Tree Diversity, Regeneration and Carbon Stock in the Forests of Chure Region, Madhesh Province, Nepal

A Dissertation Submitted for the Partial Fulfilment of the Requirement of a Master's Degree in Botany

By
Prabesh Shrestha
Exam Roll No: Bot 890/077
T.U. Regd. No: 5-2-33-174-2016
Batch: 2077/2078

Central Department of Botany
Institute of Science and Technology
Tribhuvan University
Kirtipur, Kathmandu
Nepal

June 2025

Tree Diversity, Regeneration and Carbon Stock in the Forests of Chure Region, Madhesh Province, Nepal

A Dissertation Submitted for the Partial Fulfilment of the Requirement of a Master's Degree in Botany

By
Prabesh Shrestha
Exam Roll No: Bot 890/077
T.U. Regd. No: 5-2-33-174-2016
Batch: 2077/2078

Central Department of Botany
Institute of Science and Technology
Tribhuvan University
Kirtipur, Kathmandu
Nepal

June 2025

Declaration

The dissertation entitled **"Tree Diversity, Regeneration and Carbon Stock in the Forests of Chure Region, Madhesh Province, Nepal"** which is being submitted to the Central Department of Botany, Institute of Science and Technology, Tribhuvan University, Nepal for the partial fulfilment of the requirements of M. Sc. in Botany, has been carried out by **Mr. Prabesh Shrestha** under the supervision of **Assist. Prof Dr. Narayan Prasad Ghimire** and **Assoct. Prof. Dr. Yadav Uprety**. This work has not been submitted to any other institution for any academic degree.

....

Prabesh Shrestha

Date: June 3rd, 2025

TRIBHUVAN UNIVERSITY
INSTITUTE OF SCIENCE AND TECHNOLOGY
CENTRAL DEPARTMENT OF BOTANY

Ref No:

Tribhuvan University
Central Department of Botany
Kirtipur, Kathmandu

Kirtipur, Kathmandu
NEPAL

Recommendation

This is to recommend that ' **Mr. Prabesh Shrestha**' has carried out the dissertation entitled **"Tree Diversity, Regeneration and Carbon Stock in the Forests of Chure Region, Madhesh Province, Nepal"** for the requirements of M. Sc. in Botany under our supervision. To our knowledge, this work has not been submitted to any other institution for any academic degree. He has fulfilled all the requirements of the Central Department of Botany, Institute of Science and Technology, Tribhuvan University, Kirtipur for the submission of the dissertation for the M. Sc. in Botany.

Narayan P. Ghimire

....

Supervisor
Narayan Prasad Ghimire, Ph.D.
Assistant Professor
Central Department of Botany
Tribhuvan University
Kirtipur, Kathmandu
Nepal

Uprety

....

Co-Supervisor
Yadav Uprety, Ph.D.
Associate Professor
Central Department of Botany
Tribhuvan University
Kirtipur, Kathmandu
Nepal

Tel. #: 977-1-4331322, Email: info@cdb.tu.edu.np, Website www.cdbtu.edu.np

TRIBHUVAN UNIVERSITY
INSTITUTE OF SCIENCE AND TECHNOLOGY
CENTRAL DEPARTMENT OF BOTANY

Ref No:

Tribhuvan University
Central Department of Botany
Kirtipur, Kathmandu

Kirtipur, Kathmandu
NEPAL

Letter of Approval

The dissertation work entitled **"Tree Diversity, Regeneration and Carbon Stock in the Forests of Chure Region, Madhesh Province, Nepal"** submitted at the Central Department of Botany, Institute of Science and Technology, Tribhuvan University by **Mr. Prabesh Shrestha** has been accepted for the partial fulfillment of M. Sc. in Botany.

....
External Examiner
Ramesh Prasad Sapkota, Ph.D.
Associate Professor
Central Department of Environmental Science
Tribhuvan University

....
Internal Examiner
Achyut Tiwari, Ph.D.
Assistant Professor
Central Department of Botany
Tribhuvan University

Narayan P. Ghimire
....
Supervisor
Narayan Prasad Ghimire, Ph.D.
Assistant Professor
Central Department of Botany
Tribhuvan University

....
Co-Supervisor
Yadav Uprety, Ph.D.
Associate professor
Central Department of Botany
Tribhuvan University

....
Head of the Department
Dr. Sangeeta Rajbhandary
Professor
Central Department of Botany
Tribhuvan University

Date: June 3rd, 2025

Tel. #: 977-1-4331322, Email: info@cdb.tu.edu.np, Website www.cdbtu.edu.np

Acknowledgements

Firstly, I would like to express my sincere gratitude to my supervisor, Assistant Prof. Dr. Narayan Prasad Ghimire, for his encouragement, continuous support, and suggestions throughout this research period. I would like to express my deepest gratitude and appreciation to my co- supervisor, Associate Prof. Dr. Yadav Uprety, for his guidance and support that played pivotal role in shaping the outcome of my research.

