PLANT SPECIES COMPOSITION, CARBON STOCK, AND REGENERATION OF TWO COMMUNITY FORESTS IN NAWALPARASI DISTRICT, CENTRAL NEPAL

A DISSERTATION SUBMITTED FOR PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE MASTER'S DEGREE IN BOTANY

BY

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Symbol Number: 548/074

T.U Regd. No: 5-2-19-659-2013

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September 2023

DECLARATION

I, Namrata Paudel, hereby declare that the research presented in this study, titled "**Plant Species Composition, Carbon Stock, and Regeneration of two Community Forests in Nawalparasi District, Central Nepal**", is my own work and all other sources of information used, have been acknowledged and listed in the reference section. This work has not been published or submitted elsewhere, in whole or in part, for the requirement of any other degree or professional qualification.

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RECOMMENDATION

This is to recommend that the Master's thesis entitled "**Plant Species Composition, Carbon Stock, and Regeneration of two Community Forests in Nawalparasi District, Central Nepal**." Has been carried out by Namrata Paudel under my supervision. The entire work is based on original scientific investigations and has not been submitted for any other degree in any institution. Therefore, I recommend this thesis work to be accepted for the partial fulfillment of a Master's Degree in Botany.

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LETTER OF APPROVAL

The dissertation work submitted by Namrata Paudel entitled "**Plant Species Composition, Carbon Stock, and Regeneration of two Community Forests in Nawalparasi District, Central Nepal**" to the Department of Botany, Amrit Campus, Tribhuvan University has been accepted for the partial fulfillment of the requirements for Master's Degree in Botany (Ecology).

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ACKNOWLEDGMENTS

I extend my heartfelt gratitude to Prof. Dr. Mukesh Kumar Chettri, the former Head of the Department of Botany at Amrit Campus, Tribhuvan University, for his exceptional supervision and unwavering support throughout the journey of this dissertation. His continuous guidance and insightful feedback have been invaluable.

I would like to acknowledge thanks to Dr. Shila Singh, Head of the Department, and Dr. Laxmi Joshi Shrestha, the program Coordinator, Department of Botany, Amrit Campus, T.U for their helpful suggestions and administrative assistance for the completion of this work.

I would like to express sincere thanks to the authorities of Shiva Community Forest and Budhaulikuna Community Forest, Nawalparasi District Forest Office, and Sector Forest Office for their cooperation and permission to allow research in their forests. Besides this their valuable insights have remained to be an integral part of this work.

I want to express my gratitude to my friends Mr. Prakash Godar, Mr. Roshan Adhikari, Mr. Aditya Joshi, Mr. Dinesh Acharya, Mrs. Binita Pandey, Mr. Kiran Panthi, and Mrs. Iswori Poudel for their unwavering, and constant support, precious guidance and suggestions during entire thesis work. I also want to express my sincere and warm appreciation to my friends, from the same batch, for their continuous support.

Last, but not least, my gratitude knows no bounds when it comes to my parents, family members, and relatives whose precious support remained to be like pillar during my academic pursuits.

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ABSTRACT

This research explores vegetation dynamics in Shiva Community Forest (SCF) and Budhaulikuna Community Forest (BCF) with different management practices in Nawalparasi district. SCF restricts resource collection to six months, while BCF allows year-round access. Sixty sample plots were systematically sampled to assess species diversity, carbon stock, and regeneration in these two forests with different forest management practices. Results indicated similar herb diversity at BCF and SCF, slightly lower shrub diversity in BCF than in SCF, and in the case of trees, the diversity was high at SCF. BCF exhibited higher seedling and sapling density, while SCF showed higher tree density. BCF is a comparatively matured forest and SCF is a young forest, which is evident from the DBH. Most of the trees in BCF were of the DBH class between 40 to 90 cm but in SCF it was between 10-30 cm. The density-diameter relation showed more mature trees in BCF, with a Hump-shaped curve, while SCF had a reverse j-shaped curve. Carbon stock calculations revealed BCF with significantly higher stock (163 tons/ha) dominated by Sal trees compared to SCF (81 tons/ha). Regeneration of seedlings and saplings was higher in BCF than in SCF. Controlled harvesting in SCF might have benefited trees but hindered seedling growth. On the other hand, at BCF the number of matured trees was less and this possibly supported better seedling and saplings growth because of more canopy gap. The findings suggest that both practices of forest management have certain demerits and hence need to be modified for preserving, protecting, and systematically utilizing the resources especially to maintain and protect plant diversity.

Keywords: community forest, plant diversity, biomass, Sal Forest

LIST OF ABBREVIATIONS

°C	Degree Celsius
AGB	Above-ground Biomass
APG	Angiosperm Phylogeny Group
BCF	Budhaulikuna Community Forest
BGB	Below-ground Biomass
CBFM	Community-Based Forest Management
CDM	Clean Development Mechanism
CFM	Community Forest Management
CFs	Community Forests
CFUGS	Community Forest user groups
DBH	Diameter at Breast Height
DWC	Department of Weather and Climate
GBH	Grith Base Height
GPS	Global Positioning System
IVI	Importance Value Index
Masl	Meter above sea level
REDD	Reducing Emissions from Deforestation and Forest Degradation
SCF	Shiva Community Forest
t/ha	Tons per hectare
UNFCC	United Nations Framework Convention on Climate Change

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CHAPTER.1: INTRODUCTION

Background

In Nepal, the practice of community forest management has emerged as a highly successful strategy for preserving biodiversity and effectively managing natural resources. Over the course of four decades, approximately, 2,831,707 hectares of Nepal's forests have transitioned from a state-controlled, top-down approach to a participatory one led by local communities, primarily due to organizational and policy reforms (Ghimire and Lamichhane, 2020).

The study of plant composition within the context of community forest management plays a pivotal role in understanding the dynamics of Nepal's forests. Specifically, the term "composition" in biodiversity refers to aspects such as species richness, floristic diversity, and faunistic diversity. On the other hand, the concept of "structure" delves into microhabitat occurrences, the presence of dead branches, and tree size diversity (Rad, Manthey, and Mataj, 2009). Understanding the composition of plant species is essential as it is intricately linked to the dominance of shade-resistant climax species within the forest stand. This correlation highlights the interplay between stability, maturity, productivity, evolutionary time, predation pressure, and spatial heterogeneity of diversity (Rad, Manthey, and Mataj, 2009). Nepal has implemented an exceptionally successful and significant management program known as community forestry, which effectively preserves biodiversity. Currently, the active engagement of local communities is crucial in handling natural resources (Acharya and Shrestha, 2011).

Even though scientific forest management is still a relatively new idea in Nepal, both CFUGs have a methodical approach to performing forest management operations. The primary basis for dividing the forest into distinct blocks is the presence of natural borders. With the aid of these blocks, it is feasible to control the yields of forest products and manage the forest sustainably. In community forests, where management is implemented by rural people and site-specific growth data is not accessible, such area-based yield restriction is the only practical alternative (Acharya 1997).

Conservation of natural communities is crucial because increasing industrial urbanization and deforestation hinder plant diversity (Rad, Manthey, and Mataj, 2009). The identification of economically valuable species as well as species of particular concern, such as rare, endangered, endemic, threatened, or vulnerable species, is made possible by quantitative inventories (Keel *et* *al*., 1993). Improper forest management would be the reason behind the destruction of forest communities and their habitats. Forest holders should be heedful towards the natural composition instead of replacing the pure communities with diverse ones (Rad, Manthey, and Mataj, 2009). In Nepal, there are 5.96 million ha of forest (40.36%) and 0.65 million ha (4.38%) of other woodland. Together, forests and other wood cover 44.74% of the nation's land area (DFRS, 2015). Over four decades, 2,831,707 hectares of forest have shifted from a state-controlled, top-down approach to a participatory one led by local communities, because of organizational and policy reforms (Ghimire and Lamichhane, 2020). Whereas, quantitative inventories have significant implications for the conservation and management of forests (Manna and Mishra, 2017). Increasing demand for raw wood materials and crops results in the significant protection and rational utilization of natural resources. Resources should be protected where forests not only regulate stream flow but also reduce the rate of soil erosion, among many others (Shrestha *et al*., 2000).

One of the constituents of tropical forest ecosystem dynamics is regeneration which plays a crucial role in the betterment and maintenance of biodiversity. Furthermore, the species richness, heterogeneity, and complex community organization determined the characteristics of tropical and subtropical forests (Dutta and Devi, 2013). The forest ecosystem is prominent as the sink of carbon segregated in the vegetation and soil through the activity of photosynthesis and respiration (Khanal *et al*., 2011). The Kyoto Protocol of the United Nations Framework Convention on Climate Change (UNFCCC) has acknowledged the purpose of forestry as a suitable carbon sequestration transport toward reducing greenhouse gases in the atmosphere. Afterward, the UNFCCC conference of groups in Bali, Indonesia in December 2007 resulted in the creation of Reducing Emission from Deforestation and Forest Degradation (REDD). This group creates a desirable opportunity for investigation of C pool in forest ecosystems (Khanal *et al*., 2010).

The reproduction of plants through their juvenile is called natural regeneration; is a significant process for a reproductive role as well as assuring communities that leave after the completing life cycle (Acharya and Shrestha, 2011). The characteristics of successful regeneration in the population are determined by the adequate population of seedlings, saplings, and young trees (Acharya and Shrestha, 2011). Significantly, trees and soils store the primary carbon pools more than the other types of forest ecosystems.

Low levels of public awareness and participation, high population pressures, a high incidence of poverty, weak institutional, administrative, planning, and management capacities, a lack of integrated land and water use planning, poor data and information management, and a lack of policies or strategies for biodiversity conservation are cited as reasons for the loss of biodiversity in Nepal (HMG/N, 2002). It is well known that the typical forest management approach used by CFUGs is passive or protection-oriented (Acharya 2002; NPC 2001); Shrestha 2000; Branney 1996; Karki et al., 1994), which yields fewer advantages than it might otherwise. Protection-oriented refers to a style of forest management that only permits the harvesting of dry wood and twigs as well as specific non-wood forest products, like leaf litter for use as compost and animal bedding (Branney 1996). A tree species' capacity to regenerate depends on the survival and growth of its seedlings and saplings (Good and Good, 1972). Forest management must maintain suitable age classes (age-gradation), regular increments, and normal growth stock to being silviculturally viable (Subedi, 2011). Several initiatives have been launched to create acceptable silvicultural systems, with the main focus being on creating judicious canopy openness for Sal regeneration (Troup, 1986). In plant community forests, the thinning process has been applied only when there is a need for an additional amount of fuel wood. This process includes a variety of work like the removal of low-quality timber species and shrub climbers which were done earlier time of the development of tender shoots from November to December (Acharya and Shrestha, 2011).

This study, centered on plant species composition, carbon stock, and regeneration in two community forests in Nawalparasi district, Central Nepal, highlights the significance of contrasting management approaches. Examining these critical aspects in two distinct forest management systems contributes to our understanding of how different approaches impact biodiversity conservation, Carbon sequestration, and the overall health of these ecosystems in the region.

1.2 Justification

Community forest management program is a major practice to conserve natural resources in Nepal. The participation of local people to create awareness as well as protect the nature for future is one of the common ways to create the environment favorable growth of natural habitat. There are varieties of practices applied to manage biodiversity. The forest ecosystem is only stable when there are rules and regulations to follow to use its products. Human disturbances play a significant role in species diversity around the protected areas. Little disturbance also impacts the well-developed understory vegetation. The thinning process is one of the common practices that results in a decrease in species richness because of the habit of preserving a selected few species for beneficial purposes. Management of the forest ecosystem might not be the same for the growth of trees and forest floor. It is not known if different management practices in community forests will have different impacts on plant diversity, and forest regeneration. For instance, a community forest completely bans the collection of fodder, firewood, and timber for six months in a year and the other community forests are more reluctant and open for fodder, firewood, and timber throughout the year. This research aims to investigate two community forests having these two different management practices.

1.3 Research Questions

What is the status of plant composition, diversity, regeneration, and soil carbon at two different community forests having different management practices?

1.4 Objectives of study

The general objectives of this study were to evaluate the impact of forest management practices on plant diversity in two different conservation patterns of community forests.

Specific objectives

- To enumerate plant species at two community forests
- To estimate the carbon stock of the two community forests
- To study the regeneration pattern in both forest types.

CHAPTER 2: LITERATURE REVIEW

In Nepal, natural resources were prime sources to depend upon, whereas 80% of agrarians relied upon sustenance farming (Acharya, 2002). Community-based Forest management (CBFM) was the epitome of a landmark of forest management in Nepal that has been uncommonly and mistic studied. Recent data showed that a total of 44.74% of Nepal's area occupied the forest, and CBFM covers about 2.3 million hectares of forest, comprising 38.5% of the total resources in the country (Joshi *et al*., 2021). Policies are limited to preserve biodiversity, where it appealed to promising that future legacies must add under-governed forest. Management and its effects were a significant factor to known about the importance of biodiversity still disunited to fully understood; simple ideas did not encounter what is needed (Dieler *et al*., 2017). In understanding plant species composition, systematic random sampling methods within established quadrats had been a common practice. The Shannon-Wiener diversity index had been widely utilized to quantify species richness and assess the overall composition of plant communities (Smith *et al*., 2015). Studies on Carbon stock in community forests often utilized a combination of field measurements and remote sensing technologies. Field assessments involved the measurement of tree diameter at breast height (DBH) and height to calculate the above ground biomass. Biomass equations, as proposed by Chave *et al*. (2005), were frequently employed to estimate carbon stocks. Numerous studies during this period delved into the carbon sequestration potential of community-managed forests. Investigations consistently underscored the significance of community involvement in maintaining and even enhancing carbon stocks. Notable work done by Khanal *et al*, (2010) and Sudarapanian (2016) shed light on the pivotal role of community-based initiatives in mitigating climate change through efficient carbon sequestration. Understanding the plant species composition in community forests is crucial for biodiversity conservation. Research by Rad, Manthey, and Mataj (2009) emphasized the reciprocal relationship between species diversity and stand dominance. The literature underscores that successful community forest management, as exemplified by Nepal's program (K.C, 2017), played a significant role in preserving plant diversity.

The regeneration dynamics of community forests were a focal point in studies during this period. Acharya and Shrestha (2011) explored natural regeneration processes, highlighting their significance in ensuring the longevity and diversity of forest communities. The shift toward active forest management, as observed by Khanal (2002) and others, emerged as a key theme in sustaining regeneration processes.

