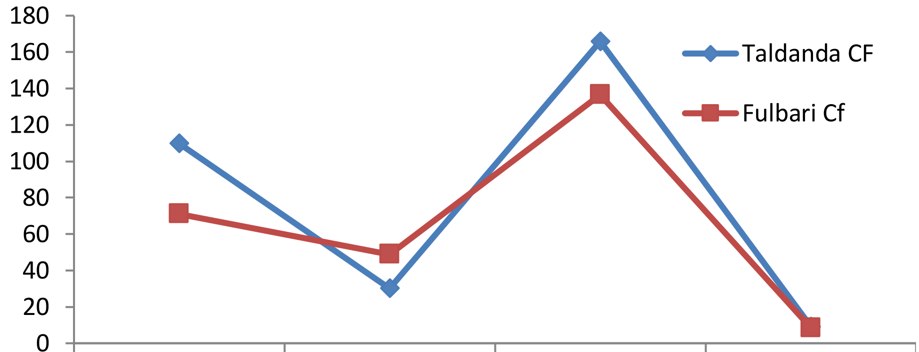


Fig.6 Species contribution on carbon stock (a) Taldanda CF (b) Fulbari CF.

5 .2.Comparision Between Forest Types

Between the two community forest types, the mean values of carbon stock, DBH and value of diversity were higher in Taldanda CF than Fulbari CF (Fig 7. 1). However there was higher value of basal area in Fulbari CF than Taldanda CF.



	Carbon stock (t ha-1)	Basal area (m² ha-1)	DBH(cm)	Density (no./100m²)
Taldanda CF	109.82	30.17	165.86	9.25
Fulbari Cf	71.11	48.83	136.5	8.5

Fig.7.1 Mean values of Carbon stock, basal area, density and DBH.

5.2.1 Carbon stock

The mean value of carbon stock of tree layers was 109.82±15.76 t ha^{-1} and 71.11±10.47 t ha^{-1} respectively in Taldanda CF and Fulbari CF (Fig 7.1). However T-test between FF and CF did not show any significant difference in mean values of carbon stock (Fig 7. 2).

5.2.2 DBH and Basal Area

Mean values of basal area were 30.55 m^2 ha^{-1} and 48.23 m^2 ha^{-1} and DBH were 165.86±9.25cm and 136.5±12.11cm (Fig 7.1) respectively in Taldanda CF and Fulbari CF. However, significant difference was seen between mean values of DBH and Basal area of two forest types (Fig.7.2.b and 7.2.c).

5.2.3 Density and Diversity

Average density of tree species of two forest types were 9.25±0.552 trees/100m^2 in Taldanda CF and 8.5±0.478 trees/100m^2 in Fulbari CF (Fig 7.1) and were not significantly different (Fig 7.2 c).

The value of Simpsons index was D=0.3945 for regenerated forest (TF) while it was D=0.475401 for old growth forest (FF). The value of Shannon waivers index was found (H1) = 1.1835 for regenerated forest (TF) and (H1) = 0.9978 old primary forest (FF). Diversity of regenerated forest was found to be higher than the diversity of old growth forest.

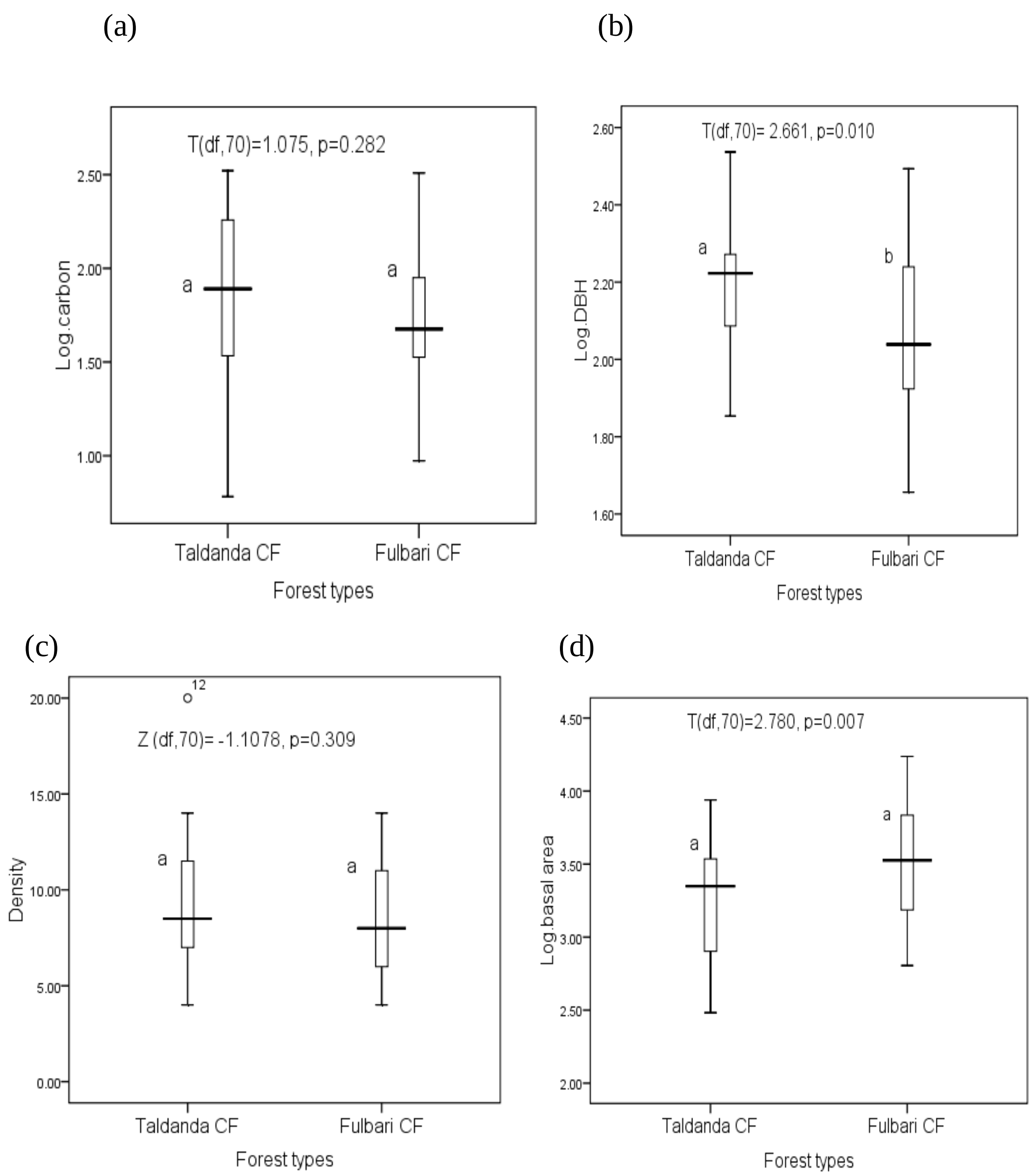


Fig.7.2 Box plot comparing the mean values (Through T-test) between Taldanda CF and Fulbari CF. (a) log. Carbon, (b) log.DBH, (c) Density, (d) log. basal area. Note: Mean values with same alphabet are not significantly different and ‘o’ represent outlier.

5.3 Property of the Forest Strata

5.3.1 Variation in Carbon Stock, Diversity and other Attributes Among the Strata of Fulbari CF.

Carbon Stock of trees increased significantly with increase in distance of strata from the settlements and roads (Fig 8.1). ANOVA - test also showed significant difference in carbon stock among the strata {F (3, 32) =9.051, *p=0.00*, Fig 8.2 a} but there was no significant increase in values of DBH {F (3, 32) =2.849, *p=0.053*, Fig 8.2 c}, basal area {F (3, 32) =1.282, *p=0.297*), Fig 8.2 e} and density {F (3, 32) =1.011, *p=0.401*, Fig 8.2 d} among the strata with increase in distance from the road or settlements.

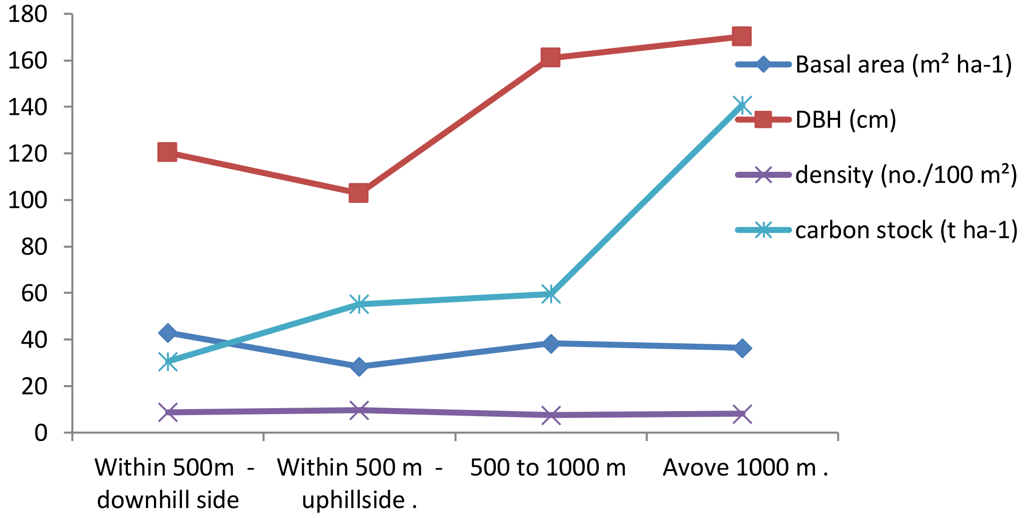


Fig 8.1.Mean values of Basal area, DBH, species richness, density, carbon stock and Biomass and Values of Shannon diversity index (H1) among the strata of Fulbari CF.