I am thankful to Prof. Dr. Sangeeta Rajbhandary, Head of Department of Botany, Tribhuvan University, for providing me with all kinds of administrative support. I would like to express my appreciation to all the Botany faculty and staffs at the Central Department of Botany for creating an environment conductive to academic growth, excellence, and administrative support. I am also thankful to Assoc. Prof. Dr. Chitra Bahadur Baniya for his guidance and moral support.

I would also like to thank to my friends Mr. Yogendra Bikram Poudel, Mr. Sandip GC and Mr. Khagendra Joshi for their continuous assistance in plant identification. I am deeply grateful to Mr. Paban Luitel, Mr. Krishna Bhandari and Mr. Santosh Rana Magar for providing their support during the entire field visits and help in data collection.

Also, I am indebted to the unwavering support of my family and friends, who have been with me every step, providing encouragement and understanding during the research and writing process.

This work was funded by the National Priority Area Research (NPAR)- Emerging Research Grant of the Office of Rector, Tribhuvan University, Kathmandu (Grant no.: TU-NPAR-079/80-ERG-03; Floristic diversity, Vegetation Ecology and Ethnobotany of Chure Region of Madhesh Pradesh, Nepal).

....

Prabesh Shrestha

Abstract

Forest plays an important role in conserving tree diversity and contributes in carbon sequestration. The current study assesses tree diversity, regeneration and carbon stock in the forests of Chure region, Madhesh Province, Nepal. The data was collected following a two-phase systematic sampling with stratified systematic cluster sampling technique. A total of 67 tree species from 57 genera and 29 families were documented in 69 plots, with Fabaceae being the most species-rich family. The Shannon-Wiener's diversity index (3.0) and Simpson diversity index (0.89) indicated high tree species diversity presence. The Margalef's richness index (9.06) indicated high species richness. The most important tree species was *Shorea robusta,* with highest Importance Value Index (80.63%). Among eight Districts, species diversity and richness was highest in Saptari and lowest in Mahottari District. The regeneration pattern followed an inverse J-shaped curve which suggests the presence of healthy regeneration trend. Riverine forests experienced the highest disturbance and lowest regeneration while the government forests had experienced higher disturbance than the community forests and protected forests. The Canonical Correspondence Analysis revealed that, the species diversity was high in less disturbed forest areas and areas that were farther away from the motorable roads. Also, *Shorea robusta* was found abundantly in more disturbed cites. The one-way ANOVA showed that the government forest experienced highest disturbance while protected forest had experienced minimum disturbance. The Kruskal-Wallis H test indicated the significant difference on carbon stock between three forest types and between three forest management regimes. The highest carbon stock was found in Sal forests and lowest in riverine forests as confirmed by Post-hoc Mann-Whitney U tests with Bonferroni correction. The protected forest (PNP) stored highest and the government forest stored the lowest carbon stock among the forest management regimes. These findings highlight the importance of forests in terms of diversity as well as its contribution in carbon stock, in different management strategies.

Key words: Diversity, Disturbed forest, Regeneration, Community forest, Forest management