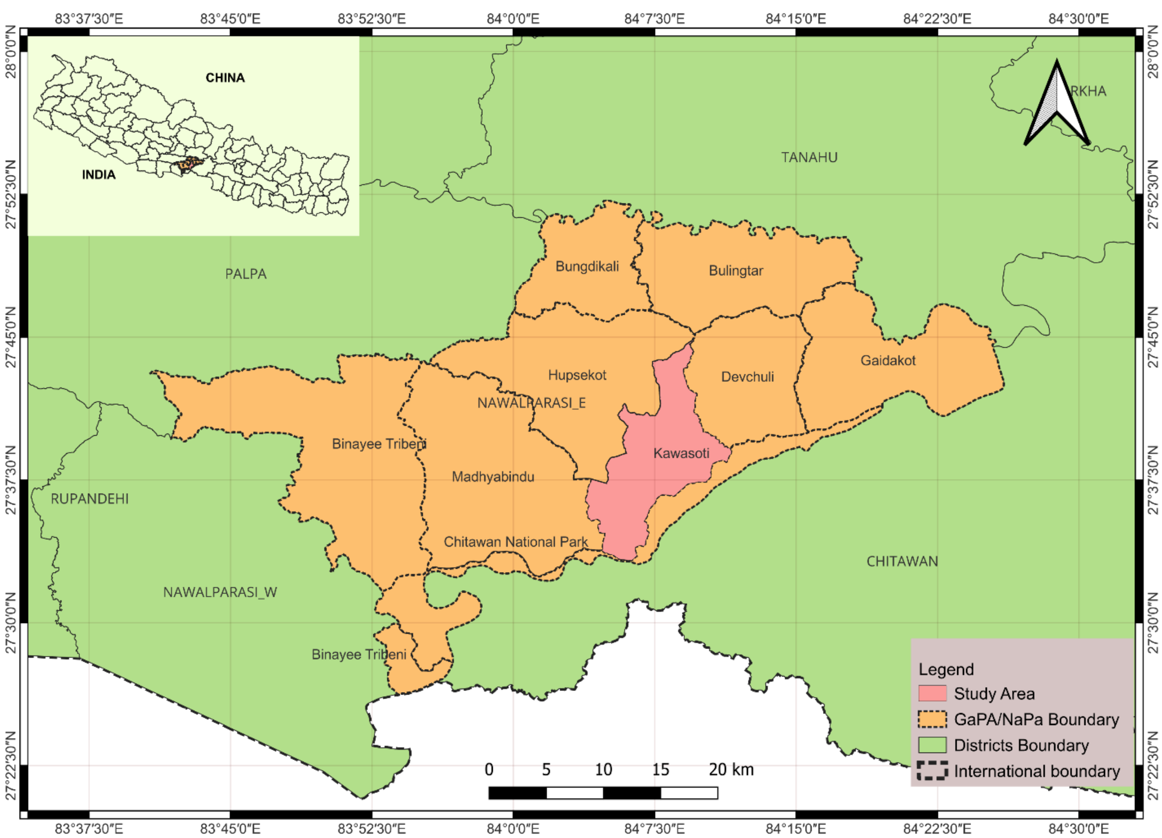
Furthermore, there is evidence that the biodiversity in community-managed forests has either decreased or changed. This essay contends that the common forest management strategy in community forestry recognizes biodiversity conservation as a secondary issue and there is evidence that biodiversity has either declined or has been altered in community-managed forests. It is based on the findings from two community forest user groups from the middle hills of Nepal (Acharya, 2004). Old-growth forests have a higher standing C-stock than recently regenerated forests (Singh and Singh, 1992). The community-based forest management strategy in Nepal has gained significant recognition for its effective participatory approach to forest management and governance. A substantial portion of Nepal's forests, approximately 2,831,707 hectares, was currently being managed through this approach. Over the course of four decades, the program transitioned from a centralized, government-led model to a community-centered participatory approach, marked by organizational and policy reforms aimed at enhancing forest management practices in Nepal (Ghimire and Lamichhane, 2020). According to Ebregt *et al*. (2007), the primary goal of forest management was to establish sustainable forest management that serves multiple purposes. These include meeting the demand for forest products, supporting the national poverty reduction agenda by generating employment opportunities, preserving and enriching biodiversity, and boosting national and local income through proactive management of the Terai and Inner Terai forests. According to the findings (Poudel and Devkota, 2021), community forests had strong regenerative potential as seen by the size class distribution of the trees that resembled an inverse j-shape. Sal density had significantly expanded in both woods following the community's acquisition of the woodlands. The productivity of the forest was greatly enhanced through community management, which had a good effect on forest regeneration. The management and maintenance of natural forests were therefore greatly affected by the research on forest were tree regeneration. Ekka and Agrawal (2017) found that, although undisturbed forests had a higher density of seedlings and saplings, forest sites were recovering. While species richness was recorded more frequently in disturbed than in undisturbed areas, density, and diversity were reported to be higher in disturbed than in undisturbed sites. According to the findings, anthropogenic disturbance is more prevalent in buffer forest sites, which may have changed the composition of the forest. The damaged forest area's climatic conditions may be able to restore by food forest management and rehabilitation efforts, which could lead to enhanced regeneration. Several variables, including seed fall, viability, nutrition availability, and microclimate, affect how quickly natural forests regenerate (Macedo *et al*., 2008). Developing nations like ours that could show net Carbon sequestration through improved forest management would get payments under the Biocarbon fund, according to the World Bank and UNFCC's COP19, which was convened in 2013 in Warsaw (Thapa Magar and Shrestha, 2015). 13 million people annually rose in population as a result of this, more than the emissions from the whole transportation system, hectares of forest were lost or degraded contribution around 20% of the world's GHG (CO2) emissions (Stern, 2007). According to Gaire and Ghimire (2019), a significant improvement in seedling status was seen in the community forest during the first year of the research (2015-16). The Tilaurakot collaborative forest's first level of implementation saw a decline in the number of saplings during the second year (2016-17). The community forest has a greater yield status cut down in the Tilaurikot collaborative forest that is undergoing regeneration felling. Between the community forest and the TIlaurikot collaborative forest, the regeneration status of species did not differ substantially ($P>0.05$). The article (Bampton *et al*., 2007) examines disputed assertions made by civil society organizations on the Community Forest Management (CFM) model. It concludes that, although recognizing the real need for a multi-stakeholder forestry program in the Terai, CFM still struggles with a lack of stakeholder involvement in developing and carrying out the policy. The community forestry program and the collaborative forestry program both aimed to transfer power and control over forest resources to user groups, particularly those with nearby and distant users. The primary goals were to fulfill local communities' needs for fuelwood and fodder, as well as to promote their participation, livelihoods, sources of income, gender equity, and governance (Sharma, 2007). *Shorea robusta* (Sal) was a dominant plant species in the Terai region of Nepal: has an economic, ecological, and socio-cultural significance. The work in a natural regeneration in plowed and un-plowed (control) areas showed that the regeneration density was found to be higher in the control site. Both the site was dominated by Sal. Similarly, the study concluded that protection from grazing and fire was essential for the natural regeneration of Sal, whether the number of species increases when the groundwork is applied although, it is not necessary in degraded Sal-forest (Malla and Acharya, 2018). *S.robusta*, ranges, a highly prized tree species, is a prominent feature within community forests. The distribution of Sal forests ranges from the lowland Terai, below 100 meters above sea level (masl), to the mid-hills, reaching up to 1500m asl. The growth patterns of Sal trees vary according to changes in altitude (Gautam and Dovoe, 2006). Sal exhibits a regenerative tendency characterized by the formation of dense clusters of seedlings under favorable conditions encompassing ample light, appropriate soil composition, and well-drained moisture (Troup, 1986; Raunainen and Suoheimo, 1997). This regenerative is predominantly composed of Sal trees alone or serves as the predominant component within mixed stands (Troup; Rautiainen and Suoheimo, 1997; Gautam and Devoe, 2005).

CHAPTER 3: MATERIALS AND METHODS

Study area

3.1. Location

Kawasoti municipality is located in Nawalparasi district Nepal. More precisely it is 31 km west of Bharatpur and 85km east of Butwal, approximately on the middle of east-west Highway. Kawasoti represents one of the beautiful green cities, where 60% of the land is occupied by forests where local people take recreational services from nature. The district comprises community forests, which span an area of 19,515.39 hectares. These forests are home to 5,470 households, housing a population of 3,198,134 individuals (DFO, Nawalparasi, 2014). Additionally, 250 user groups are managing various types of community forests, such as religious forests, leasehold forests, and private forests. The forested areas account for 55.7% of the total land area in the district (Pathak, 2015).



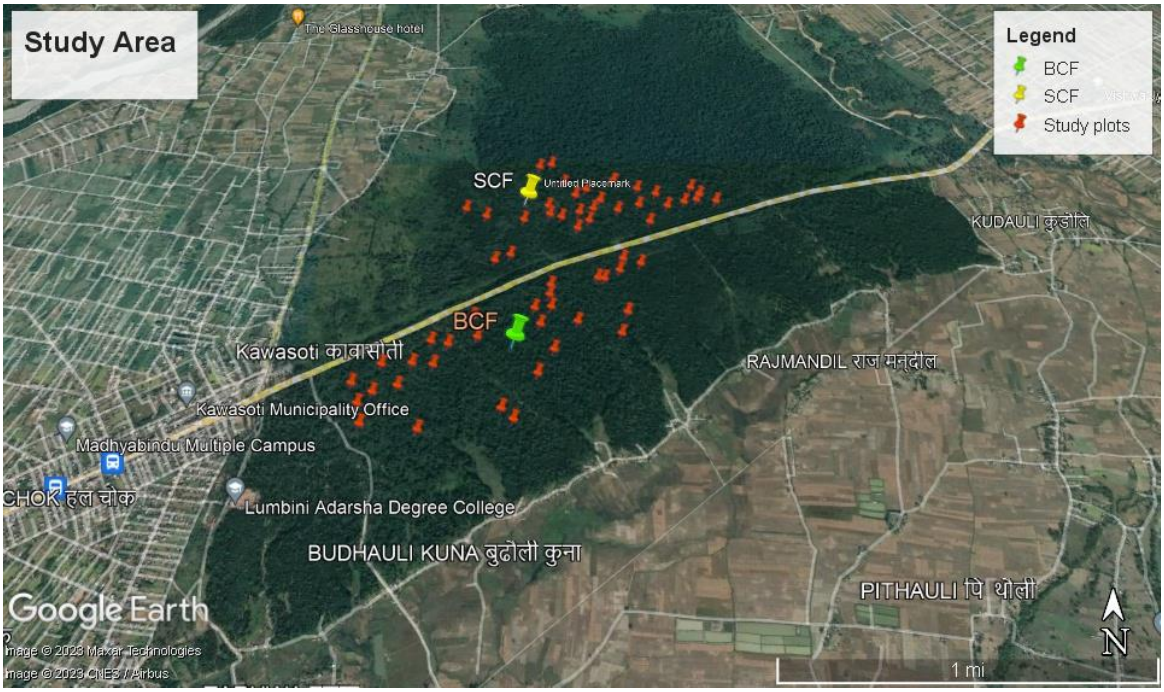


Figure 1: Map of Nepal, (a) Study area showing Nawalparasi District and Kawasoti Nagarpalika. (Source: QGIS 3.4.8 with GRASS 7.6.1)

3.2 Climate and Hydrology

Nawalpur has a subarctic climate, marked by dry winters and cool summers (DWC classification). The average annual temperature in the district is 19.6° C (67.28°F), s%. Typically, Nawalpur receives about 358.65 millimeters (14.12 inches) of rainfall over 212.98 rainy days, accounting for around 58.35% of the year (Climate and Hydrology, 2021). The graph shows Nawalparasi district’s average annual temperature at 19.21°C and rainfall at 345.81mm. May has the highest average maximum temperature at 28.47°C, while December records the lowest minimum temperature at 7.04°C. Rainfall peaks in August at 922mm and hits a low of 13.33mm in December.

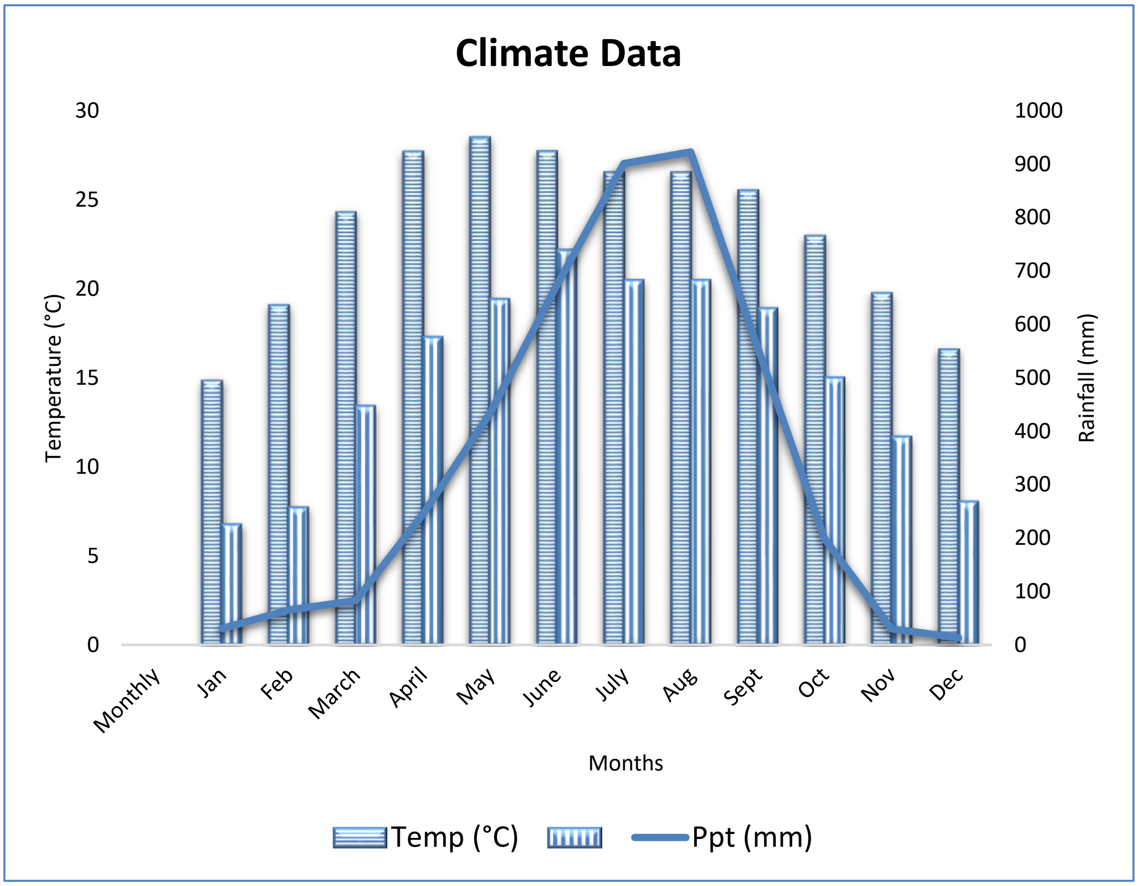


Figure 2: Variation in monthly average (minimum and maximum) temperature and total precipitation of the last 11 years (from 2010 to 2021) at Nawalparasi district.