Values of diversity index were 0.376, 0.39, 0.499 and 0.53 respectively in strata 1, 2, 3 and 4 and ANOVA - test also showed significant increase in diversity among the strata of forest with increase in distance from the road or settlements {logH1, F (3, 32) =6.879, *p=0.001*, Fig 8.2 b}.

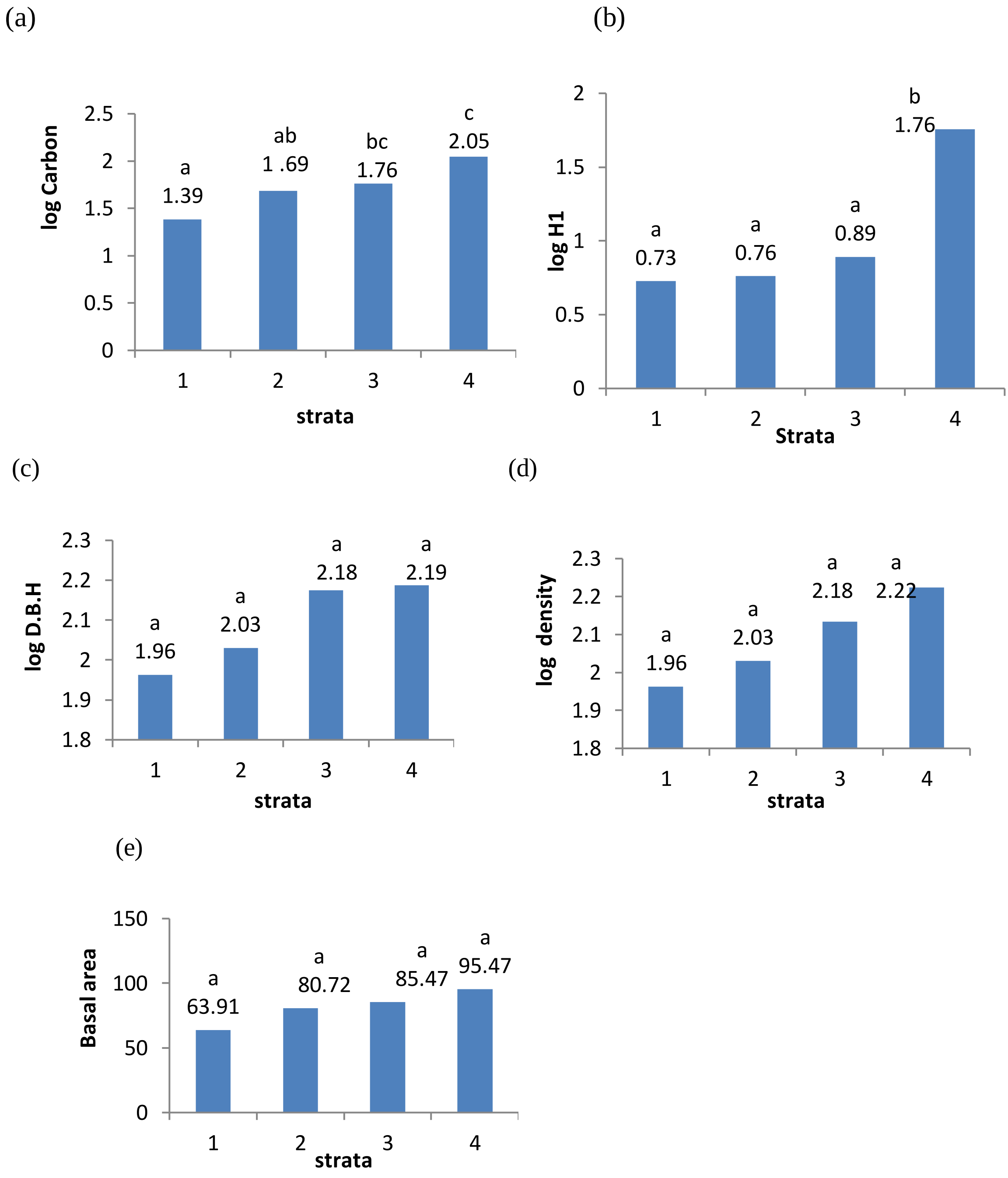
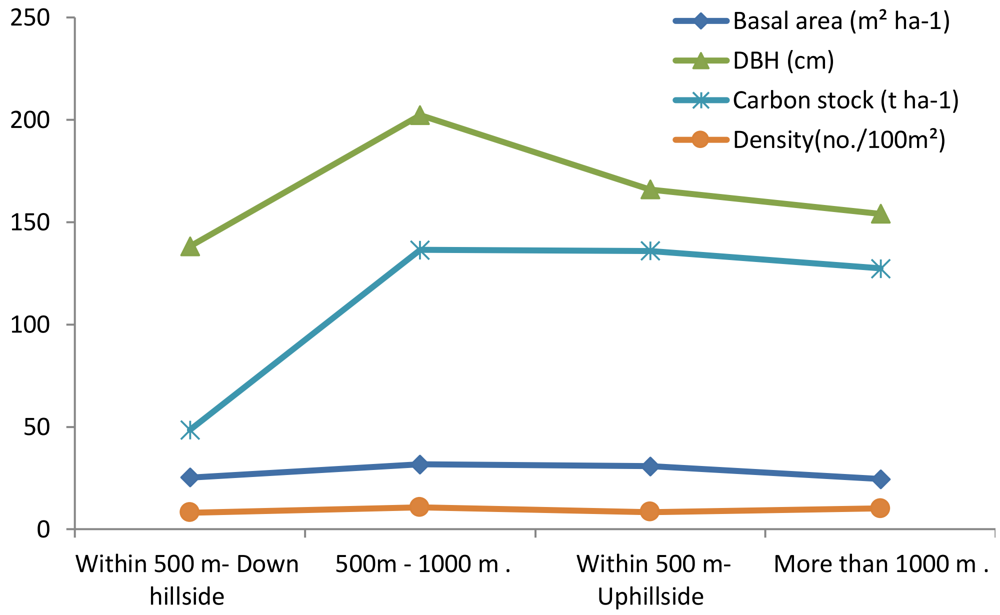


Fig 8.2 Comparisons of Mean values through Tukey's –b test, (a) carbon stock, (b) Diversity (c) DBH, (d) Density and (e) Basal area among the strata of Fulbari CF. (Note: Mean value with same alphabet and superscript indicate no significant difference Strata 1- downhill within 500 m, Strata 2- 500 m in uphill, Strata 3- Between 500 m-1000m, Strata 4–More than 1000 m from settlements).

5.3.2 Variation in Carbon Stock, Diversity Index (H1) and other Attributes among the Strata of Taldanda CF

The mean values of carbon stock, density, DBH and basal area were lowest in first strata (within 500 m from settlement) and increased significantly in strata 2 (500 m - 1000 m from settlement) and decreased slightly in strata 3 (within 500 m- uphill side) and 4 (Fig 9.1). ANOVA –test under the assumption homogeneity of variance did not show significant difference in mean values of carbon stock (Fig 9 2.a), DBH (Fig 9.2 c) and basal area (Fig 9.2 d).



9.1. Mean values of basal area, carbon stock, DBH and density, among the strata of Taldanda CF.

The value of diversity index increased significantly with increase in distance of strata from the settlements and road. The values of diversity index (H1) were 0.376, 0.3, 0.499 and 0.53 in strata first, second, third and four respectively (Fig 9.2 b).