शोध सार

यो अध्ययन चुरे वनको वृक्ष विविधता, पुनर्जनन र कार्बन सञ्चयलाई मूल्याङ्कन गर्न केन्द्रित छ। डाटा सङ्कलनका लागि दुई चरणीय प्रणालीगत नमूना विधि प्रयोग गरियो, जसअन्तर्गत वन क्षेत्रमा मात्र नमूना संकलन गरियो र कृषि भूमिलाई बाहिर राखियो। कुल ६७ प्रजातिका रुखहरू, ५७ वंश र २९ कुलहरू ६९ वटा plots मा पहिचान गरियो। Fabaceae सबैभन्दा धेरै प्रजातिहरू भएको Family पाइयो। Shannon-Wiener's विविधता सूचकांक (३.०) र Simpson सूचकांक (०.८९) बाट रूख प्रजातिको उच्च विविधता देखिएको छ। *Shorea robusta* प्रमुख प्रजातिको वनस्पतिको रूपमा पहिचान गरिएको छ। Margalef's richness index (९.०६) ले उच्च प्रजाति समृद्धि देखाएको छ। जिल्लागत रूपमा सबैभन्दा बढी प्रजाति विविधता र प्रजाति समृद्धि सप्तरी र सबैभन्दा कम महोत्तरी जिल्लामा देखिएको छ। पुनरुत्पादन अवस्था उल्टो J आकारको वक्र देखिएको छ, जसले सन्तुलित वन पुनरुत्पादनको संकेत गरेको पाइयो। नदी नजिकका वनहरू सबैभन्दा बढी अवरोध स्तर रहेको पाइयो र ती क्षेत्रमा पुनरुत्पादन स्थिति पनि न्यून देखियो। संरक्षित वनहरूभन्दा बढी अवरोध राष्ट्रिय वनहरू र सामुदायिक वनहरूमा देखिए। Canonical correspondence analysis ले रुखहरुको विविधता कम अवरोध भएका स्थानहरुमा धेरै देखायो र *Shorea robusta* बढी अवरोध भएका स्थानहरुमा धेरै देखायो। । One-way ANOVA परीक्षणले वन-प्रबन्धनका तीन प्रकारहरूबीच महत्वपूर्ण फरक रहेको देखायो। राष्ट्रिय वनमा सबैभन्दा धेरै अवरोध देखिएको छ भने संरक्षित वनमा सबैभन्दा कम अवरोध देखिएको छ। Kruskal-Wallis H परीक्षणले तीन वन प्रकारहरू बीच र वन व्यवस्थापन प्रणालीहरु बीच कार्बन भण्डारणमा महत्वपूर्ण फरक देखाएको छ। Post-hoc Mann-Whitney U परीक्षण Bonferroni सुधारसहित अनुसार (साल वनहरूमा (SF) सबैभन्दा धेरै कार्बन सञ्चयन भएको र नदीकिनारका वनहरूमा (RF) सबैभन्दा कम भएको पाइएको छ। संरक्षित वन (PNP) मा सबैभन्दा धेरै र सरकारी वनहरूमा (NF) सबैभन्दा कम कार्बन सञ्चयन देखिएको हो। यी निष्कर्षहरूले विविधताको संरक्षण तथा कार्बन सञ्चयनको दृष्टिकोणले विभिन्न वन व्यवस्थापन रणनीतिहरू अन्तर्गत वनहरूको महत्वलाई उजागर गर्छन्।

शब्द कुञ्जिका: विविधता, प्रभावित वन, पुनर्जनन, सामुदायिक वन, वन व्यवस्थापन

List of Abbreviations and Acronyms

AGTB	Above ground tree biomass
ANOVA	Analysis of variance
BA	Basal area
CCA	Canonical correspondence analysis
CF	Community forest
CCSP	Concentric circular sampling plot
C-stock	Carbon stock
℃	Degree Celsius
D	Density
DBH	Diameter at breast height
DCA	Detrended correspondence analysis
DI	Disturbance index
F	Frequency
IVI	Importance value index
m	Meter
ton/ha	Ton per hectare
MF	Mixed forest
NF	Government forest
NTFP	Non-timber forest product
PNP	Parsa National Park, Protected forest
RBA	Relative basal area
RD	Relative density
RF_r	Relative frequency
RF	Riverine forest
SF	Sal forest
SA per ha	Saplings per hectare
SE per ha	Seedlings per ha
H'	Shannon-Wiener’s diversity index
1-D	Simpson diversity index

List of Tables

Table 1: Detrended correspondence analysis (DCA) summary 28

Table 2: Canonical correspondence analysis (CCA) significance testing............. 29

Table 3: Regeneration status of ten important tree species 33

Table 4: One-way ANOVA between the diversity indices and the disturbance index 35

Table 5: Descriptive summary on diversity indices and disturbance index 36

Table 6: Pair wise comparisons using the Post-hoc Mann-Whitney U test with Bonferroni correction (adjusted α = 0.0167): C-stock vs. Forest types .. 37

Table 7: Pair wise comparisons using the Post-hoc Mann-Whitney U test with Bonferroni correction (adjusted α = 0.0167): C-stock vs. Forest management regimes.. 38

List of Figures

Figure 1: Chure region of Madhesh Province with sampling points 15

Figure 2: Average monthly temperature and precipitation of the past 30 years (1991-2022) AD (Data from the climate knowledge portal retrieved on January 25, 2025).. 16