3.3 Community forests

The main features of community forests and dominant tree species found there are given in Table 1. Shiva community forests have been managed for the last 12 years but the Budhaulikuna community forest is relatively young with only 8 years of management practices.

Table 1: Major characteristics of Shiva community forest and Budhaulikuna community forest.

Characteristics	**Shiva Community Forest**	**Budhaulikuna Community Forest**
Location	Kawasoti-2, Nawalparasi	Kawasoti-2, Nawalparasi
Altitude	208m	197m
Aspect	Northern (east-west highway)	Southern (east-west highway)
Topography	Terai	Terai
Forest origin	Natural	Natural
Forest type	Sal *(Shorea robusta*)	Sal (*Shorea robusta*)
Forest area	104.39 hector	
Number of households	708	122
Service used by the consumers for	6 months remain close for collection of fodder and firewood (from December to June)	All year round remains open for the collection of fodder and firewood
Years managing the forest actively	12 years	8 years
Aim	To protect forest To gain fodder products	To protect forest and wild animals To use forest products
Associated plant species	*Lagerstoemia parviflora, Dalbergia sissoo, and Cleistocalys operculata*	*Bombax ceiba, Ficus hispida, Casearia graveolens, Syzygium cumini*

3.4 Method of Data Collection

3.4.1 Sampling Design

Fieldwork took place from November to December 2021. We used systematic random sampling to collect data on trees, saplings, shrubs, and herbs in 60 quadrats, with 30 each in Shiva Community Forest (SCF) and Budhaulikuna Community Forest (BCF). Circular plots with a 20m diameter and 10m radii were used. We measured the circumference of trees and young plants at 1.37m above the ground (DBH) and converted it to Grith Base Height (GBH). Trees had GBH greater than 10cm, saplings less than 10cm. Within each quadrat, a 5m×5m square assessed saplings, seedlings, and shrubs, and a 1m×1m measured herbaceous plants. GPS coordinates and elevation were recorded elevation were recorded for each 10m radius plot using a GPS device at the center (Jhariya *et al*., 2011).

From each quadrat, soil samples were collected between November and December. Soil was taken from 15m depth from the surface to 15m depth. A total of 20 soil samples were collected from Shiva community forest and Budhaulikuna community forest. Each soil sampled was carefully packed into airtight plastic bags covered with aluminum foil for preservation until laboratory analysis. However, for soil carbon analysis, samples were dried outdoors in the shade for a week and then sealed in airtight plastic bags before being sent to the laboratory.

During the sampling process, the majority of specimens were identified on-site using field guides provided by community forest members. Additionally, local experts were consulted to ensure accurate identification. The plants were identified by their local name according to "Terrestrial Plants Around Historical Kawasoti Lake, Nawalpur District, Nepal" (Neupane, Timilsina, and Dumre, 2022). The nomenclature of species was based on the APG III system (Chase and Reveal, 2009) and Press *et al*. (2000).

3.4.2 Quantitative Analysis

The field data was used to calculate the frequency, density, coverage, and Importance Value Index (IVI) of plant species following the method described by Zobel *et al*., (1987). The formula used for the calculation of these attributes is given below:

The number of plants per unit area is called the density of the plant species.

$$\text{Density (D)} = \frac{\text{Total no. of species occurred}}{\text{Total no. of quadrat studied} \times \text{Area of quadrat}}$$

Relative density is the density of a species concerning the total density of all species, and is expressed as,

$$\text{Relative Density (R.D.)} = \frac{\text{Density of individual species}}{\text{Total density of all species}} \times 100\%$$

Frequency is the number of times a plant species occurs in a given number of quadrats.

$$\text{Frequency (F)} = \frac{\text{No. of quadrats in which species occured}}{\text{Total no of qudrats studied}} \times 100\%$$

Relative frequency is the frequency of a species about the frequency of all other species, and is expressed as,

$$\text{Relative Frequency (R.F.)} = \frac{\text{Frequency of individual species}}{\text{Total no frequency of all species}} \times 100\%$$

The percentage of the ground surface covered by vegetation is called the coverage of that area. It is done in terms of 100%

Coverage (C) = Visual Estimation

$$\text{Relative coverage (R.C.)} = \frac{\text{Coverage of individual species}}{\text{Total coverage of all species}} \times 100\%$$

The importance Value Index (IVI) was used to analyze species distribution according to the formula introduced by Cottam and Curtis (1956) for comparison of plant richness. Similarly, IVI and its relative frequency, relative density, and relative coverage are also calculated by using a formula.

Importance Value Index (IVI) = R.D. + R.F. +R.C.

3.4.3 Diversity indices

Shannon - Wiener diversity index (H')

To quantitatively describe the community, the forest's species diversity was assessed. The Shannon-Wiener diversity index (H´) was used for calculation.

Shannon-Wiener index (H') can be calculated as: H'= -∑ (ni/N) ln(ni/N) = - ∑ Pi ln pi (Shannon-Wiener 1963), Where, N =Total no of species., ni = number of individuals of species., Pi = ni/N.

Index of dominance (c)

Simpson Diversity Index(D)

The Simpson diversity index quantifies species diversity in an ecological community, taking into account species dominance. It's calculated using the formula:

D= 1-$\sum(Pi^2)$

Where,

D is the Simpson Diversity Index; Pi represents the proportion of individuals of the ith species relative to the total number of individuals.

Higher values indicate lower diversity, while lower values suggest higher diversity.

3.4.4 Index of Similarity

The degree of similarity between two ecological communities, indicative of inter-specific association, is assessed using the index of similarity. This index, modified by Smith (1964) based on Sorenson's formula, quantifies the similarity based on shared species and is instrumental in comparing different groups.

IS = $\frac{2C}{A+B} \times 100$

In this context, A represents the total number of species in one sample, B stands for the total number of species in another sample, and C denotes the total number of species shared by both samples.

3.4.5 Basal Area

Basal area refers to the ground, penetrated by the stems in the soil. It is expressed in square meters. Basal area is regarded as an index of dominance of a species. The higher the basal area greater the dominance. The basal area of a tree species was determined by measuring either the diameter or circumference of the average tree at the breast height (1.37m) and was calculated using the following formula of Zobel *et al*. (1987).

Basal area (m^2) = $\frac{\pi D^2}{4}$

Where, π= 3.1415

D=Diameter at breast height

The basal area in each plot was obtained by the summation of the basal area of all trees in the plot and is given as m^2/ha.

3.4.6 Estimation of Above and Below Ground Biomass

The equation developed by Chave *et al*. (2005) for moist forest stands was used to estimate above ground tree biomass. The equation was;

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

whereas,

AGTB = above-ground tree biomass (kg)

P = dry wood density (gm/cm^3)

D = tree diameter at breast height (cm)

H = height of tree (m)

Similarly, below-ground biomass was calculated assuming 15% of the above-ground tree biomass (Mack Dicken, 1997).

3.4.7 Estimation of Total Biomass and Carbon Stock

The sum of the above- and below-ground biomass was used to compute the total biomass. 15% of the biomass above ground was assumed to be below ground. By multiplying the whole biomass (above ground plus below ground) by 0.47, the standard carbon proportion in tree biomass, the total biomass (above ground plus below ground) was converted to carbon stock (IPCC, 2006). The biomass stock density was converted to kg/m² by multiplying the total weights (in kg) of each component of a sampling plot by the area of the plot. The value may increase this amount by 100 to get the t/ha equivalent.

3.4.8 Carbon Stock of Tree Species

The carbon stock of a single species inside a forest was calculated by averaging its carbon stock values across all plots within that forest. The ratio of the total carbon stock (in t/ha) of all species in the forest to the total carbon stock of a specific species in the same forest was used to compute the percentage contribution of each species' carbon stock in a forest. It was determined using the equation given below:

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

3.4.9 Regeneration Status of Forest

Following the approach outlined by Zobel *et al*. (1987) the density of seedlings, saplings, and trees of each species was evaluated independently to estimate the forest's state of regeneration. The equation was used to estimate density;

$$\text{Density (stem/ha)} = \frac{\text{Total number of individual of each species in each life form}}{\text{Total number of plots studied} \times \text{size of plt } (m^2)} \times 10000$$

Total count of plants was obtained by summation of the number of plants from all sampling plots.

3.5 Soil Samples Collection and Analysis

Soil samples were collected from different plots; at the depth of 15-20cm from ground level. A measuring scale was used while measuring deepness from the ground. A total of 15/15 soil samples were accumulated from both community forests. Gathered soil samples were air dried in Amrit Campus to analyze soil carbon, pH, and soil organic content. The soil organic carbon (%) was measured using the Walky and Black technique (1934). SOC (t/ha) was determined using (Awasthi *et al*., 2005).

CHAPTER 4: RESULTS

4.1 Plant diversity

Altogether 65 species were reported in SCF (Shiva community forest) and 43 in BCF (Budhaulikuna community forest) (Figure 3). Among them, 36 herbs, 14 shrubs, and 14 trees were recorded in SCF whereas 31 herbs, 7 shrubs, and only 5 trees were found in BCF. Species richness was higher in SCF than in BCF. In addition, quite a high number of herb species were found in both community forests.

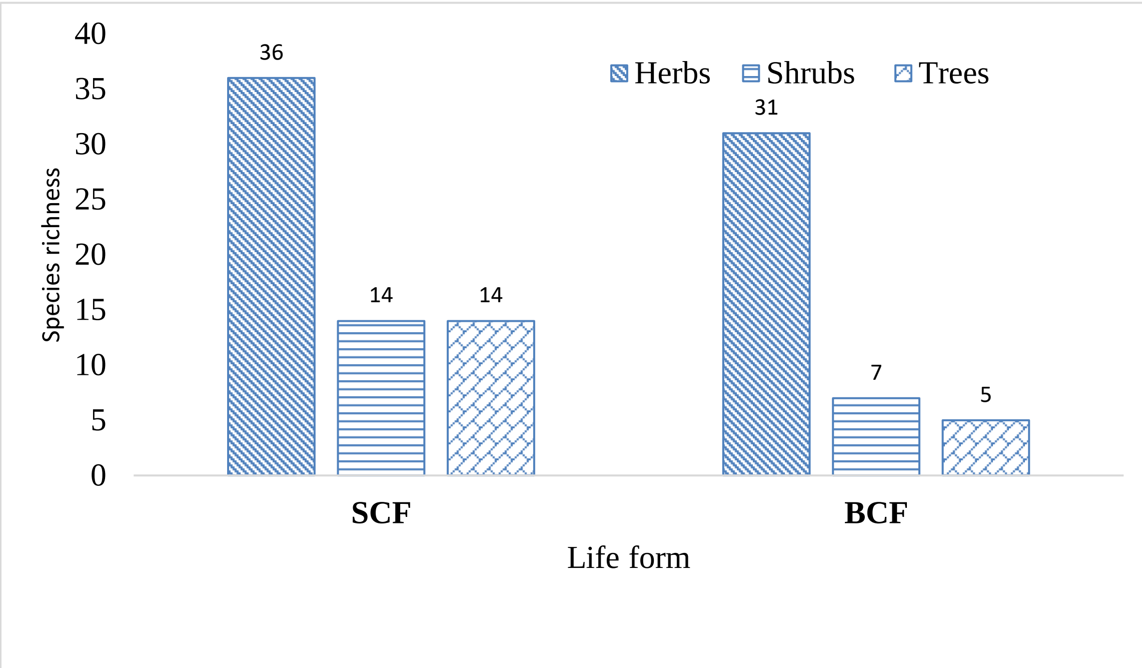


Figure 3: Species richness of different life forms at Budhaulikuna Community Forest and Shiva Community Forest.

4.1.1 Herbs diversity

Altogether 36 species belonging to 19 families were recorded in Shiva Community Forest and 31 species related to 19 families in Budhaulikuna Community Forest (Appendix 1). At SCF dominating species among herbs were *Spermacoce alata, Paspalum conjugatum*, *Chromolaena odarata,* and *Phyllanths niruri*, and had high IVI value (Appendix 3.1*)*. Among these plants, *Paspalum conjugatum* had the highest importance value index (43.7), followed by *Spermacoce alata* (38.84), *Chromolaena odorata (*19.94), *Achyranthus aspera (*17.3), and *Urena lobata (*16.31) at SCF. *Ageratum conyzoides* had the lowest IVI value at SCF. The herbs like *Elephantopus scaber*, *Hedychium ellipticum*, *Smilax* sp, *Elephantopus japonica*, *Spilanthes acmella, Rungia pectinate, Bauhinia variegata, Mesophaerum suaveolens, Angiopteris helferiana*, *Senna occidentalis, Lindernia diffusa, Cyperus* sp*, Senna tora, Lygodium flexors*, *Axonopus compressus*, *and Axonopus* sp were recorded from SCF only.

Table 2: Importance value index (IVI) of major herbaceous plant species at Shiva community forest and Budhaulikuna community forest.