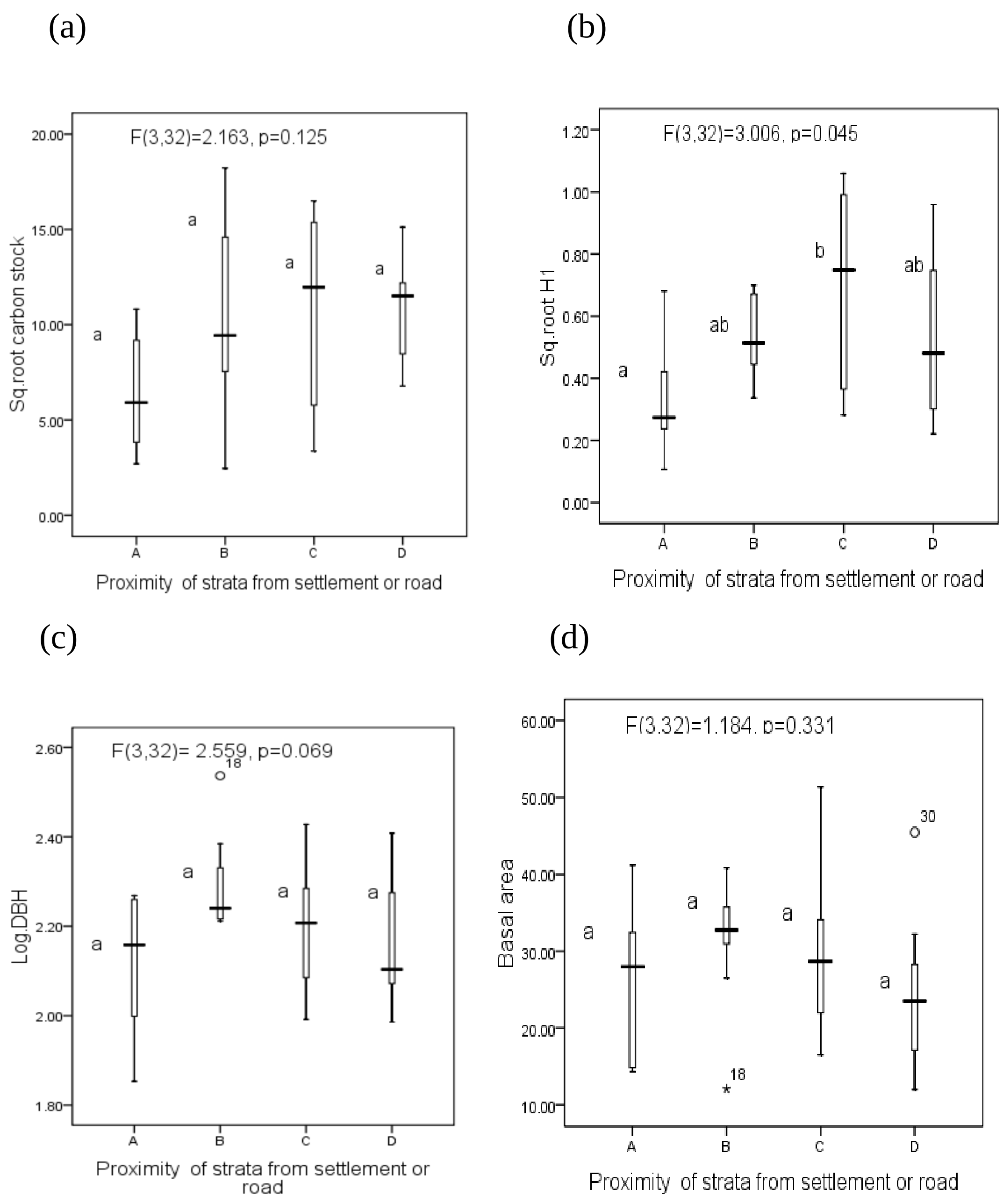


Fig.9.2 Box plot showing variation in mean values through Tukeys –b test
Among the strata Taldanda CF.
(a) Carbon stock (b) Species diversity (c) DBH and (d) Basal area.
Note: A-Within 500m of downhill settlement ,B-Between 500m an 1000m of settlement and roads, C-Within 500m of settlements on riverside, D-Above 1000m of settlement .Bar represent mean value, error bar represent deviation from mean, o represent outlier.

5.4. Relationship of Carbon Stock with Diversity and Other Attributes

5.4.1 Old Growth Forest (Fulbari CF)

Pearson's correlation test showed significant correlation of carbon stock with DBH (r=0.560, $p=0.00<0.05$). Similarly there was significant correlation between DBH and diversity (H1) {r=0.460, $p=0.005<0.05$), Annex 4 a}.

However regression showed significant positive relationship between carbon stock and species diversity index (R^2=0.143, $p=0.023$, Fig 10 a), carbon stock with DBH (R^2=0.328, $p=0.000$, Fig 10 b), and density (R^2=0.328, $p=0.030$, Fig 10 c).

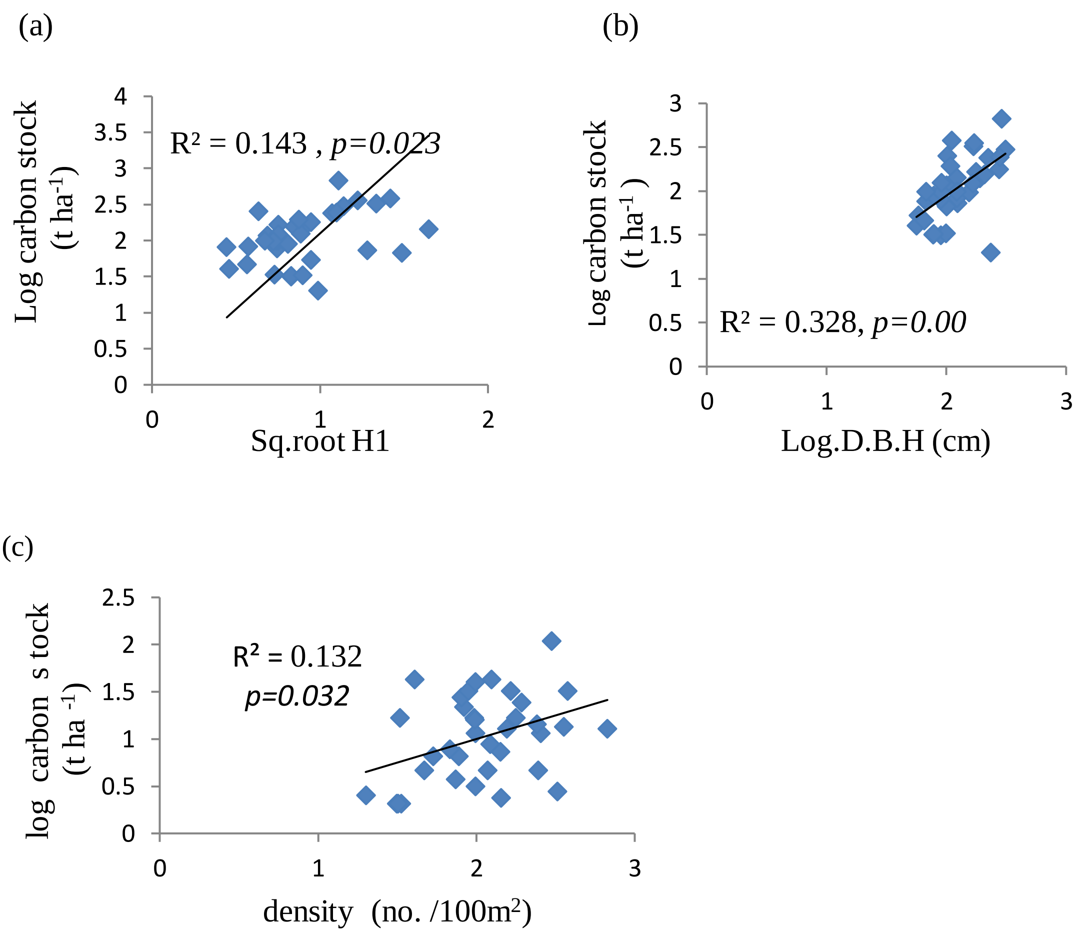


Fig.10 Regression graph showing relationship of Carbon stock with DBH and Diversity Index in old growth forest (Fulbari CF). Note: R^2= coefficient of determination at ($P < 0.05$) has significant relationship.

5.4.2 Regenerated Forest (Taldanda CF)

Correlation among different attribute showed significant correlation between carbon Stock with density (r=0.345, $p=0.040$), DBH with density (r=0.551, $p=0.00$) and density with diversity (r= -0.357, $p=0.033$). There was also positive but insignificant correlation of carbon stock with D.B.H, basal area, and species diversity index (H1) - Annex 4 b).

Regression test showed significant relationship between carbon stock with density (R^2=0.118, $p=0.040$, Fig 11 a) and diversity index (H1) with density (R^2=0.123, $p=0.035$, Fig 11 c) as well as there was significant positive relationship between density with DBH (R^2= 0.304, $p=0.00$, Fig 11 b).