Plant species	Shiva Community Forest (SCF)	Plant species	Budhaulikuna Community Forest (BCF)
Paspalum conjugatum	44.22	*Paspalum conjugatum*	30.33
Spermacoce alata	39.26	*Spermacoce alata*	60.71
Chromolaena odorata	20.16	*Chromolaena odorata*	35.12
Achyranthus aspera	17.51	*Phyllanthus niruri*	17.88
Urena lobata	16.51	*Ageratum haustonianum*	16.57

Similarly, at Budhaulikuna community forest, the major part of the herb layer with high IVI value was occupied by *Spermacoce alata* (60.71), followed by other associated plants like *Chomolaena odorata* (35.72), *Paspalum conyzoides* (30.33), *Phyllanthus niruri* (17.88), and *Ageratum haustorium* (16.57) (Appendix 3.2, Table:2). Herbs like *Acmella oleracea*, *Trifolium* sp, *Solanum virginianum, Desmodium triflorum, Conyza Canadensis, Desmanthus virgatus, Cynodon dactylon, Conyza* sp, *Hyptis suaveolens, Bohemia platyphylla, and Stellaria* sp was found at BCF only.

4.1.2. Shrubs diversity

A total of 14 species falling under 7 families of shrub species were found in the Shiva community forest. The dominant shrubs were *Clerodendrum viscosum*, *Pogostemon benghalensis*, *Lantana camara*, and Khasropaat with IVI values of 129.51, 112.59, 28.82, and 11.25 respectively (Appendix 3.1, Table 3).

Table 3. Importance value index of major Shrub species of Shiva community forest and Budhaulikuna community forest.

Scientific name of plants	Shive Community Forest (SCF)	Scientific name of plants	Budhaulikuna Community Forest (BCF
Clerodendrum viscosum	144.63	*Clerodendrum Viscosum*	129.51
Pogostemon benghalensis	41.04	*Pogostemon benghalensis*	112.66
Lantana camara	28.82	*Lantana camara*	28.82
Khasropaat (Unknown 1)	28.55	Khasropaat (Unknown 1)	11.26
Murraya koenigii	18.96	*Flemingia macrophylla*	7.76

On the other side, altogether 7 species of individual plants were found in the Budhaulikuna community forest. The highest importance value index was recorded for *Clerodendrum viscosum* i.e., 129.6, and was followed by *Pogostemon benghalensis* (112.59), *Lantana camara* (28.82), and Khasropaat (11.75) (Appendix 3.2, Table 3).

4.1.3 Tree diversity

In the present study, a total number of 14 tree species were found in Shiva community forest (SCF) whereas only 5 tree species were recorded in Budhaulikuna community forest (BCF). The highest importance value index of 260.23 and 104.05 was found in *Shorea robusta* (Sal) at both BCF and SCF respectively (Table 4). The highest IVI value of Sal was recorded at BCF other species of trees only one individual was recorded.

Table 4: The importance value index of trees in both community forests.

Scientific name of plants	**Shiva Community Forest (SCF)**	**Budhaulikuna community forest (BCF)**
Shorea robusta	104.05	260.23
Cleistocalyx operculate	25.51	-
Holarrhena pubescens	27	-
Casearia graveolens	3.07	11.93
Lagerstroemia parviflora	59.06	-
Ficus hispida	-	9.11
Syzygium cumini	-	13.56
Tectona grandis	19.37	-
Dalbergia sissoo	15.35	-
Psidium guajava	2.85	-
Alstonia scholaris	5.2	-
cassia fistula	3.33	-
Bombax ceiba	6.16	5.16
Terminalia alata	12.79	-

Aegle marmelos	9.88	-
Litsea monopetala	2.11	-

4.2 Diversity Indices

Simpson diversity index values of herbs and shrubs were more or less similar at SCF and BCF, but for tees, it was quite higher at SCF (0.63) than at BCF (0.036). Similarly, Shannon diversity indices (evenness) values were found almost similar among herbs and Shrubs but for trees, it was quite higher at SCF (1.5) than at BCF (0.025) (Table 5).

Table 5: Shannon Wiener index (and evenness) and Simpson index of herbs, shrubs, and trees in Shiva community forest (SCF) and Budhaulikuna community forest (BCF).

Life form	**Shannon's diversity(H)**		**Simpson's diversity (D)**	
	SCF	**BCF**	**SCF**	**BCF**
Herbs	2.64	2.38	0.91	0.88
Shrubs	1.41	1.08	0.58	0.58
Trees	1.5	0.025	0.63	0.036

The similarity index between SCF and BCF was highest among shrubs (57.14), followed by herbs (41.38%), and the least was observed among trees (30%) (Table 6).

Table 6: Similarity index between Shiva community forest (SCF) and Budhaulikuna community forest (BCF).

Habit	**Index of similarity (%)**
Herbs	41.37931
Shrubs	57.14286
Trees	30

4.3 Regeneration

The regeneration status of plant species at two different community forests: Shiva Community Forest (SCF) and Budhaulikuna Community Forest (BCF) (Figure 4). For regeneration status, plants were categorized into three stages: seedlings, saplings, and trees. The measurements are given in terms of individuals per hectare. SCF had approximately 1159.23 seedlings whereas BCF showed 2818.47 seedlings per hectare. Similarly, sapling numbers were 785.56 saplings/ ha at SCF and 1605.09 stems/ha at BCF. In SCF trees were found to be 466.02 stems/ ha and at BCF it was 233.54 (stem/ha). Budhaulikuna Community Forest generally has a higher number of seedlings and saplings per hectare compared to Shiva Community Forest. However, Shiva Community Forest has a higher number of fully grown trees per hectare as compared to Budhaulikuna Community Forest.

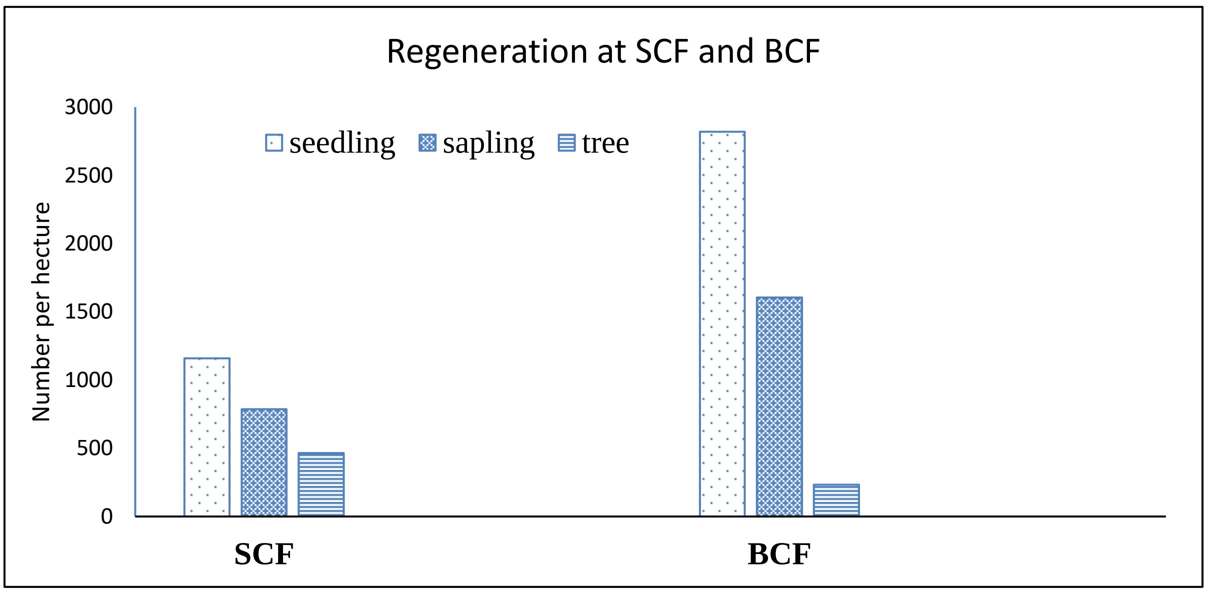


Figure 4: Regeneration status of seedlings, saplings, and trees in Shiva community forest (SCF) and Budhaulikuna community forest (BCF).

4.4 Density diameter relationship

The highest tree density per hectare was observed in the 10-20 density class, with 208 stems/ha in SCF (Shiva community forest), shown in fig5. Followed by DBH with 20-30cm were with 107stems/ha, on the other hand, DBH class over 100cm was absent. At BCF (Budhaulikuna community forest), the highest number of individuals were recorded in 60-70 cm DBH class, with 64 stems/ha, followed by DBH class 50-60cm (52stems/ha), and individuals over 100cm DBH were recorded only 3 stems/ha. The trend line in the SCF graph shows a rapid decrease in density as the diameter at breast height (DBH) of trees increases and forms an inverted J pattern. At BCF the density diameter curves showed a hump-shaped structure as the highest density occurred in the 60-70 cm DBH class (Figure 5,6).

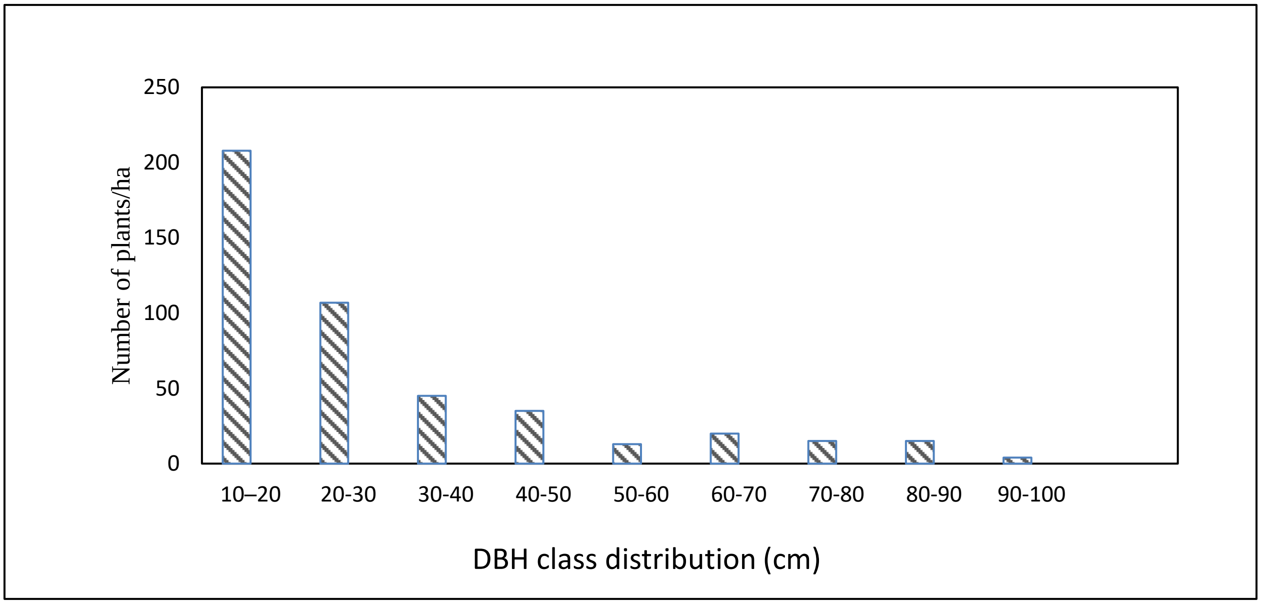


Figure 5: Density diameter relationship of trees ≥10cm at SCF.

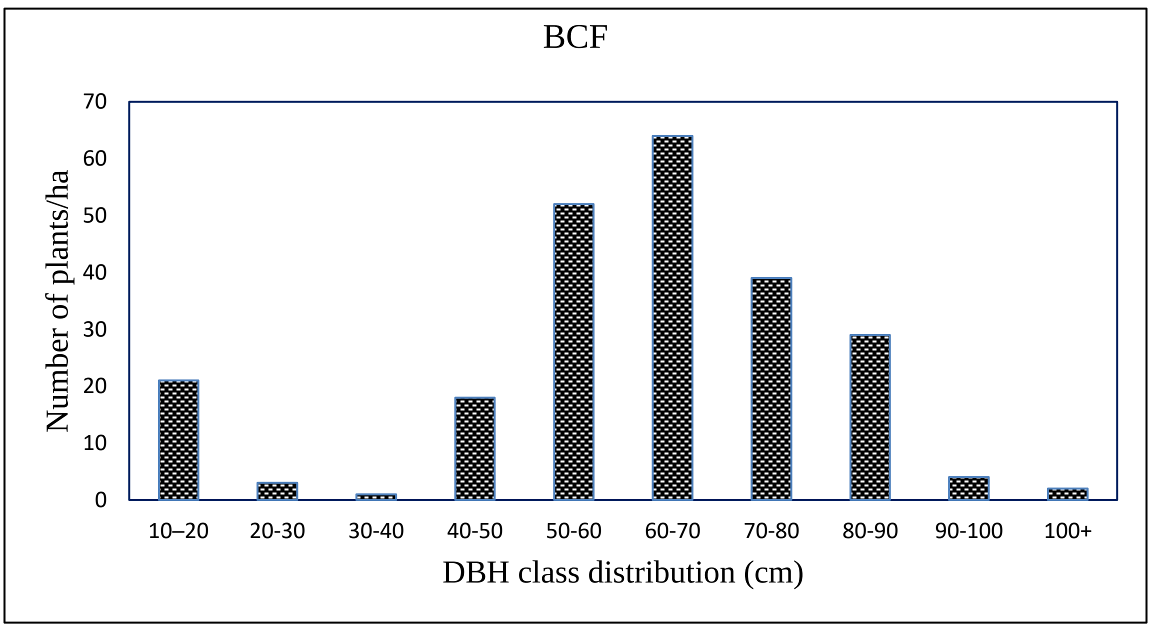


Figure 6: Density diameter relationship of trees ≥10cm at BCF.

4.5 Basal area relationship

The common tree species present in both community forests were *Shorea robusta*, *Casearia graveolens,* and *Bombax ceiba*. The total basal area (m^2/ha) of all species at SCF (Shiva community forest) was 47.70 m^2/ha and at BCF (Budhaulikuna community forest), it was 72.62 m^2/ha. Comparatively, BCF had a higher basal area than SCF. The major contribution of the basal area was of *Shorea robusta* in both community forests, 37m^2/ha in SCF and 76.51m^2/ha in BCF. In both communities, *Casearia graveolens* had an equal basal area (0.038m^2/ha), followed by *Bombax ceiba* which is higher in SCF 0.087m^2/ha than at BCF 0.0078m^2/ha.