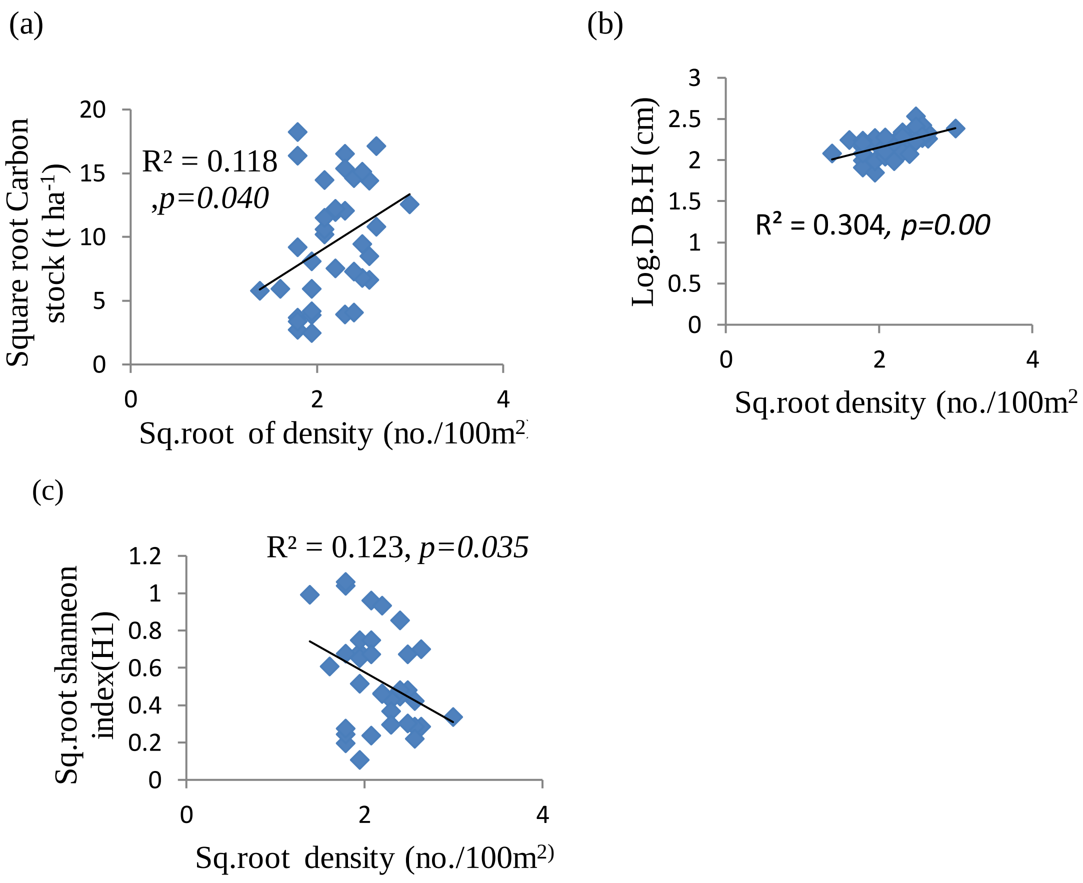


Fig.11 Regression graph showing relationship among carbon stock, Diversity Index, Density and DBH of regenerated forest (TF).

Note: R^2= coefficient of determination at ($P< 0.05$) has significant relationship.

5.5. Effect of Disturbance and Settlements on Tree Carbon stock

The variation in carbon stock of Fulbari CF was significantly affected by Proximity of strata from the road or settlement ($p=0.003$, Table I) but not significantly affected by intensity of disturbance ($p=0.882$). 63.7 % of variation in carbon stock was affected by disturbance level and proximity of strata from settlement and road. However there was no significant impact of disturbance and proximity from settlement to bring variation of carbon stock of Taldanda CF. 44.7% of variation in carbon stock was explained by disturbance and proximity of strata from settlement (Table II).

Table I. Two way Anova test among the strata of Fulbari CF.

Tests of Between-Subjects Effects					
Dependent Variable:Log.Carbon stock					
Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	2.763[a]	13	.213	2.973	.012
Intercept	83.526	1	83.526	1.168E3	.000
Disturbance	.047	3	.016	.219	.882
Strata	1.342	3	.447	6.258	.003
disturbance * strata	.687	7	.098	1.372	.266
Error	1.573	22	.071		
Total	110.763	36			
Corrected Total	4.335	35			
a. R Squared = .637 (Adjusted R Squared = .423)					

Table II.Two way Anova test among the strata of Taldanda CF.

Tests of Between-Subjects Effects					
Dependent Variable:sqare root carbon					
Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	341.074[a]	9	37.897	2.331	.044
Intercept	839.204	1	839.204	51.614	.000
Strata	93.394	3	31.131	1.915	.152
Disturbance	85.383	3	28.461	1.750	.181
strata * Disturbance	97.881	3	32.627	2.007	.138
Error	422.744	26	16.259		
Total	4034.654	36			
Corrected Total	763.818	35			
a. R Squared = .447 (Adjusted R Squared = .255)					

6. DISCUSSION

6.1. Regeneration and Other Attributes

Numbers of individual were found to be decreasing from young regeneration phase to successive development phases in both community forests (Fig 3 a and Fig 3 b).

Number of individuals at different phase was affected by the year of management rather than the age of stand as individuals of regeneration phase in Fulbari CF were higher than Taldanda CF (ie. 90% in FF and 85% in TF) but individuals at pole stage was significantly higher in TF than FF (ie. 3% in FF and 11% in TF).

However density diameter curve of trees with DBH>5cm showed sustainable regeneration in both community forests.

Result indicate that old growth forest was more disturbed than regenerated forest in relation to *Shorea robusta* forest of Nawlparasi, Nepal (Sapkota *et al*. 2009) where high density of saplings were found in disturbed forest stands than other forests.

Basal area of *Shorea* was higher (67.1 m^2 ha^{-1} in TF and 51.67 m^2 ha^{-1} in FF) than other major associated species like *Schima wallichi* with basal area 16.89 m^2 ha^{-1} in TF and *Acacia catechu* 16.7 m^2 ha^{-1} in FF (Fig 4).

Similarly density of *Shorea* was 1462.7 ha^{-1} in TF (Fig 3 a) and 1162 ha^{-1} in FF (fig 3 b). The value was higher than other species like *Schima wallichi* (671.2 per ha in TF and 398 per ha in FF), *Acacia catechu*, *Dalbergia sisso, Lagerstroemia parvifolia* etc (Fig 3 a, 3 b).

Shorea robusta contributed 65% of carbon Stock in FF and 44.7% of carbon stock in TF, the value was less than the 95% and 86% contribution by *Shorea robusta* in above ground carbon of Laxmi CF and Jalbire CF of Gorkha, Nepal (Neupane and Sharma 2014).

6.2 Tree Carbon stock and Diversity in two Forest Types

6.2.1Carbon stock

Carbon stock in tree layers of old growth Forest (Fulbari CF) was found to be 71.11 t ha^{-1} and the regenerated forest (Taldanda CF) was found to be 109.82 t ha^{-1}.

Carbon stock in Tree layers of old growth forest was lower than carbon stock of similar location with similar dominant species. Carbon stock in tree layers of Regenerated forest is comparable with 101.66 t ha^{-1} of carbon stock in *Shorea robusta* forest of Palpa (Shrestha 2008) , 97.86 t ha^{-1} in *Shorea* robusta forest of Midhills (Baral *et al.* 2009) but higher than the 44.33 t ha^{-1} of carbon stock in *Schima castonopsis* forest of Palpa (Shrestha 2008).

However carbon stocks of present studied forest were higher than above ground biomass carbon of Neelbarahi Community Forest (67.663t ha^{-1}) and Gauradevi Community Forest (28.435 t ha^{-1}) of Bhaktapur, Nepal (Khayamali 2010).

Result of present studied forest is quite similar with the above ground carbon pools in Jalbire Mahila CF (131.54 t ha^{-1}) and Laxmi Mahila CF (52.90 t ha-^{1}) of Gorkha distinct of Nepal (Neupane and Sharma 2014). Carbon stock in Taldanda CF of present study might be higher than Fulbari CF due greater density of large sized trees (poles) as in Jalbire Mahila CF (with higher density of trees than Laxmi Mahina CF). The species Sal (*Shorea robusta)* sequestrated more carbon pool in both CFs as in present studied forest.

The carbon stock reported in *Shorea robusta* forest (tree layer only) of Royal Chitwan National Park (468 t ha^{-1}, Sejuwal 1994) was higher than the present study forests. This might be due to the age and succession stage forest as with increase in age of stand more carbon is sequestrated by the plant so carbon stock of old growth forest is higher than newly regenerating forest (Singh and Singh 2006).

The findings showed that the levels of carbon stocks in the three studied CFMs of Mahottari District of Nepal were different depending on how the drivers and management units influence them (Mandal *et al.* 2014). So different in carbon stock of present studied forest might be due to the influence of management system.

Variations in carbon might be due to some environmental conditions which influence the productivity of forest like warm temperature and high rainfall and fertility of soil (Odum 1971, Barbour *et al.* 1999).

6.2.2 Diversity Value

Higher value of Shannon waivers index (H1=1.1835) in regenerated forest (Taldanda CF) than the old growth forest (Fulbari CF, H1=0.997) indicate diversity of trees was higher in regenerated forest than old growth forest.Value of Simpsons index was lower (D=0.394) in regenerated forest and higher (D=0.4754) in old growth forest. As Simpson's index is more sensitive to dominant species,old growth forest was dominated by *Shorea robusta* species.

Diversity of both forest are found to be lower than the community managed Hill sal forest of central Nepal (H1=2.42, Sapkota *et al.* 2008) but diversity of regenerated forest is comparable with Namjung community managed hill sal forest (H1=1.09) and Khari community managed hill sal forest (H1=1.30) of Gorkha District (Shrestha 2005).

6.2.3 Variation in Carbon stock and Diversity among the Strata

Strata of old growth forest (Fulbari CF) showed significant variation in carbon stock and diversity of tree species (Fig 8.1). There was significant difference in mean values of carbon stock between strata 1 and 4, 1 and 3, 2 and 4 (Fig 8.2 a). Variation in carbon stock was found to be affected by the proximity of strata from the settlements and roadside ($p=0.003<0.05$, Table I) but not affected by level of disturbance ($p=0.882$, Table I).

Among the strata of old growth forest, the mean value of Shannon diversity index (H1) was significantly higher in strata 4 than other strata (Fig 8.2 b). This might be due to human activities like grazing, fodder collection on nearby area of community forest.

In Regenerated forest (Taldanda CF), there was no significant difference in mean carbon stock among the strata (Fig 9.2 a) but there was significant difference in Species diversity among the strata of regenerated forest (Fig 9.2 b).

However there was no significant impact of disturbance and proximity from settlement to bring variation of carbon stock of Taldanda CF. 44.7% of variation in carbon stock was explained by disturbance and proximity of strata from settlement. (Table II). This might be due to positive impact of management system in conservation or there is no or very less influence of human on edges of forest.

Burenguer *et al.* (2014), found edge effect to be most significant factor to bring variation in carbon stock in living tree biomass of disturbed forest across the landscape in human modified tropical forests of Brazil like an old growth forest of present study.

Variation in carbon stock among the strata can be compared with soil vegetation carbon pool in four types of forest stands in Pokhare Khola watershed of Nepal (Shrestha and Singh 2007) where, carbon stock in the dense *Shorea robuta* forest (DS) was higher than degraded forest (DF) and other types of forest stands.

Variation in tree diversity and stand attributes among the strata of present studied forests stands is similar with *Shorea robusta* forest of Nawalprasi district of Nepal (Sapkota *et al.* 2009), where species richness was found to be affected by disturbance Intensity (41 species in less disturbed forest and 10 species in heavily disturbed forest) with no significant difference in basal area but quadriliner change in overall stand density along the disturbance gradient.

Result is also similar with higher diversity (H1=3.9) and richness in low disturbance forest stands and lower in high disturbed forest stands (H1=2.7) in Annikhhaty hills of Western Ghats where low disturbance was due to past logging and high disturbance was due to human (Anitha *et al.* 2009) .

Shau *et al.* 2007 also found negative impact of disturbance factors like foot trails on diversity, density and richness in forty two sites of the Anchanakmar-Amarknatak Biosphere Reserve of Central India.

6.3 Relationship of tree carbon Stock with diversity and other forest attributes

Tree carbon stock of Fulbari CF found to have significant positive correlation with tree diversity (H1) and DBH. There was significant correlation between DBH and diversity (Annex 4.a).

There was significant positive relationship between Carbon stock and diversity (*p=0.023*) as well as Carbon stock and DBH (*p=0.03*) in old growth forest (Fig 11.1).

In regenerated forest, Density found to show significant correlation and relationship with carbon stock, species diversity and DBH (Fig 11.2).

Tree carbon stock and species diversity of old growth forest found to have significant positive correlation and positive relationship but in regenerated forest there was no significant correlation between carbon stock with tree diversity however relationship was found to be significant between carbon stock and tree density (Fig 11.2).

Relationship between density and Carbon stock in of present studied forests is similar with higher value of carbon pool in Jalbire Mahila CF (131.54 t ha^{-1}), than of Laxmi Mahila CF (52.90 t ha^{-1}) of Gorkha District of Nepal due to greater density of the larger sized trees (Neupane and Sharma 2014).

Recent study show positive relationship between carbon stock with diversity and other attributes: Nakakaawa *et al.* (2009) found positive relationship of tree carbon stock with diversity in pilot carbon offset projects south western Uganda). Wang *et al.* (2011) also found positive correlation of carbon stock with diversity in Spurce dominated forest of Uganda.

Burenguer *et al.* (2014) found positive correlation between biodiversity and C storage across land use but no evidence for a positive relationship between tree-species diversity and above-ground biomass or soil carbon in either forests or agro forests.

7. CONCLUSION AND RECOMMENDATION

7.1 Conclusion

Regenerated (Taldanda CF) and old growth (Fulbari CF) forests on south facing slopes of Tanahun were dominated by *Shorea robusta*. Other associated species were *Schima wallichi, Acacia catechu, Dalbergia sisso, castanopsis indica* etc. Number of seedlings and saplings and trees were higher in Fulbari CF but individuals at mature stage (poles and mature regeneration) were higher in Taldanda CF.

The tree carbon stock (109.82 t ha^{-1}) and tree diversity (H1=1.1835) in Taldanda CF were higher than tree carbon stock (71.11 t ha^{-1}) and tree diversity (H1=0.9978) of Fulbari CF. Proximity of strata from road and settlement was found to be the most influencing factors for both tree carbon stock and tree diversity among the strata of Fulbari CF while it did not affect on tree carbon stock and tree diversity among the strata of Taldanda CF. Level of disturbance (fodder collection, grazing etc) did not affect on the overall tree carbon and diversity.

Shorea robusta was the dominant species and showed significant contribution in carbon stock of both community forests (64% in Fubari CF and 44.7% in Taldanda CF. There was significant contribution of other species *like Schima wallichi, Acacia catechu* and *Dalbergia sisso.*

Significant positive correlation between carbon stock with species diversity in old growth forest and positive correlation in regenerated forest indicate carbon sequestration has positive impact on biodiversity but either community forests needs more measures to enrich the tree diversity.

7.2 Recommendation

Managers may prioritize species for management using species' overall contribution to carbon storage in the forest and their per capita contribution to carbon storage. Fast regeneration is essential near the roadsides and settlements proximity in Fulbari CF to recover the degraded carbon, for that they can choose *Schima wallichi* or *Dalbargia sisso* along with *Shorea robusta.*

REFERENCES

Acharya K. P. and Sharma R.R. 2004. Forest Degradation in the Mid-hills of Nepal. In: *Journal of Institute of Forestry*, IOF, Pokhara, Nepal: Balla M.K, Bajracharya R.M, Sitaula B.K, eds.), **12:** 90-99.

Acharya K.P., Dangi R.B., Tripathi D.M., Bushley B.R., Bhandary R.R. and Bhattarai B. eds. 2009. Ready for REDD? *Taking Stock of Experiences, Opportunities and Challenges in Nepal*. Kathmandu, Nepal: ICIMOD [International Centre for Integrated Mountain Development].

Arag~ao LEOC., Poulter B. and Barlow J. 2014. Environmental change and the carbon balance of Amazonian forests. *Biological Reviews*. [online] URL:doi: 10.1111/brv.12088.

Anitha K. S., Joseph E., Ramashamy V. and Prasad S. N. 2009. Changes in structural attributes of the plants along the disturbance gradients in Dry Deciduous forest of the Western Ghats, India, *Environmental Monitoring and Assessment*. **155:**393-405**.**

Arag~ao LEOC and Shimabukuro Y. E. 2010. The incidence of fire in Amazonian forests with implications for REDD. *Science*. **328:**1275–1278.

Banskota M. 2000. The Hindu Kush-Himalayas: searching for viable socio-economic and environmental options. In: *Growth, Poverty Alleviation and Sustainable Resource Management in the Mountain Areas of South Asia*. ICIMOD (Banskota M., Papola T.S., Rischter J. eds.), Kathmandu, Nepal.

Banskota B., Karki B.S. and Skutsch M. 2007. *Reducing Carbon Emissions through Community-managed Forests in the Himalaya*. International Centre for Integrated Mountain Development, Kathmandu, Nepal.

Barbour M.G., Burk J.H., Pitts W.D., Gilliam F.S. and Schwartz M.W. 1999. *Terrestrial Plant Ecology*. Benjamin/Cummings, an imprint of Addison Wesley Longman, California, USA.

Barlow J., Parry L., Gardner T.A. *et al.* 2012. The critical importance of considering fire in REDD+ programs. *Biological Conservation*. **154:** 1–8.

Baral S.K., Malla R. and Ranabhat S., 2009. Above Ground Carbon Assessment in Different forest Types of Nepal. *Banko Janakari*. **19**(2) pp.10-14.

Balvanera P., Fisterer A P., Buchmann N., He J., Nakashizuka T., Raffaelli D. and B. Schmid. 2006. Quantifying the evidence for biodiversity effects on ecosystem functioning and services. *Ecological Letters.* **9**(10):1146 – 1156.

Berenguer E., Joice F. and Toby A.G. 2014. A large-scale field assessment of carbon stocks in human-modified tropical forests, *Global Change Biology***. 20:** 3713–3726.

Behera S.K. and Misra M.K. 2006. Aboveground tree biomass in a recovering tropical sal (*Shorea robusta* Gaertn. f.) forest of Eastern Ghats, India. *Biomass and Energy*. **30:** 509-521**.**

Brown S.J. and Schroeder P. E. 1999. Spatial patterns of aboveground production and mortality of woody biomass for eastern US forests. *Ecology Application.* **9:** 968–980.