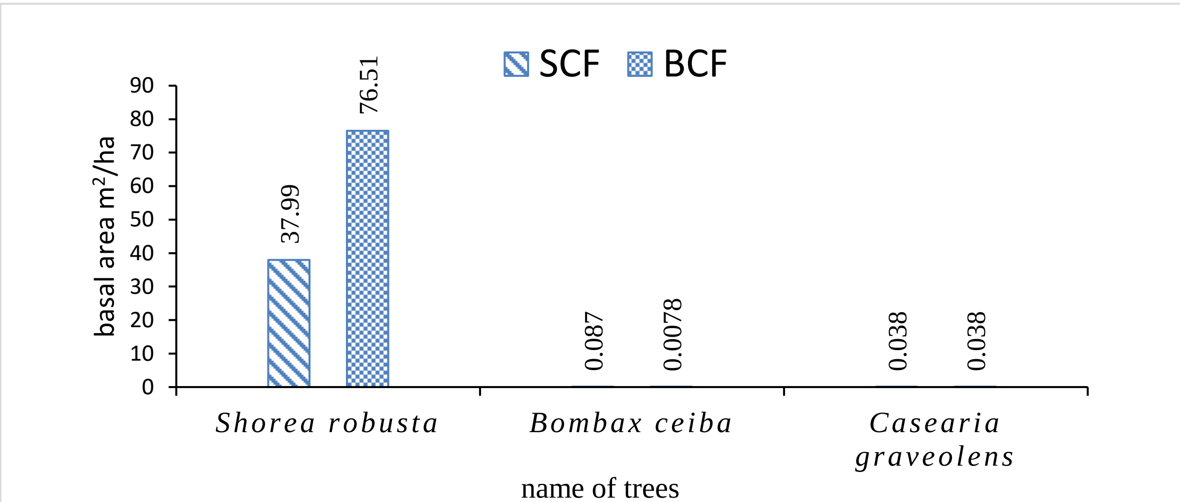


Figure 7: Basal area(m^2/ha) of common tree species in both community forests.

Other than these common species present at both community forests, at SCF *Lagerstroemia parviflora* and *Tectona grandis* had equal basal area of 2.195m^2/ha. The least basal area in SCF

i.e.,0.16 m^2/ha was found in *Litsea monopetala* and *Psidium guajava*. On the other hand, the remaining two species found only in BCF were *Ficus hispida* and *Syzygium cumini* and had low basal area i.e., 0.025m^2/ha and 0.045m^2/ha respectively.

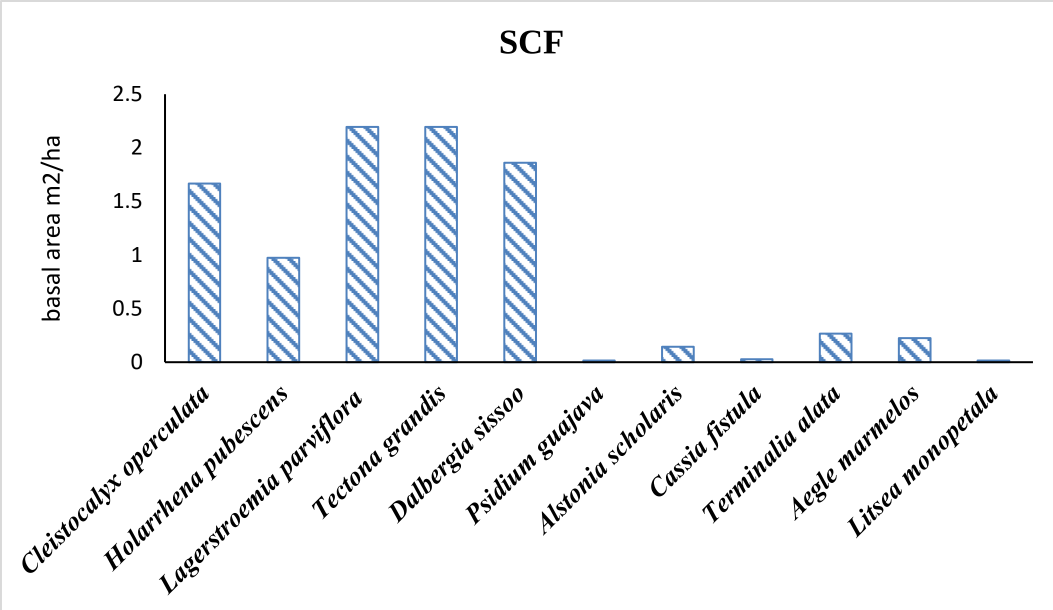


Figure 8: Basal area (m^2/ha) of species only found in SCF.

4.6 Species Carbon stock

Comparatively both of the community forests; Shiva community forest (SCF) and Budhaulikuna community forest (BCF), had a high percentage of carbon stock in *Shorea robusta* with 91% and 99.9% respectively. The common species such as *Casaeria graveleons* and *Bombax ceiba* had very low contribution (>0.1%) of carbon content (Figure 9) at both SCF and BCF. Figure (10) represents the contribution of the remaining 9% in SCF by other remaining tree species. In SCF, other 11 tree species were not recorded from BCF. Those species contributed approximately 9% of the total carbon content in the Shiva community forest. In BCF, *Ficus hispida* and *Syzygium cumini* were not common species which contributed 0.1% of total carbon content.

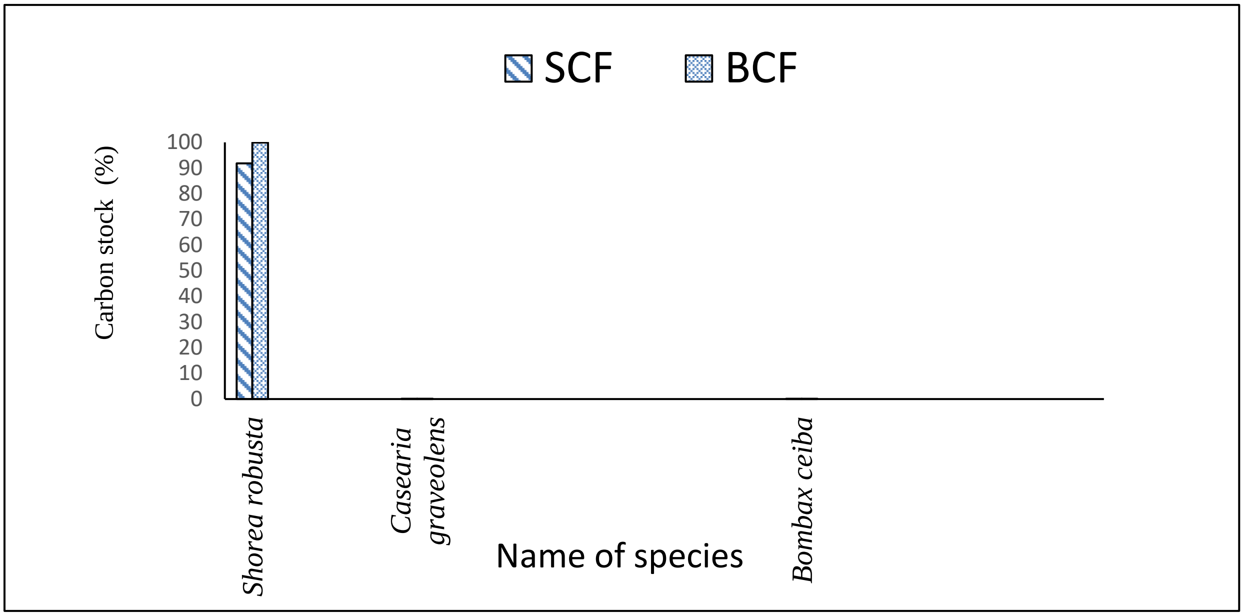


Figure 9: Percentage Contribution of major common species to total carbon stock at both community forests.

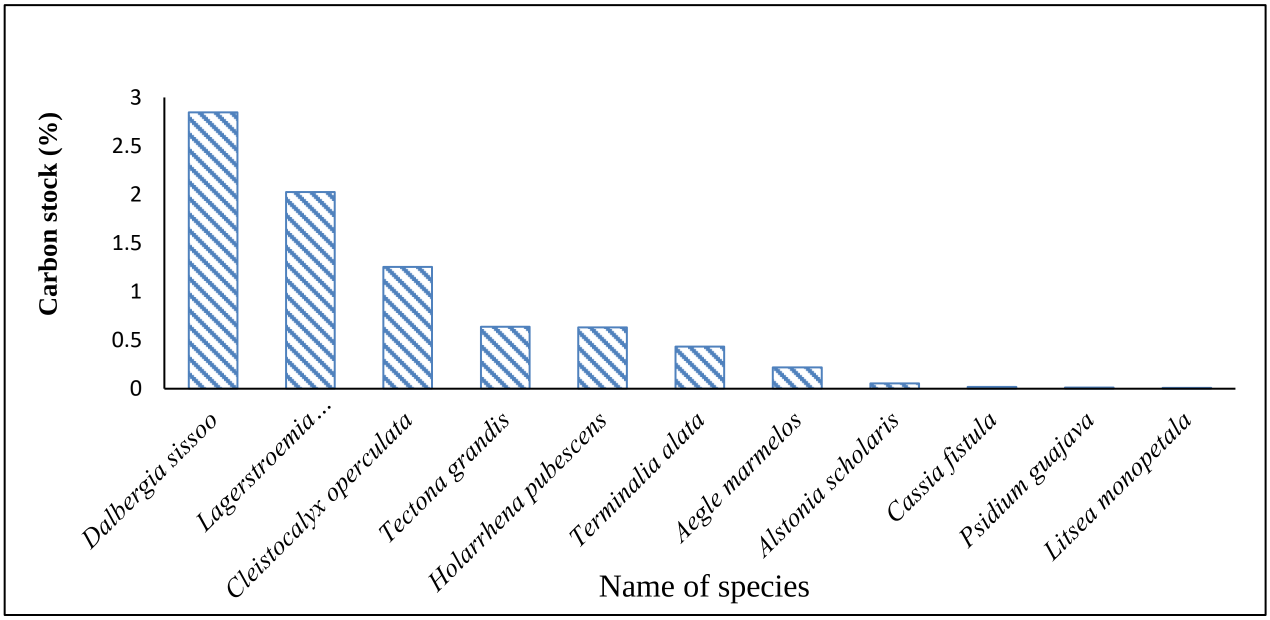


Figure 10: Percentage Contribution of remaining species to total carbon stock at SCF.

4.6.1 Total Biomass and Carbon Stock

Total biomass and carbon stock at Shiva community forest (SCF) were found to be 191 tons/ha and 81 tons/ha respectively (Figure 11). Similarly, Budhaulikuna community forest (BCF) had comparatively high biomass i.e., 383 tons/ha, and carbon stock had 163.14 tons/ha (Figure 12).

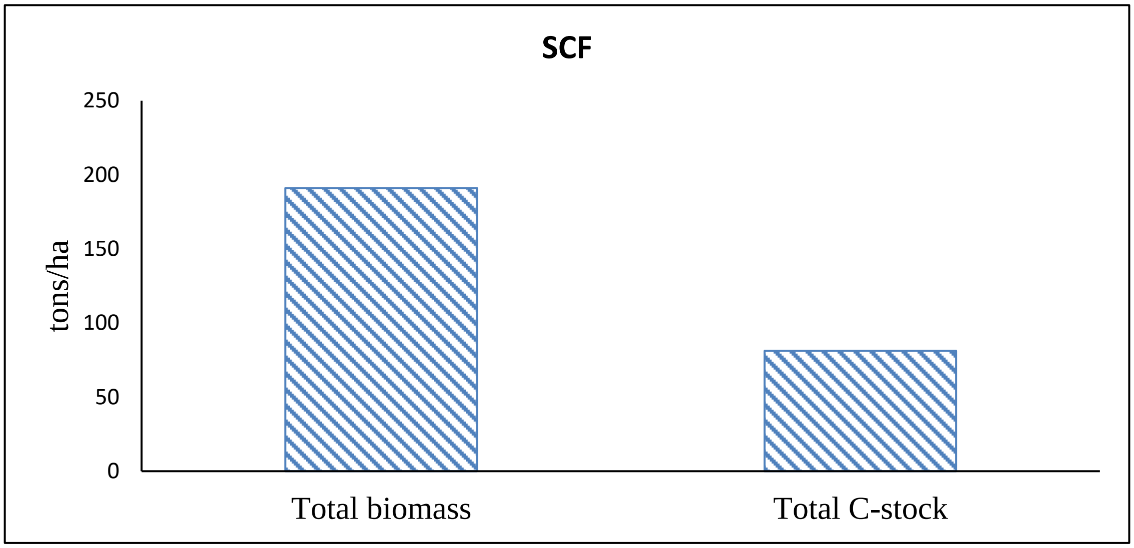


Figure 11: Total biomass and carbon stock at SCF.

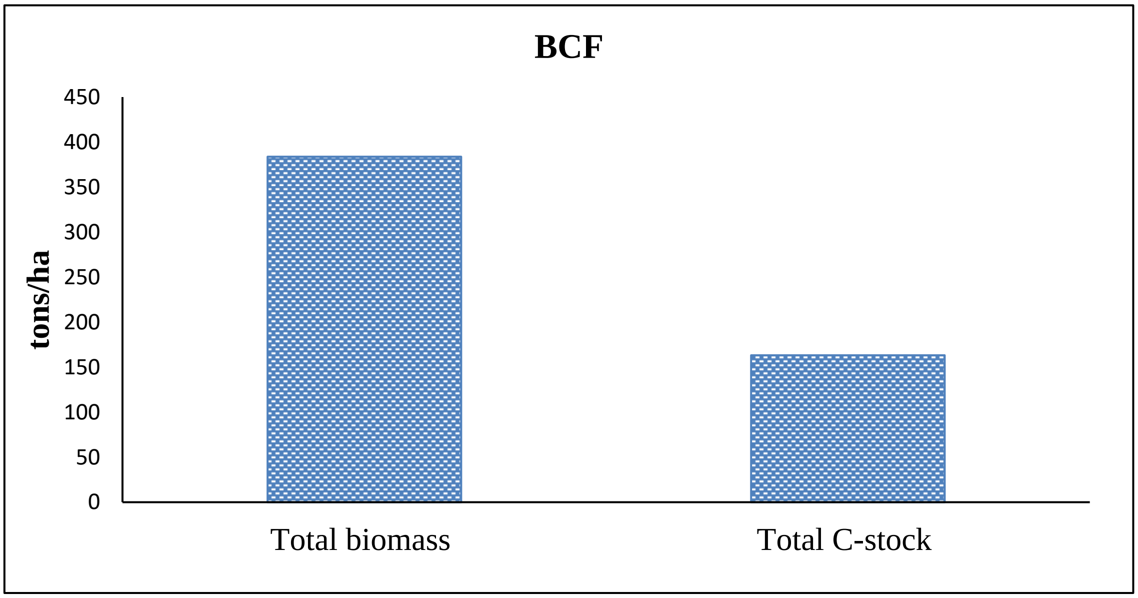


Figure 12: Total biomass and carbon stock at BC

Shorea robusta had the highest biomass content in both community forests: Shiva community forest (SCF) and Budhaulikuna community forest (BCF), in above and below-ground biomass. In SCF above the above-ground biomass of *S.robusta* was 146.18 t/ha and the below-ground biomass was 29.32 t/ha. BCF had quite a higher biomass than that of SCF and were 319.73t/ha above ground and 63.94 t/ha below ground. In SCF, next to *Shorea robusta, Holarrhena pubescens* and *Dalbergia sisso* scored second and third highest above and below-ground biomass (i.e., 10.04 t/ha and 0.20t/ha for *Holarrhena pubescens*, and 4.53t/ha, 0.91t/ha for *Dalbergia sisso* respectively). Other species like *Casearia graveolens, Lagerstroemia parviflora, Cleistocalyx operculata,* and *Tectona grandis* had total biomass below 4t/ha. Remaining tree species such as *Psidium guajava, Alstonia scholaris, Cassia fistula, Bombax ceiba, Terminalia alata, Aegle marmelos,* and *Litsea monopetala* had biomass less than 1t/ha. In BCF, all of the other four species (*Casearia graveleons, Ficus hispida, syzygium cumini*, and *Bombax ceiba*) had biomass less than 1t/ha both above and below ground. The data showed the increasing amount of carbon stock directly concerned with the amount of biomass.

Table 7: Above and below-ground biomass in Shiva Community Forest (SCF) and Budhaulikuna Community Forest (BCF).

Tree species	**AGB in SCF (tons/ha)**	**AGB in BCF (tons/ha)**	**BGB in SCF (tons/ha)**	**BGB in BCF (tons/ha)**
Shorea robusta	146.18	319.74	29.32	63.95
Cleistocalyx operculata	1.99	-	0.39	-
Holarrhena pubescens	10.04	-	0.20	-
Casearia graveolens	3.22	0.068	0.008	0.014
Lagerstroemia parviflora	3.22	-	0.64	-
Ficus hispida	-	0.043		0.0086
Syzygium cumini	-	0.048		0.0095
Tectona grandis	1.01	-	0.203	-

Dalbergia sissoo	4.53	-	0.91	-
Psidium guajava	0.02	-	0.004	-
Alstonia scholaris	0.08	-	0.02	-
Cassia fistula	0.03	-	0.0054	-
Bombax ceiba	0.05	0.0042	0.009	0.00085
Terminalia alata	0.69	-	0.138	-
Aegle marmelos	0.34	-	0.069	-
Litsea monopetala	0.012	-	0.0025	-

In trees, the carbon content is generally higher in above-ground biomass compared to below-ground biomass (Table 4.6). Among the tree species studied, *Shorea robusta* exhibited the highest carbon content in both SCF and BCF forests. Specifically, in SCF, *S. robusta* had 78.56 t/ha of carbon. Similarly, BCF had 150.28 t/ha of carbon in above-ground biomass and 12.79 t/ha in below-ground biomass. In SCF, *Dalbergia sisso* scored 4.44 t/ha, and *Cleistocalyx operculata* and *Lagerstroemia parviflora* had 1.02 and 1.65 t/ha carbon content. The remaining species (*Holarrhena pubescens, Casearia graveolens, Tectona grandis, Psidium guajava, Alstonia scholaris, Cassia fistula, Bombax ceiba, Terminalia alata, Aegle marmelos, Litsea monopetala)* scored less than 1t/ha carbon stock in SCF. In BCF, other than *Shorea robusta*, all the other four species *Casearia graveolens, Ficus hispida, Syzygium cumini, Bombax ceiba)* also had less than 0.1 t/ha of carbon stock.

Table 8: Total carbon stock of tree species in Shiva community forest (SCF) and Budhaulikuna community forest (BCF).

Tree species	**Total carbon stock in SCF (tons/ha)**	**Total carbon stock in BCF (tons/ha)**
Shorea robusta	74.56	163.07
Cleistocalyx operculata	1.02	-

Holarrhena pubescens	0.51	-
Casearia graveolens	0.05	0.0327
Lagerstroemia parviflora	1.65	-
Ficus hispida	-	0.0217
Syzygium cumini	-	0.044
Tectona grandis	0.52	-
Dalbergia sissoo	4.44	-
Psidium guajava	0.00999	-
Alstonia scholaris	0.0436	-
Cassia fistula	0.0141	-
Bombax ceiba	0.2118	0.00216
Terminalia alata	0.348	-
Aegle marmelos	0.174	-
Litsea monopetala	0.0064	-

4.7 Soil properties

4.7.1 Soil pH

The average pH of the soil was found acidic i.e., 5.8 value in the Budhaulikuna community forest (BCF) whereas the Shiva community forest (SCF) showed a value towards the neutral range i.e., 6.4 from the total plots taken from sample plots.

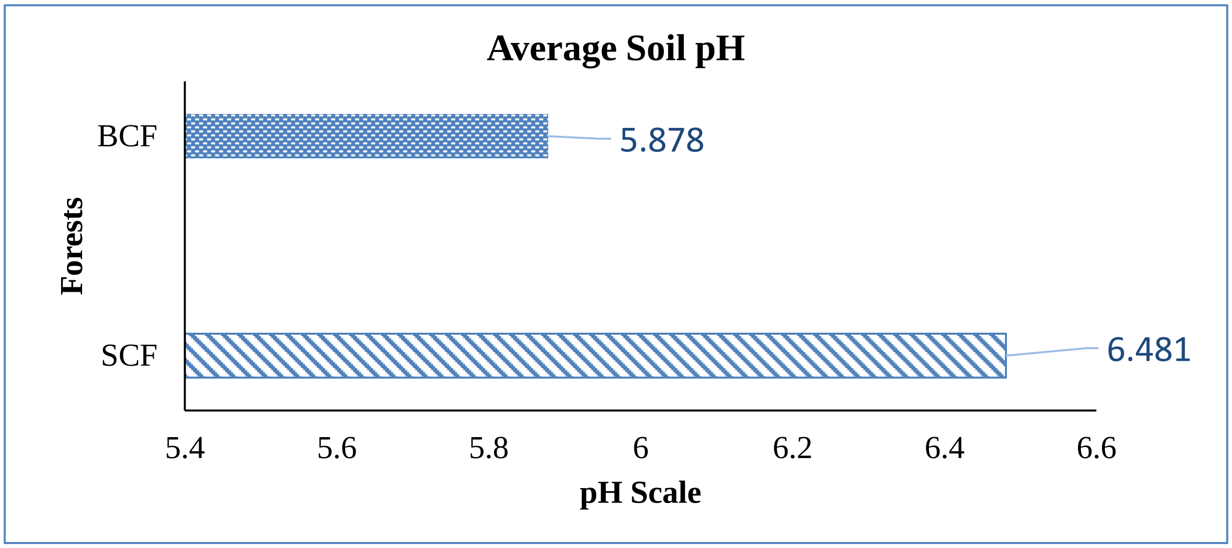


Figure 13: Average result of pH value in both community forests.

4.7.2. Soil Organic Carbon

Soil samples were collected from ten places of both community forest; Shiva community forest (SCF) and Budhaulikuna community forest (BCF). The result data shows the minimum and maximum carbon percentage in SCF ranges from 0.015% to 1.59% respectively. Similarly, at BCF it ranged from 0.33% to 1.18% respectively. The average percentage of soil organic carbon was higher in SCF than in BCF i.e., 0.936 and 0.867 respectively.

CHAPTER:5 DISCUSSION

5.1 Species composition

The comparative result showed that the species richness was found higher at Shiva community forest (SCF) which remains strictly protected (closed from January to June) for 6 months per year, than Budhaulikuna community forest (BCF) which remains open throughout the year to manage and to use forest products by local people. Altogether 65 species in SCF and 45 plant species in BCF were recorded. Among the plant species, 36 were herbs in SCF 31 were herbs in BCF and some of them were uncommon species in both sides. SCF showed high species richness with 15 tree species and 14 shrub species, whereas, BCF showed less species richness with 5 tree species and the only 7 shrub species. BCF had smaller number of dominant species in comparison to SCF. Subedi et al. (2009) documented almost similar results that the total of 11 tree species in the Patapati Lulpani community forest located in the Nawalparasi district. Another research carried out in Kawasoti found about 27 species of herbs and 12 species of shrubs which is almost same findings as in this community forests (Neupane, Timilsina, and Dumre, 2022). However, the number of trees and shrubs was more in Sal dominated forest in Dadheldhura with 42 trees and 41 shrubs (Bhatta and Devkota, 2020). Less number of species in a forest suggests that the major species in that area might have experienced frequent human exploitation and pressure (Sagar *et al*., 2003).

Shannon Weiner Diversity index (H') of SCF was comparatively higher for herbs, shrubs and trees. Whereas, calculation of Simpson diversity index (D') was almost similar in both forests; SCF and BCF, in herbs and shrubs. Trees shows comparatively low species richness in BCF. Sundarapanian (2016) also mentioned that differences in the age structure of forest types, in the extent of human influence and variations in climatic conditions could contribute to the diversity in species composition and richness.

The biodiversity of undisturbed mature forests tends to be more resilient and stable, whereas human disturbances pose a threat to its stability. As tree size increases from small to emergent trees, there is a decrease in the number of species and stems, while the occurrence rate of species (species number per 1000 stems) shows an increase. A significant negative correlation between relative species richness (species number per 1000 stems) and tree densities across all size classes indicates a universal negative power-law relationship between them (Huang *et al*., 2003).

The IVI (Important Value Index) result of herbs showed that the highest value was of *Paspalum conjugatum* with 44.22 at SCF whereas it was 60.71 in *Spermacoce alata* at BCF. The species with high IVI value indicated its dominance and ecological success, also good potential for regeneration and greater ecological scopes (Subedi *et al*., 2009), which might be the reason of these species were rich in this area. Community members used to plant these herbs *Paspalum congugatum* and *Spermacoce alata* for fodder purposes for daily use, and this might be the reason for their high IVI value.

Similarly, a total of 14 shrubs species at SCF, and 7 species at BCF were recorded. High IVI values were recorded in *Clerodendrum viscosum* and were followed by *Pogostemon benghalensis* both sites. The study by Berlow *et al*. (2003) found that places with fewer shrubs had more different kinds of herbs. This was because the herbs either grew better when the shrubs were removed or when there weren't many shrubs available in those areas.

High IVI value in the tree layer was occupied by *Shorea robusta* (Sal) in both community forest. Other associate species in Sal-forest was *Lagerstoemia parviflora*,and *Cleistocalyx operculata* with high IVI values at SCF. *Shorea robusta* is the main dominant tree species of Nawalparasi district. CFs commonly engaged in disturbances such as species preference, management activities, excessive utilization, and the extraction of other species from mixed forest stands, as documented by Shrestha et al. (2010) and Winfrey et al. (2017).

Per-capita fuelwood consumption and domestic animals are higher in the Nawalparasi district, which might be due to the availability of grasses as main fodder source (Subedi et al, 2009). Similar disruptions were noted in the case of field sampling, where adequate measures for protection were taken for Sal. The prevalence of Sal's dominance could potentially be attributed to the protective measures employed (Mandal and Joshi, 2014).

Disturbances in the forest result in the creation of fragmented, exposed, and nutrient-poor sites that require recolonization. Successional species typically establish themselves in these disturbed areas through sprouts from stumps, roots, rhizomes, and seeds. In the disturbed area in the forest, both herb and shrub species exhibit higher numbers (Gautam and Mandal, 2018). This can be attributed to the edge effect and the presence of an open canopy, which provides favorable conditions for plants that thrive in well-lit environments. Conversely, the undisturbed area in the forest has a lower species count, likely due to the dense tree canopy that restricts sunlight. This lack of sufficient sunlight inhibits the germination, growth, and development of light-loving species in undisturbed areas of the forest (Gautam and Mandal, 2018).

5.2 Regeneration

The overall regeneration status of Shiva community forest (SCF) and Budhaulikuna community forest (BCF) showed only one species i.e., *Shorea robusta* had high regeneration capacity among other species. Comparatively, BCF had better regeneration status in seedling and sapling numbers. At BCF, total number of 2818 seedlings per hectare was recorded and only 1159 seedlings per hectare was found at SCF. Number of saplings were also low in SCF as compared to BCF i.e., 785 saplings per hectare and 1605 saplings per hectare respectively. As per the guidelines provided in the Community Forestry Inventory Guideline of 2002, the regeneration condition of the forest can be classified as favorable when the number of seedlings per hectare exceeds 5000 and saplings exceeds 2000 (MFSC, 2002). On the other hand, the number of trees were 233 individuals/hectare at BCF and 466 trees/ha at SCF. Another co-dominant species as *Lagerstroemia parviflora* showed little more than the other species as both seedlings and saplings at SCF. Overall, 80% of the trees have surpassed the 50-year mark. These semi-natural forests exhibit a substantial buildup of biomass, yet their carbon sequestration rate remains relatively low. The older *Shorea* trees, in particular, demonstrate a gradual annual increase in carbon storage at BCF (Pathak and Baniya, 2017). The rate of growth and the density of trees that are planted are influenced by both the specific species of trees and the amount of nutrients present in the soil (Lal, 2005; Norgrove and Hauser, 2013; Sharma *et al.*, 2014).

The availability of adequate gaps in the forest canopy permits an ample amount of sunlight to reach the understory, creating a favorable environment for the abundant growth of young *Shorea robusta* trees. This light exposure serves two important purposes: it enhances the process of photosynthesis and raises the temperature of the forest floor, thereby accelerating the decomposition of organic litter (Sapkota *et al*., 2009).