Brown S.J., Cannell M. and Kauppi P.1996. Mitigation of carbon emission to the atmosphere by forest management. *Complete forestry review.***75:**80-91.

Campbell A., Miles L., Lysenko I., Hughes A. and Gibbs H. 2008. *Carbon storage in protected areas:* Technical report. United Nations Environment, Program-World Conservation Monitoring centre.

Caspersen J.P. and Pacala S.W. 2001. Successional diversity and forest ecosystem function. *Ecological Research*. **16**(5):895–903. [Online] URL:

doi:10.1046/j.1440.

Chave J., Andalo C., Brown S., Cairns M., Chambers J. *et al.* 2005. Tree allometry and improved estimation of carbon stocks and balance in tropical forests *Oecologia*. **145:**87-99.

Clark D**.** 2000. Landscape-scale variation in forest structure and biomass in a tropical rain forest. *Forest Ecology and Management*. **137:**185–198.

Clark D.B. and Kellner J.R. 2012 Tropical forest biomass estimation and the fallacy of misplaced concreteness. *Journal of Vegetation Science*, **23:** 1191–1196.

Dixon R.K., Brown S., Houghton R.A., Solomon A.M., Trexler M.C. and Wisniewski J. 2005. Carbon pools and flux of global forest ecosystems. *Global Forest Resources Assessment Science.* **263:** 185–190.

DOF 2012. *Community Forests User Groups Database*. Community Forest Division, Department of forest Kathmandu. [Online] URl:http://www.dof.gov.np.

DFO Tanahun 2012. Annual *Monitoring and Evaluation of Community Forests:An Analysis Report.* District Forest Office (DFO), Tanahun,Nepal.

DHM 2014. Annual and Monthly report of precipitation and temperature of Khairentar weather station of Tanahun, Nepal.

Feldpausch T.R., Jirka S., Passos C.A.M., Jasper F.A. and Riha S.J. 2005. When big trees fall: damage and carbon export by reduced impact logging in southern Amazonia.*Forest. Ecology and Management*, **219:** 199–215**.**

Fornara D. and Tilman D. 2008. Plant functional composition Influences rates of Soil carbon and nitrogen accumulation. *Journal of Ecology*. **96** (2):314 – 322.

Gillman L.N. and Wright S.D. 2006. The influence of productivity on the species Richness of plants: A critical assessment. *Ecology*. **87**(5):1234 –1243.

Harmon M., Whigham D., Sexton J. and Olmsted I. 1995. Decomposition and mass of Woody detritus in the dry tropical forests of the northeastern Yucatan Peninsula, Mexico. *Biotropica*. **27**: 305–316.

Houghton J.T., Filho L.G., Callander B.A., Harris N., Kattenberg A. and Maskell K.1996. *Climate Change 1995: The Science of Climate Change, Contribution of Working Group 1 to the Second Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge University Press, Cambridge, UK.

Houghton R.A. 2005. Aboveground forest biomass and the global carbon balance. *Global Change Biology*. **11:** 945–958**.**

Hughes R.F., Kauffman J.B. and Jaramillo V.J. 1999. Biomass, carbon and nutrient Dynamics of secondary forests in a humid tropical region of Mexico. *Ecology* **80:**1892–1907.

Hunt C. A. G. 2009. Carbon sinks and climate change, Forest *in fight against Global Warming*. Edward Elger Publishing Limited, U.K. pp.236.

IPCC. 2006[a]. *Good practice guidelines for National Greenhouse gas inventories.* Switzerland : Intergovernmental panel on climate change.

IPCC. 2006[b.] *Forestland*. In: IPCC Guidelines for National Greenhouse Gas Inventories .eds Eggleston HS., Buendia L., Miwa K., Ngara T. and Tanabe K), pp. 4.1–4.83. IPCC, Japan.

IPCC. 2007. *Climate Change* 2007: The Physical Science Basis. Contribution of working Group I to the fourth assessment report of the Intergovernmental panel on climate change.

IPCC. 2013. Working group I contribution to the IPCC. Fifth Assessment Report: *Climate change 2013*: The Physical Science Basis Summary for policymakers.

Janne A.E., Lopez G., Coomes D.A., Ilic J. *et al.* 2009. Global wood density database. [online] URL:http://hdl.handle.net/10255/dryad.235.

Kanel R. K. 2004. Twenty Five Years' of Community Forestry: Contribution to Millennium Development Goals. In: *Twenty-five Tears of Community Forestry* (Kanel R.K., Mathema P., Kandel B.R., Niraula D.R., Sharma A. R. and Gautam M. eds.). pp 4-18: Proceedings of the Fourth National Workshop on Community Forestry 4-6 August, 2004, Kathmandu.

Karky B.S., and Skutsch, M. 2009. The cost of carbon abatement through community forest management in Nepal Himalaya, *Ecological Economics*. [online] URL: doi:10.1016/j.ecolecon. 2009.10.004.

Khayamali B.P. 2010. *Assessing carbon benefits from Neelbarahi and Gauradevi community forest of Bhakatapur.* M.Sc. Dissertation, Department of Enviromental Science,Khwopa college Bhakatapur.

Keeling C.D., Piper S.C and Heimann.1989. A three –diamensional model of atmospheric Co_2 transport based on observed winds: *Mean annual gradients and interannual variations* **4:**305-363. American Geophysical Union,USA.

Kirby K.R. and Potvin C. 2007. Variation in carbon storage among tree species: Implications for the management of a small-scale carbon sink project. *For Ecol Manage.* **246**:208–221. [online] URL:www.sciencedirect.com.

Kunwar R.M. and Sharma S.P. 2004. Quantative Analysis of tree species in two community forest of Dolpa District, Mid west Nepal*: Himalayan Journal of Science.* **2 (**3): 23-28.

Laurance W.F., Nascimento H.E.M., Laurance S.G., Andrade A.C., Fearnside P.M., Ribeiro J.E.L. and Capretz R.L. 2006. Rain forest fragmentation and the proliferation of successional trees. *Ecology*.**87:** 469–482.

Mac Dicken K. 1997. A guide to monitoring carbon storage in forestry and agro-agriculture development. Winrock International Institute for Agricultural Development, Arlington, USA pp 87.

Mandal R.A., Dutta I.C, Jha P.K., Kamacharya S.B., Yadav K.K. and Haque S. 2012. Effects of drivers of deforestation and forest Degradation on Collaborative forest of Nepal, *e-planet*. **10** (1): 1-6.Journal of Organization for Protection of ecosystem and Endangered species.

Mc Minn J.W. 1992. Diversity of woody species 10 years after four harvesting treatments in the oak-pine type. *Canadian Journal For Resource*. **22**:1179–1183.

MoFSC. 2012. *Community Forestry*. Department of Forest, Ministry of Forest and Soil Conservation (MoFSC), Government of Nepal. .URL: http://dof.gov.np/division/community-forest-division/community forestry [Accessed on August-27, 2012].

MoPE. 2003. *State of the Environment Report*, Ministry of Population and Environment, Kathmandu.

MoPE. 2004. Nepal Initial National Communication to the Conference of the Parties of the United Nations Framework Convention on Climate Change. July, 2004. Kathmandu, Nepal: Ministry of Population and Environment.

Nakakaawa C., Aune J. and Vedeld P. 2009. Changes in carbon stocks and tree diversity in agro-ecosystems in south western Uganda: what role for carbon sequestration payments?. *New Forests*; [online] URL:*DOI* 10.1007/s11056-009- 9180-5.

Nangendo G., Stein A., Gelens M. *et al.* 2002. Quantifying differences in biodiversity Between a tropical forest area and a grassland area subject to traditional Burning. *Forest Ecological Management*. **164:**109–120.

Neupane B. and Sharma R.P. 2014. An assessment of an effect of vegetation size and type and altitude on above ground carbon and biomass. *Journal of Agriculture and crop Research*.**2**(3) 44-50.

Odum E.P.1971. *Foundamentals of Ecology*.W.B. Saunders Company USA.

Oli B. N. and Shrestha K. 2009. Carbon Status in Forests of Nepal. *Journal of Forest and Livelihood*. **8**:1.

Pacala S. and Tilman D. 2002. The transition from sampling to complementarily. *In:* the functional consequences of biodiversity: empirical progress and theoretical extensions. Princeton University Press, Princeton, *N.J.* pp. 151–166.

Paula M.D., Costa C.P.A. and Tabarelli M. 2011. Carbon storage in a fragmented landscape of Atlantic forest: the role played by edge-affected habitats and emergent trees. *Tropical Conservation Science*. **4**: 349–358.

Pearson T., Brown S. and Birdsey R. 2007. *Measurement guidelines for the sequestration of forest carbon*. General Technical Report NRS-18,U: Northern research Station.

Pearson T., Walker S. and Brown S. 2005. *Sourcebook for land use, land-use change and forestry projects*. Winrock International and the Bio Carbon Fund of the World Bank,Washington, DC.

Parrotta J.A, Wildburger C. and Mansourian S. 2012. Understanding relationships between biodiversity, carbon, forests and people: the key to achieving REDD +objectives. *A Global Assessment Report. Vol. 31*. International Union of Forest Research Organizations (IUFRO), Vienna, Austria Department of Agriculture.

Rana E.B., Shrestha H.L. and Silwal R. 2008. Participatory carbon estimation in community forest: methodologies and learning. *The Initiation*. **2:**91-98.

Ramachandran A., Jayakumar S., Haroon R.M., BhakaranA. and Arockiasamy D.I. 2007. Carbon sequestration: estimation of carbon stock in natural forest using geospatial technology in the Eastern Ghats of Tamil Nadu India.*Current Science* **92:**323-331.

Ramakrishanan P.S. 1996. Conserving the sacred: from species to landscapes. *Nat. Resource*. **32:** 11–19.

Sapkota I. P., Tingbu M. and Oden P. C. 2008. *Tree diversity and Regeneration of community managed forests of Bhabar region and Hill sal forest of Mid hill of Nepal*: *Bois Et Forests Des Tropiques* **300** (2).

Sapkota I.P., Tingbu M. and Oden P.C. 2009. Spatial distribution,Advanced regeneration and stand structure of Nepalease Sal forest (*Shorea robutsa*) Subject to different disturbance Intensity; *Forest ecolgy and management*, **257:**1966-1977.

Sejuwal M. 1994. *Aboveground biomass estimation in tropical forest of Royal Chitwan National Park*. [M.Sc. Dissertation]. Central Department of Botany, Kirtipur, Kathmandu.

Shau P.K., Sagar R. and Singh G.S. 2008. Tropical forest structure and diversity in relation to altitude and disturbance in Biosphere reserve in Central India, *Applied Vegetation Science* **11:**461-70.

Shannon C.E and Weaver W. 1949. *The mathematical theory of communication.* University of Illinois Press,Champaign.

Shannon C.E.1948. A Mathmatical theory of communication. *The Bell system Technical Journal* **27**:379-423.

Shrestha B.B. 2005. Fuel wood harvest management and regeneration of two community forests in Central region of Nepal. *Himalayan Journal of Sciences.* **3**(5):75-80.

Shrestha B.P. 2008. Carbon Sequestation in *Schima Castonopsis* Forest. A case study from Palpa District. *The Greenery*. **7**:34-40.

Shrestha B.M and Singh B.L. 2007. Soil and vegetation carbon pools in a mountain watershed of Nepal. *Nutrient Cycling in Agro ecosystems*. **81**:179-191**.**

Shrestha U.B., Shrestha B.B and Shrestha S. 2010. Biodiversity conservation In Community forests of Nepal :Rheotoric and reality. 2009. *International Journal of Biodiversity and conservation.* **2** (5): 98-104. [Online] URL: Http://Www.Academicjournals.Org/Ijbc.

Sierra R. and Russman E. 2006. On the efficiency of environmental service payments: a forest conservation assessment in the Osa Peninsula, Costa Rica. *Ecological Economics*. **59**:131–141.

Simpson E.H. 1949. Measurement of diversity. *Nature* **163**:688-689.

Singh J.S., Singh S.P. and Gupta S.R. 2006. *Ecology, Environment and Resource Conservation*. Anamaya Publishers, New Delhi.

Springate-Baginski O., Dev O.P., Yadav N.P and Sousan J. 2003. Community forest Management in the middle hills of Nepal: the changing context. J. For. Livelihood. **3**: 5-20.

Subedi B.P., Pandey S.S., Pandey A., Rana E.B., Bhattrai S., Banskota T.R., Charma kar S. and Tamrakar R. 2010. *Guidelines for measurement of carbon stock in community managed forests*. Federation for community forestry Nepal; FECOFUN, Asia network for sustainable and agriculture Bioresearches (ANSB) International centre of integrated mountain Development (ICIMOD) and Norwegian Agency for Development Cooperation (NORAD).

Szwagrzyk J. and Gazda A. 2007. Above-ground standing biomass and tree species diversity in natural stands of Central Europe. *Journal of Vegetation. Science*.**18** (4):555– 562.

Thapa. 2010. *An estimation of soil Fertility status and Carbon stock estimation of Hansatar Community Forest and its adjoining areas*. M.Sc. Dissertation, Central Department of Environmental Science, TU.

Tilman D., Wedin D. and Knops J., 1996. Productivity and sustainability influenced by biodiversity in grassland ecosystems. *Nature* **379:** 718–720.

Tilman D., Reich P.B., Knops J., Wedin D., Mielke T. and Lehman C. 2001. Diversity and productivity in the long-term grassland experiment. *Science* .**294:** 843–845.

UNEP (United Nations Environment Programme, 1992. Convention on Biological Diversity. United Nations Environment Programme, Nairobi, Kenya.[online] URL: http://www.biodiv.org/convention/default.shtml.

UNFCCC (United Nations Framework Convention on Climate Change), 1992.United Nations Framework Convention on Climate Change, Geneva,UNEP/WMO. [online] URL: http://www.unfccc.int/.

UNFCCC (United Nations Framework Convention on Climate Change), Conference of the Parties, Third Session, 199. Kyoto Protocol to the United Nations FrameworkConventiononClimateChange.[online]URL:FCCC/CP/1997/7/Add.1.: http://www.unfccc.int/.UNFCCC (United Nations Framework Convention on Climate Change). Conference of the Parties, Eleventh Session, 2005.FCCC/CP/2005/L.2[online] URL: http://cdm.unfccc.int/.

Verlag S. B., Condit R., Robinson W.D., Aguilar S., Sanjur., *et al.* A.2001. The status of the Panama Canal Watershedand its biodiversity at the beginning of the 21st century. *Bioscience.* **51:**389–398.

Wang W., Lei X., Ma Z., Kneeshaw D.D. and Changhui P. 2011. Positive relationship between aboveground carbon stocks and structural diversity In spruce-dominated forest stands in New Brunswick, Canada *Forest Science*. **57**(6):506-515.

Whittaker R.J. and Heegaard E. 2003. Comment: what is the observed relationship? between species richness and productivity? *Ecology*, **84**(12): 3384–3390 .[online] URL doi:10.1890/02-3128.

Zar J.H., 1998. *Biostatistical Analysis*, 4th ed. Prentice Hall, 929 pp.

Zobel D. B., Jha P.K., Behan M.J. and Yadav U.K.R. 1987. *A Practical Manual for Ecology*. Ratna Pustak Distributors, Kathmandu, Nepal.

ANNEX 1

1.1 Value of Taldanda CF

:a	plot no	Species no	Density	Species richness Index	DBH	Basal area per ha	Tree biomass per ha	tree Carbon per ha	RRI	Diversity Index
1	1	1	6	0.408248	143.949	27.963	15.48	7.27	1.1779	0.038
1	2	1	6	0.816497	99.6915	14.839	179.36	84.3	3.7832	0.0598
1	3	2	8	0.353553	117.834	14.546	219.99	103.39	0.45091	0.05632
1	4	1	5	0.894427	176.565	36.79	74.44	34.98	1.2598	0.368
1	5	1	6	0.816497	81.741	15.18	28.44	13.36	0.992	0.0748
1	6	2	7	0.755929	71.3376	14.31	31.34	14.73	0.4014	0.0113
1	7	1	7	0.377964	184.713	41.18	36.71	17.25	1.049	0.4643
1	8	2	14	0.534522	181.774	32.48	243.65	116.95	1.0135	0.0799
1	9	2	13	0.27735	185.669	29.72	93.8	44.08	1.231	0.1766
2	10	1	7	0.755929	162.739	30.95	12.87	6.05	0.8373	0.2639
2	11	1	11	0.603023	171.656	34.5	452.85	212.84	0.0165	0.1984
2	12	2	20	0.447214	242.357	32.6	336.29	158.06	0.3773	0.1131
2	13	1	10	0.632456	164.65	26.52	32.39	15.22	0.3102	0.1821
2	14	2	14	0.801784	214.013	35.74	623.47	293.03	0.665	0.4893
2	15	1	9	0.333333	162.739	32.75	121.28	57.01	1.2189	0.2151
2	16	1	7	0.377964	184.395	39.36	138.24	64.97	1.2287	0.4221
2	17	1	6	2.041241	173.885	40.84	691.86	332.09	1.2859	0.4561
2	18	6	12	0.57735	344	12.07	189.52	89.07	0.5441	0.45
3	19	1	4	1.5	120.701	28.68	71.01	33.37	0.571	0.98
3	20	5	6	0.408248	121.656	21.98	570.71	268.23	0.8885	1.08
3	21	1	10	0.632456	218.471	51.39	566.9	272.11	1.7715	0.1339
3	22	1	6	0.816497	161.146	34.10	24.23	11.38	1.2628	1.12
3	23	2	7	1.511858	98.0892	16.52	74.92	35.21	1.2666	0.56
3	24	1	11	1.206045	169.427	29.79	35.18	16.54	1.1117	0.73
3	25	1	9	1	144.268	27.93	304.28	143.21	1.2436	0.212
3	26	2	13	0.5547	267.781	21.77	433	207.84	1.0948	0.08
3	27	2	10	0.632456	192.625	44.30	492.34	236.32	1.34004	0.08728
4	28	2	8	0.707107	109.809	32.22	436.08	209.31	0.9705	0.5574
4	29	2	10	0.948683	124.395	11.97	301.11	144.53	1.1939	0.0867
4	30	2	12	0.57735	256.019	45.46	476.326	228.64	0.9471	0.09106
4	31	3	13	1.1094	197.58	28.27	152.48	71.66	1.01816	0.0484
4	32	3	12	0.288675	169.682	23.48	97.84	45.98	1.2962	0.231
4	33	3	11	0.301511	117.994	19.39	109.8	52.7	1.3023	0.231
4	34	4	8	1.414214	126.983	17.13	233.04	111.86	0.9379	0.45
4	35	4	8	0.707107	188.312	26.94	276.12	132.53	1.06196	0.92
4	36	2	9	0.666667	96.79	15.76	309.55	148.584	0.6984	0.87