Trees such as *Holarrhena pubescens*, *Psidium guajava*, *Terminalia alata*, *Litsea monopetala*, and *Alstonia scholaris* showed no regeneration at SCF which might be due to lack of proper management of forest, illegal logging, illegal grazing and bush fire were also observed and evident during the field study. Additionally, there was new species such as *Ficus hispida*, *Malotus* *philipines* were new regenerating species with poor growing status. Similarly, at BCF, *Ficus hispida* was co-dominant species and had high regeneration status but Bombax ceiba had no regeneration. Species like *Premna interifolia*, *Cassia fistula*, and *Malotus philipines* were poorly regenerating at BCF. Regeneration plays a crucial role in ensuring the long-term sustainability of forests. The act of tree cutting likely resulted in an open canopy which in turn created favorable conditions for robust regeneration in BCF area. Despite the absence of environmental variations such as soil, topography, and climate between the SCF and BCF forest, BCF which has the community management history of eight years exhibited greater seedling and sapling density (Sapkota et al.,2009).

The size class distribution in Shiva community forest showed a reverse j-shaped structure and this is the indication of sustainable regeneration (Acharya *et al*., 2007, Shrestha, 2005). According to the findings from Sapkota et al. (2009) in Nawalparasi, the study revealed that old growth forests experienced more disturbance compared to regenerated forests in the context of *Shorea robusta* forests. The disturbed forest stands showed a higher density of saplings in comparison to other types of forests (Gairhe, 2015). Although, regeneration was not called sustainable when mature tree stands is higher than the seedlings and saplings number, as it mentioned in a report (Rai *et al*., 1999). However, regeneration was not sustainable in natural dense forests with a high density of larger trees (Rai *et al*.,1999; Basyal *et al*., 2011). In Budhaulikuna community forest showed hump-shaped regeneration pattern where more trees were matured in stage. Hobbs and Harris (2001) discussed hump-shaped regeneration in the context of disturbances and recovery in restoration ecology. The hump-shaped curve reflects a period of disturbance followed by a subsequent increase in regeneration, showcasing the ecosystem's resilience and ability to recover after disturbances. In the lower girth class, the elevated stem density is a result of limitations on cutting smaller trees and favorable environmental conditions for their growth. Conversely, the reduced stem density in the highest girth class can be attributed to the extraction of larger trees, as reported by Sapkota *et al*. (2009) and Sarkar and Devi (2014). This underscores the impact of selective cutting practices on the distribution of stem density across different girth classes.

Several studies conducted by Gautam *et al*. (2002), Sakurai *et al*. (2004), Yadav *et al*. (2003) have suggested that the controlled grazing within Community Forests (CFs) in Nepal aims to promote favorable ecological outcomes of the CF program. This measure is expected to result in the growth of forest cover, an increase in stem density, and the facilitation of natural regeneration. Similarly, the act of controlled grazing might be promoted a greater number of seedings and sapling at BCF than at SCF. SCF might have faced illegal grazing while opening months to use forest products that leads to destruction of seedlings from the study sites which was also observed during our field trip. Abundant young growth not only signals active regeneration but also promises future canopy development, enhancing long-term stability. This phase fosters biodiversity, offering new genetic material and diverse habitats. Preserving areas in this regeneration phase is crucial for effective land management and biodiversity conservation (Hobbs and Harris, 2001; Pickett and White, 1985).

5.3 Carbon Stock

The process of capturing carbon dioxide from the atmosphere, known as carbon sequestration, occurs more rapidly in young and regenerating forests. However, when it comes to the overall amount of carbon stored, mature and old forests have a higher carbon stock compared to newly regenerating forests. The variability in forest carbon stock and its capacity to sequester carbon is influenced by multiple factors, not confined to a single aspect. These factors include the type of forest, forest age, tree size, tree density, biomass decomposition, stand condition, the extent and nature of disturbances as well as land management practices (Dixon *et al*., 1994). While the mentioned factors can influence biomass and forest carbon stock, they do not consistently act as variation factors. For instance, the size of individual trees may not always result in an increase in forest carbon stock (Baral *et al*., 2009; Thapa-Magar and Shrestha, 2015).

The study conducted by Luysaert *et al*. (2008) and Nair *et al*. (2009), the standing carbon stock in old growth forests (BCF) is greater than that of newly regenerating forests (SCF). Besides this, the density of seedling and saplings were also high in BCF. The total biomass in SCF was 191 tons/ha whereas in BCF it was 383.88 tons/ha. Similarly, total carbon stock in BCF was 163.14 tons/ha and at SCF it was only 81 tons/ha. The study carried out at Chitwan national park's buffer zone at same elevation was found to have greater amount of carbon stock accumulated in Dalbergia sissoo followed by Acacia catechu (Sharma *et al*., 2014). The differences in carbon stock levels can be attributed to various environmental factors that impact forest productivity, such as warm temperatures, high rainfall, and soil fertility. These climatic conditions, like temperature, rainfall, and soil fertility can influence the amount of carbon stored in forest as noted by Odum (1971) and Barbour *et al*. (1999).

Similarly, at SCF, there was a high density of tree individual with diameter 10-25cm at breast height. The outcome showed that the number of tree individual with low diameter at SCF regarded as regenerating forest. On the other hand, BCF had more individuals at diameter at 50-80cm at breast height which indicating it to be mature forest than SCF. The carbon stock was high but species richness and evenness both were poor at BCF whereas, the connection between carbon stock and species evenness demonstrated a limited and unfavorable correlation. This outcome of BCF resembles a prior investigation (Vance-Chalcraft *et al*., 2010; Ayer *et al*., 2022) that discovered a similar negative link between species evenness and aboveground biomass within the subtropical forest of Puerto Rico.

High density of tree individuals with 10-25cm diameter at breast height was observed in SCF. The result showed great number of tree individual with minimum diameter because SCF was regenerating forest. But in BCF more tree individuals with 40-55cm diameter at breast height was observed indicating it to be older than the SCF. In both community forest *Shorea robusta* contributed about 91% and 99% in SCF and BCF respectively. *Shorea robusta* was the dominant species in two community forests in Gorkha, and it accounted for 95% and 86% of the carbon stock, according to Neupane and Sharma (2014). In both forests, *Shorea robusta* had the highest Importance Value Index (IVI) compared to other associated species. Similar findings were found in the study at Bhabar lowland and hill Sal-forest in Central Nepal (Sapkota et al, 2009). Other than *Shorea robusta*, species like *Bombax ceiba*, *Dalbergia sissoo*, *Cleistocalyx operculata*, and *Casearia graveolens* exhibited lower density levels, potentially due to their sporadic presence in the forests. These tree species had relatively lower population densities, suggesting their rarity within the forest. Khadka and Schmidt-Vogt (2008) classified forests in the Godawari Hills, Kathmandu as dense when the tree density ranged from 390 to 1460 trees per hectare.

The similar survey done by Subedi *et al*. (2020) found that the dominated *Shorea robusta* contributed the highest carbon stock around (mean±SE) 33.23±0.23, 28.15±0.25 and 20.61±0.65 tons/ha in Baghkhor, Goraksha and Sungure community forests respectively. Whereas *S.robusta* was 38.61 to 41.31% higher than other associated species. In a preliminary investigation conducted by Gurung (2009) in western Terai region, the average carbon stock in the forests was estimated to be approximately 231 tons per hectare. The similar to our study conducted by Bhatta and

Devkota (2020) in Dadheldhura district revealed that community forests managed for a longer duration exhibited a higher carbon stock ranging from 148.5 to 202.3 ma/ha compared to those managed for shorter periods. However, our study revealed Budhaulikuna community forest with only 8 years of management (163.14 tons/ha) than Shiva community forest (91 tons/ha) with 12 years of protection. This indicates that these forests have effectively served as carbon storehouses, accumulating significant amounts of carbon over time only in BCF. The results of this study align with previous research, consistently demonstrating that carbon stocks exhibit a continual increase within undisturbed forest regions (Sharma *et al*., 2014). This might be the indication of disturbed.

5.4 Soil Carbon Content and pH

The average Soil organic percentage was found between 0.33-1.18% at Shiva community forest and in Budhaulikuna community forest ranges 0.015 to 1.59%. Soil pH ranged from 5.8 to 6.4 in the study sites. Tewari *et al*. (1995) reported the Sal trees can flourish in soil ranging from alluvial to lateritic compositions. Addition of, Sal trees exhibit a preference for slightly acidic to neutral sandy soils (pH between 5.1-6.8) and organic content with in a range of 0.11 to 1.8 percent, as documented by studies conducted by Rana et al, (1988), Gangopadhyay et al, (1990) and mentioned by Gautam and Devoe (2006).

The community forests have substantial potential to sequester atmospheric CO2 in to the soil, effectively aiding in climate change mitigation. The study emphasized the crucial role of local community participation in sustainable forest management, which enhances soil quality and contributes to strategies for combatting climate change (Joshi *et al*., 2021). This might be the reason to have good soil carbon percentage in both SCF and BCF. Active engagement of local people in conserving forests can effectively reduce CO2 levels in the atmosphere, making it essential for environmental preservation and a sustainable future, such practices had been seen in the both SCF and BCF community forests. Sal trees have the ability to thrive in a diverse array of soil types, with the exception of extremely sandy or gravelly soils found directly adjacent to rivers and areas with the excessive waterlogging (Jackson, 1994). Both the community forest had not been joined with the rivers but during monsoon much water flowing can been seen in the cannel that flows from northern to southern part of the forest.

CHAPTER 6: CONCLUSION AND RECOMMENDATION

6.1 Conclusion

Shiva community forest (SCF), with a longer management history but restricted resource collection by opening forest at 6 months interval, exhibited higher tree density but lower carbon stock and limited regeneration. In contrast, Budhaulikuna community forest (BCF), which allows collection of fodder and firewood throughout the year, are with low human pressures and also have more matured trees, demonstrated higher carbon stock and a more favorable environment for regeneration of diverse seedlings and saplings. Both these forest management practices have some drawback on the ecological dynamics of community forests. When restricted for long time, the forest regeneration is low due to high density of trees, but when firewood and fodder collections are allowed throughout the year, the biodiversity reduced. Hence optimum time for silviculture practices need to be ascertain especially to conserve biodiversity and maintain carbon sequestration.

6.2 Recommendation

- More studies are needed on community forest management (with different time duration allowing for forest resource collection) especially to understand its impact on plant diversity and forest regeneration.

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APPENDICES

1.List of Plant Species Found in Shiva community (SCF) and Budhaulikuna community forest (BCF)

Where symbol (+) is used as a presence and (-) used as absence of plant species.

Herbs and Shrubs					
S.N.	Scientific name	Family	Local name	Shiva Community Forest (SCF)	Budhaulikuna Community Forest (BCF)
1	*Achyranthes aspera* L.	Amaranthaceae	Datiwan	+	+
2	*Acmella oleracea* (L.) R.K. Jansen	Asteraceae	Goraspaan	-	+
3	*Ageratum conyzoides* L.	Asteraceae	Seto gandhe	+	+
4	*Ageratum hautonianum* Mill.	Asteraceae	Nilo gandhe	+	+
5	*Angiopteris helferiana* C.Presl	Marattiaceae		+	-
6	*Axonopus compressus* (SW) P. Beauv	Poaceae	Blanket ghass	+	-
7	*Bauhinia variegate* L.	Caesalpiniaceae	Koiralo	+	-
8	*Bidens Pilosa* L.	Asteraceae	Kalo kuro	+	+
9	*Boehemia platyphylla* D. Don	Urticaceae	Kamle	-	+
10	*Chromolaena odorata* (L) R.M. King & H.Rob.	Asteraceae	Banmara	+	+
11	*Clerodendron viscosum* L.	Lamiaceae	Ghatisare	+	-
12	*Colebrookea oppositifolia* Sm.	Lamiaceae	Dhursel	+	-
13	*Conyza* sp	Asteraceae	Salaha jhar	-	+
14	*Cynodon dactylon* (L.) Pers.	Poaceae	Dubo	-	+
15	*Cyperu*s sp	Cyperaceae	Mothe	+	-
16	*Dendrocalamus sp*	Poaceae	Bass	+	-
17	*Desmanthus virgatus* L	Fabaceae		+	+
18	*Desmodium triflorum* (L.) DC.	Fabaceae	Bute kanike	-	+

19	*Dioscorea bulbifera* L.	Dioscoreaceae	Ban tarul	+	+
20	*Dioscorea deltoidei* Wall. Ex G.	Dioscoreaceae	Kukur tarul	-	+
21	*Dryopteris* sp	Dryopteridaceae	Niuro	+	+
22	*Elephantopus japonicum* L.	Asteraceae	Thinko	+	-
23	*Elephantopus scaber* L.	Asteraceae	Saharsa buti	+	-
24	*Eragrostis minor* host	Poaceae	Ghass	+	+
25	*Flemingia macrophylla* (Willd.) Merr.	Fabaceae	Bhamasi	+	+
26	*Hemarthria compressa* (L.f.) R.Br.	Poaceae	Mkaiya-ghas	+	+
27	*Imperata cylindrica* (L.)	Poaceae	Siru	+	+
28	*Lantana camara* L. Mol.	Verbenaceae	Banmara	+	+
29	*Lindernia diffusa* L	Linderniaceae		+	-
30	*Lygodium flexuosum* (L)	Lygodiaceae	Nagbeli	+	+
31	*Mesophaerum suaveolens* (L.) Kuntze	Lamiaceae	Ban baawaree	+	-
32	*Micania micrantha* Kunth.	Asteraceae	Lahare banmara	+	+
33	*Mimosa pudica* L.	Fabaceae	Lajjawoti jhar	+	+
34	*Murraya koengii (L.) Spreng.*	Rutaceae	Kadipatta	-	+
35	*Paspalum conjugatum* P.J Bergius	Poaceae	Buffalo ghas	-	+
36	*Phyllanthus niruri* L.	Phyllanthaceae	Bhumi amala	-	+
37	*Pogostemon benghalensis* (Burm.f.)O. Kuntze	Lamiaceae	Rudhilo	+	-
38	*Rungia pectinata* (L.) Nees	Acanthaceae	Ukuche jhar	+	-
39	*Senna occidentalis* (L.) Link	Fabaceae	Tapre	+	-
40	*Senna tora* (L.) Roxb.	Fabaceae	Thulo tapre	+	-
41	*Smilax sp*	Smilaceae	Kukur daino	+	-
42	*Solanum torvum* Sw.	Solanaceae	Thulo biheen	+	+
43	*Spermococe alata* Aubl.	Rubiaceae	Aalupate	+	+