1. 2 Values of Fulbari CF

:a	Plot no	Species no	Density	Species richness Index	DBH	Basal area	Biomass	Carbon per ha	RRI	Diversity Index
1	1	1	7	0.377	122.45	43.41	143.7	67.54	1.1934	0.8
1	2	1	6	0.408	234.5	17.752	20	9.4	1.0431	0.97379
1	3	1	10	0.316	89.56	22.031	31.49	14.8	1.2028	0.68663
1	4	1	10	0.316	98.9	69.229	33.38	15.69	1.1082	0.5312
1	5	1	10	0.316	77.78	22.002	32.03	15.37	1.153	0.68814
1	6	1	6	0.812	67.8	68.375	77.31	36.34	1.171	0.556
1	7	1	12	0.577	123.1	46.6	73.63	34.6	0.2894	1.6386
1	8	1	6	1.224	78.62	51.2479	32.83	15.43	1.2473	0.801
1	9	1	12	0.866	190.26	45.854	141.96	66.72	1.2488	2.7085
2	10	1	8	1.060	101.28	54.144	255.5	122.64	0.7654	0.4035
2	11	1	13	1.109	289.9	57.2754	672	322.56	0.4124	1.229
2	12	1	6	2.041	311.4	51.269	298.49	140.29	1.2046	1.3031
2	13	1	5	0.447	167.45	38.991	324.4	155.71	0.5431	1.78
2	14	1	7	1.133	170.3	35.769	356.4	171.07	1.1133	1.503
2	15	1	11	1.507	111.09	25.812	378.73	181.79	1.3456	2.01
2	16	1	12	1.155	222.2	23.857	240.81	115.58	0.8765	1.149
2	17	7	5	0.894	100.3	23.95535	67.75	32.52	1.2345	2.21
2	18	7	6	0.816	58.39	16.53686	53.35	25.6	1.3214	0.893
3	19	7	4	0.5	123.08	43.918	98.61	47.33	1.3209	0.5675
3	20	7	9	0.667	99.87	35.475	117.89	56.58	1.4012	0.4715
3	21	7	7	1.511	176.94	46.007834	165.43	79.4	0.9871	0.564
3	22	7	5	1.341	123	29.393	83.21	39.94	0.7893	0.328
3	23	7	6	1.224	154.53	41.924	97	46.56	0.8764	0.6182
3	24	7	6	1.224	275.15	28.56	178.12	85.49	1.009	0.8983
3	25	7	8	1.06	122.43	32.55	98.76	47.4	1.1121	0.5501
3	26	1	13	1.109	207.52	47.76	156.32	75.033	1.1208	0.7193
3	27	2	10	0.948	167.32	39.98	122.73	58.91	1.1412	0.5673
4	28	1	6	1.632	56.3	24.43	40.76	19.56	1.2309	0.2101
4	29	2	12	1.443	89.97	29.32	80.56	38.67	1.3201	0.1982
4	30	2	7	1.511	78.55	28.32	88.74	42.59	1.4009	0.6564
4	31	1	9	0.666	65.51	18.34	46.78	31.45	1.4037	0.3213
4	32	1	11	1.206	90.87	22.32	97.52	46.81	0.9879	0.5214
4	33	1	9	0.666	278.54	54.32	245.9	117.6	0.99601	1.2078
4	34	2	6	1.632	90.62	26.65	124.89	59.95	0.951	0.7841
4	35	2	13	1.386	107.53	32.1	193.5	92.88	0.8911	0.7654
4	36	2	14	1.603	67.92	18.43	98.78	47.41	0.8745	0.4541

ANNEX 2

2 A T-Test between Mean Values of Taldanda CF and Fulbari CF.

Independent Samples Test				
		t-test for Equality of Means		
		T	Sig. (2-tailed)	Mean Difference
Log .biomass		1.169	.246	.11806
Logcarbon		1.085	.282	.10972
Log DBH		2.661	.010	.11718
Log.Basal area		-2.780	.007	0.1139

2. b Mann Whitney U Test with mean rank values of Taldanda and Fulbari CF.

Mann Whitney U Test Test Statistics[a]			
	Shannon index of diversity(H1)	No of species	Species richness
Mann-Whitney U	108.000	558.500	368.500
Wilcox on W	774.000	1224.500	1034.500
Z	-6.082	-1.017	-3.150
Asymp. Sig. (2-tailed)	.000	.309	.002
a. Grouping Variable: forest types			

Mean rank values			
	forest types	N	Mean Rank
Shannon index of spp diversity(H1)	Taldada CF	36	21.50
	Fulbari CF	36	51.50
	Total	72	
Density	Taldada CF	36	38.99
	Fulbari CF	36	34.01
	Total	72	
Species richness	Taldada CF	36	28.74
	Fulbari CF	36	44.26
	Total	72	

ANNEX 3

3. a Homogeneity test for Taldanda CF

Test of Homogeneity of Variances				
	Levene Statistic	df1	df2	Sig.
Log.basal area	1.139	3	32	.348
Log.species number	1.122	3	32	.355
Sq.root carbon density	3.742	3	32	.051
Sq.root H1	2.366	3	32	.061
sq.root species richness	.141	3	32	.935
Log.D.B.H	1.068	3	32	.376

3. b ANOVA test of Taldanda CF

ANOVA			
		F	Sig.
Log. basal area	Between Groups	1.418	.256
	Within Groups		
	Total		
Log. species number	Between Groups	1.734	.180
	Within Groups		
	Total		
Sq. root carbon density	Between Groups	2.063	.125
	Within Groups		
	Total		
Sq. root biomass	Between Groups	2.051	.126
	Within Groups		
	Total		
Sq.root H1	Between Groups	3.006	.045
	Within Groups		
	Total		
sq.root species richness	Between Groups	1.208	.323
	Within Groups		
	Total		
Log.D.B.H	Between Groups	2.599	.069
	Within Groups		

3 .c Homogeneity test for Fulbari community forest

Test of Homogeneity of Variances				
	Levene Statistic	df1	df2	Sig.
Square root of H1	1.832	3	32	.161
Log. Species number	.160	3	32	.922
Log D.B.H	1.005	3	32	.403
Log. Carbon density	2.611	3	32	.068
Species richness	.151	3	32	.928
Basal area	.084	3	32	.968

3. f ANOVA table of Fulbari CF

ANOVA			
		F	Sig.
Square root of H1	Between Groups	6.732	.001
	Within Groups		
	Total		
Log. Density	Between Groups	1.011	.401
	Within Groups		
	Total		
Log D.B.H	Between Groups	2.849	.053
	Within Groups		
	Total		
Log. Carbon density	Between Groups	9.051	.000
	Within Groups		
	Total		
Log .Biomass	Between Groups	8.617	.000
	Within Groups		
	Total		
Basal area	Between Groups	1.282	.297
	Within Groups		
	Total		

ANNEX 4

4. a Correlation Test of Taldanda CF

Correlations						
		Sq carbon	sqH1	Log density	Log ba	Log dbh
Sq carbon	Pearson Correlation	1.000**	.027	.345*	.126	.308
	Sig. (2-tailed)	.000	.878	.040	.464	.068
sqH1	Pearson Correlation		.026	.344*	.129	.307
	Sig. (2-tailed)		.881	.040	.453	.069
L0g density	Pearson Correlation			-.352*	.222	-.020
	Sig. (2-tailed)			.035	.193	.906
Log basal area	Pearson Correlation				-.024	.551**
	Sig. (2-tailed)				.888	.000

4. b Correlation Test of Fulbari CF.

Correlations					
		Log D.B.H	Log. density	Square root of H1	Basal area
Log. Carbon	Pearson Correlation	.560**	.177	.378*	.271
	Sig. (2-tailed)	.000	.302	.023	.110
Log D.B.H	Pearson Correlation		.048	.460**	.315
	Sig. (2-tailed)		.783	.005	.061
Log. density	Pearson Correlation			.028	-.005