44	*Spilanthes acmella* (L.)	Asteraceae	Marauti	+	-
45	*Stellaria* sp	Caryophyllaceae	Armale jhar	-	+
46	*Stephania japonica* (Thunb.)	Menispermaceae	Taro lahara	+	+
47	*Trifolium* sp	Fabaceae	Banmethi	-	+
48	*Triumfetta Pilosa* Wall.	Malvaceae	Dalle kuro	+	+
49	*Urena lobata* L.	Malvaceae	Naalukuro	+	-

Trees					
	Scientific name of plants	Family	Local name	SCF	BCF
50	*Shorea robusta* Gaertn.	Dipterocarpaceae	sal	+	+
51	*Cleistocalyx operculatus* (Roxb.) Merr. & Perry	Myrtaceae	Kemuna	+	-
52	*Horrarrhena pubescens* (Buch. -Ham.) Wall. Ex G. Don	Apocynaceae	Dudhe	+	-
53	*Casearia graveolens* Dalzell	Flacourtiaceae	Chaichue	+	+
54	*Lagerstroemia parviflora* Roxb.	Lythraceae	Butdhairo	+	-
55	*Tectona grandis* L.f.	Verbenaceae	Tik	+	-
56	*Dalbergia sissoo* Roxb. Ex DC.	Fabaceae	Sisau	+	-
57	*Psidium guazava* L.	Myrtaceae	Belauti	+	-
58	*Alstonia scholaris* (L.) R. Br.	Apocynaceae	Chaatiwan	+	-
59	*Cassia fistula* L.	Fabaceae	Raajbrikxya	+	-
60	*Bombax ceiba* L.	Bombacaceae	Simal	+	+
61	*Terminalia alata* Heyne ex Roth	Combretaceae	Saaj	+	-
62	*Aegle marmelos* (L.) Correa	Rutaceae	Bel	+	-
63	*Litsea monopetala* (Roxb.) Pers	Lauraceae	Kalikath	+	-
64	*Ficus hispida* L.f.	Moraceae	Debare	-	+
65	*Syzgium cumini* (L.) Skeels	Myrtaceae	jamun	-	+

2. List of trees wood density given by Chave *et al*., (2005).

Scientific Name of Tree	Specific Wood Density(cm^3)
Shorea robusta	0.72
Cleistocalyx operculata	0.66
Horrarrhena pubescens	0.64
Caesaria graveolens	0.606
Lagerstroemia parviflora	0.62
Tectona grandis	0.50
Dalbergia sissoo	0.64
Psidium guazava	0.60
Alstonia scholaris	0.36
Cassia fistula	0.71
Bombax ceiba	0.33
Terminalia alata	0.75
Aegle marmelos	0.75
Litsea monopetala	0.40

3.1 **Frequency, density, coverage and their relatives value of Herbs, shrubs and tree in Shiva community forest**

Herbs

Scientific name of plants	Total number of individuals	Frequency	Relative frequency	Density	Relative density	Coverage	Relative coverage	Importance value index (IVI)
Paspalum conjugatum	342	73.33	9.24	11.4	20.54	466	14.44	44.22
Spermacoce alata Rubiaceae	276	66.66	8.40	9.2	16.57	461	14.28	39.26
Triumfetta pilosa	69	46.66	5.88	2.3	4.14	141	4.36	14.39
Stephania japonica	20	33.33	4.20	0.66	1.20	60	1.85	7.26
Ageratum houstonianum	22	16.66	2.10	0.73	1.32	35	1.08	4.50
Achyranthes aspera	87	56.66	7.14	2.9	5.22	166	5.14	17.51
Chromolaena odarata	61	63.33	7.98	2.03	3.66	275	8.52	20.16
Lygodium japonicum	61	43.33	5.46	2.03	3.66	162	5.02	14.14
Elephantopus scaber	24	10	1.26	0.8	1.44	35	1.08	3.78
Hedychium ellipticum	9	6.66	0.84	0.3	0.54	60	1.85	3.24
Urena lobata	82	53.33	6.72	2.73	4.92	157	4.86	16.51

Smilax sp	9	16.66	2.10	0.3	0.54	40	1.23	3.88
Elephantopus japonica uk1	7	6.66	0.84	0.23	0.42	15	0.46	1.72
Spilanthes acmella	14	6.66	0.84	0.46	0.84	22	0.68	2.36
Eragrostis minor	116	33.33	4.20	3.86	6.96	142	4.40	15.56
Cynodon dactylon	43	26.66	3.36	1.43	2.58	96	2.97	8.91
Rungia pectinata	21	10	1.26	0.7	1.26	35	1.08	3.60
Bidens pilosa	12	10	1.26	0.4	0.72	18	0.55	2.53
Dioscorea bulbifera	27	26.66	3.36	0.9	1.62	94	2.91	7.89
Dryopteris	59	13.33	1.68	1.96	3.54	150	4.64	9.87
Bauhinia variegata	8	3.33	0.42	0.26	0.48	10	0.30	1.2105 35656
Mesophaerum suaveolens	7	3.33	0.42	0.23	0.42	15	0.46	1.30
Angiopteris helferiana	6	3.33	0.42	0.2	0.36	13	0.40	1.18.
Micania micrantha	5	6.66	0.84	0.16	0.30	39	1.20	2.34
Mimosa pudica	15	10	1.26	0.5	0.90	22	0.68	2.84
Imperata cylindrica	15	6.66	0.84	0.5	0.90	24	0.74	2.48
Senna occidentalis	4	6.66	0.84	0.13	0.24	10	0.30	1.39
Lindernia diffusa	21	6.66	0.84	0.7	1.26	18	0.55	2.65
Phyllanthus niruri	21	16.66	2.10	0.7	1.26	30	0.92	4.29
Hemarthria compressa	22	3.33	0.42	0.73	1.32	25	0.77	2.51
Cyperus sp	4	3.33	0.42	0.13	0.24	5	0.15	0.81
Senna tora	45	26.66	3.36	1.5	2.70	85	2.63	8.69
Dioscorea deltoidea	36	33.33	4.20	1.2	2.16	130	4.02	10.39

Shrubs

Plant name	Total number of individuals	Frequency	Relative frequency	Density	Relative density	Coverage	Relative coverage	Importance value index (IVI)
Clerodendrum viscosum	480	100	30.937	16	62.17	1248	51.52	144.63
Lantana camara	46	43.33	13.40	1.53	5.95	202	8.34	27.70
Pogostemon beghalensis	91	53.33	16.49	3.03	11.78	309	12.75	41.04
Solanum torvum	21	10	3.09	0.7	2.72	70	2.89	8.70
Banpatuwa	7	6.67	2.06	0.23	0.90	30	1.23	4.20
Xeromphis longispina	2	6.67	2.06	0.07	0.25	35	1.44	3.76
khasropaat	58	43.33	13.40	1.93	7.51	185	7.63	28.55
Desmanthus virgatus	6	6.67	2.06	0.2	0.77	27	1.11	3.95
Colebrookea oppositifolia	3	3.333	1.03	0.1	0.38	30	1.23	2.65
Murraya Koenigii	33	23.33	7.21	1.1	4.27	181	7.47	18.96
Flueggea sp	8	6.67	2.06	0.27	1.03	20	0.82	3.92
Dendrocalamus sp	4	3.33	1.03	0.13	0.51	25	1.03	2.58
Flemingia macrophylla	12	13.33	4.12	0.4	1.55	50	2.06	7.74

Trees

Plant name	Total number of individuals	Frequency	Relative frequency	Density	Relative density	Coverage	Relative coverage	Importance value index (IVI)
Shorea robusta	259.00	8.63	57.94	100.00	26.09	0.16	20.03	104.05
Cleistocalyx operculata	28.00	0.93	6.26	46.67	12.17	0.05	7.07	25.51
Horrarrhena pubescens	43.00	1.43	9.62	56.67	14.78	0.02	2.60	27.01
Casearia graveolens	3.00	0.10	0.67	3.33	0.87	0.01	1.53	3.07
Lagerstroemia parviflora	47.00	1.57	10.51	56.67	14.78	0.26	33.76	59.06
Tectona grandis	21.00	0.70	4.70	36.67	9.57	0.04	5.12	19.38
Dalbergia sissoo	19.00	0.63	4.25	13.33	3.48	0.06	7.63	15.36
Psidium guajava	2.00	0.07	0.45	6.67	1.74	0.01	0.67	2.86
Alstonia scholaris	2.00	0.07	0.45	10.00	2.61	0.02	2.18	5.23
Cassia fistula	2.00	0.07	0.45	6.67	1.74	0.01	1.15	3.33
Bombax ceiba	5.00	0.17	1.12	13.33	3.48	0.01	1.57	6.17
Terminalia alata	6.00	0.20	1.34	10.00	2.61	0.07	8.84	12.79
Aegle marmelos	2.00	0.07	0.45	10.00	2.61	0.05	6.83	9.89
Litsea monopetala	1.00	0.03	0.22	3.33	0.87	0.01	1.02	2.11
Shorea robusta	259.00	8.63	57.94	100.00	26.09	0.16	20.03	104.05
Cleistocalyx operculatus	28.00	0.93	6.26	46.67	12.17	0.05	7.07	25.51
Horrarrhena pubescens	43.00	1.43	9.62	56.67	14.78	0.02	2.60	27.01

3.2 Frequency, density, coverage and their relatives value of Herbs, shrubs and tree in Budhaulikuna community forest.

Herbs

Plant name	Total number of individuals	Frequency	Relative frequency	Density	Relative density	Coverage	Relative coverage	Importance value index (IVI)
Spermacoce alata	480	80.00	12.44	16.00	25.07	847.00	23.21	60.71
Ageratum conyzoides	41	23.33	3.63	1.37	2.14	71.00	1.95	7.71
Imperata cylindrica	107	16.67	2.59	3.57	5.59	72.00	1.97	10.15
Paspalum conjugatum	248	60.00	9.33	8.27	12.95	294.00	8.06	30.33
Hemartha compressa	18	10.00	1.55	0.60	0.94	27.00	0.74	3.23
Chromolaena odarata	121	73.33	11.40	4.03	6.32	657.00	18.00	35.72
Dryopteris sp	8	6.67	1.04	0.27	0.42	15.00	0.41	1.87
Triumfetta pilosa	53	30.00	4.66	1.77	2.77	104.00	2.85	10.28
Acmella oleracea	16	10.00	1.55	0.53	0.84	25.00	0.69	3.08
Achyranthes aspera	31	23.33	3.63	1.03	1.62	57.00	1.56	6.81
Dioscorea bulbifera	27	26.67	4.15	0.90	1.41	125.00	3.43	8.98
Urena lobata	6	10.00	1.55	0.20	0.31	14.00	0.38	2.25
Trifolium sp	35	10.00	1.55	1.17	1.83	27.00	0.74	4.12
Stephania japonica	5	10.00	1.55	0.17	0.26	24.00	0.66	2.47
Lygodium japonicum	25	26.67	4.15	0.83	1.31	61.00	1.67	7.12
Solanum virginianum	1	3.33	0.52	0.03	0.05	5.00	0.14	0.71

Micania micrantha	11	13.33	2.07	0.37	0.57	65.00	1.78	4.43
Dioscorea deltoidea	4	6.67	1.04	0.13	0.21	27.00	0.74	1.99
Desmodium triflorum	8	6.67	1.04	0.27	0.42	12.00	0.33	1.78
Ageratum haustianum	106	43.33	6.74	3.53	5.54	157.00	4.30	16.57
Conyza canadensis	82	20.00	3.11	2.73	4.28	124.00	3.40	10.79
Desmanthus virgatus	10	10.00	1.55	0.33	0.52	20.00	0.55	2.62
Cynodon dactylon	4	3.33	0.52	0.13	0.21	5.00	0.14	0.86
Phyllanthus niruri	128	46.67	7.25	4.27	6.68	144.00	3.95	17.88
Conyza sp	7	10.00	1.55	0.23	0.37	11.00	0.30	2.22
Eragrostis minor	8	6.67	1.04	0.27	0.42	12.00	0.33	1.78
Hyptis suaveolens	50	26.67	4.15	1.67	2.61	83.00	2.27	9.03
Boehemia platyphylla	6	3.33	0.52	0.20	0.31	25.00	0.69	1.52
Stellaria sp	37	16.67	2.59	1.23	1.93	66.00	1.81	6.33
Mimosa pudica	5	3.33	0.52	0.17	0.26	10.00	0.27	1.05
Bidens pilosa	8	6.67	1.04	0.27	0.42	22.00	0.60	2.06

Shrubs

Plant name	Total number of individuals	Frequency	Relative frequency	Density	Relative density	Coverage	Relative coverage	Importance value index (IVI)
Clerodendrum viscosum	274	73.33	36.07	9.13	49.02	894.00	44.43	44.43
Pogostemon benghalensis	229	66.67	32.79	7.63	40.97	783.00	38.92	38.92
Lantana camara	27	30.00	14.75	0.90	4.83	186.00	9.24	9.24
Khasropaat	11	13.33	6.56	0.37	1.97	55.00	2.73	2.73
Flemingia macrophylla	7	10.00	4.92	0.23	1.25	32.00	1.59	1.59
Callicarpa macrophylla	4	3.33	1.64	0.13	0.72	20.00	0.99	0.99
Murraya koenigii	7	6.67	3.28	0.23	1.25	42.00	2.09	2.09

Trees

Plant name	Total number of individuals	Frequency	Relative frequency	Density	Relative density	Coverage	Relative coverage	Importance value index (IVI)
Shorea robusta	216	7.2	98.18	100	88.23	0.32	73.82	260.23
Bombax ceiba	1	0.033	0.45	3.33	2.94	0.0078	1.76	5.15
Ficus hispida	1	0.033	0.454	3.33	2.94	0.025	5.71	9.11
Casearia graveolens	1	0.033	0.45	3.33	2.94	0.038	8.53	11.93
Syzygium cumini	1	0.033	0.45	3.33	2.94	0.045	10.16	13.55

Photoplates

Alstonia scholaris

Collecting the soil samples

Measuring DBH of Trees