Figure 3: Sampling point in each 4km×4km grid cells in Chure region of each District of Madhesh Province.. 18

Figure 4: A concentric circular sampling plot (CCSP) design 19

Figure 5: Tree richness with their respective family in the Chure region of Madhesh Province... 27

Figure 6: District wise diversity index and Margalef's richness index in the Chure region of Madhesh Province 28

Figure 7: Canonical Correspondence Analysis biplot 30

Figure 8: IVI (%) of ten important tree species with highest values in Chure region of Madhesh Province.. 30

Figure 9: District wise IVI (%) in the Chure region of Madhesh Province............ 32

Figure 10: Inverse J-shaped distribution of tree individuals per hectare in different DBH classes 32

Figure 11: Regeneration and disturbance score in three forest types 34

Figure 12: Regeneration and disturbance score in three forest management regimes.. 34

Figure 13: Average carbon stock in three forest types and management regimes in the Chure region of Madhesh Province.. 37

Table of Contents

Declaration ... ii
Recommendation ... iii
Letter of Approval ... iv
Acknowledgements ... v
Abstract ... vi
शोध सार ... vii
List of Abbreviations and Acronyms ... viii
List of Tables ... ix
List of Figures ... x
Table of Contents ... xi
1 Introduction ... 1
1.1 Background ... 1
1.1.1 Tree diversity ... 2
1.1.2 Regeneration ... 4
1.1.3 Disturbance ... 5
1.1.4 Carbon Stock ... 5
1.2 Rationale of the study ... 7
1.3 Hypothesis ... 7
1.4 Objectives ... 8
1.5 Limitations ... 8
2 Literature Review ... 9
2.1 Tree diversity ... 9
2.2 Regeneration ... 10
2.3 Disturbance ... 11
2.4 Carbon stock ... 12
2.5 Research gap ... 14
3 Materials and Methods ... 15
3.1 Study area ... 15
3.1.1 Climate ... 16
3.2 Sampling design ... 16
3.2.1 Sampling Point ... 19

3.3 Forest categorization 20
3.4 Data analysis 20
3.4.1 Frequency and relative frequency 20
3.4.2 Density and relative density 21
3.4.3 Basal area and relative basal area 21
3.4.4 Importance value index (IVI) 21
3.4.5 Shannon-Wiener's diversity index 22
3.4.6 Simpson diversity index 22
3.4.7 Margalef's richness index 22
3.4.8 Regeneration 23
3.4.9 Disturbance 23
3.4.10 Carbon stock 24
3.4.11 Ordination 24
3.4.12 Plant collection, herbarium preparation and identification 25
3.4.13 Statistical data analysis 25
4 Results 27
4.1 Tree diversity 27
4.2 Regeneration 32
4.3 Disturbance 33
4.4 Carbon stock 36
5 Discussion 39
5.1 Tree diversity 39
5.2 Regeneration 43
5.3 Disturbance 45
5.4 Carbon stock 47
6 Conclusion and Recommendations 49
6.1 Conclusion 49
6.2 Recommendations 49
7 References 50
Appendices 67
Photo plates 98

1 Introduction

1.1 Background

As the spread of plant diversity is strongly affected by increasing environmental temperature (Allen et al., 2002), the tree species diversity is strongly affected by both temperature and spatial scale in which the tree species richness increases rapidly at large spatial scale which is attributed by exponential increase in environmental temperature in eastern Asia than in North America (Wang et al., 2009). Trees are defined as the perennial, self-supporting plant that have an adult height of at least 5 m and has one erect stem with diameter of at least 10 cm (Ricker et al., 2010). The Global tree assessment had evaluated nine threats to tree species which includes, agricultural expansion, over-exploitation, livestock farming, Urban development, fire regime changes, energy production and mining, wood and pulp plantation, the spread of IAPS and the climate change (Fremout et al., 2020). Most of the global centers for plant species richness lie in the humid tropics like Tropical Andes, South Africa, and Borneo however, not all parts of tropics shows high species richness like central Europe, Congo basin which shows moderate species richness (Barthlott et al., 2005). Studies have shown that variables such as evapotranspiration, net primary productivity and precipitation patterns are the predictors of plant species richness (O' Brien, 1998; Francis & Currie, 2003), but the strength of their relationship is not uniform across climatic regions.

In temperate regions, species richness is influenced by mean annual temperature, length of the vegetation period and the number of frost days whereas, in the tropical and sub-tropical regions, it is influenced by actual evapotranspiration, annual precipitation and number of dry months (Mutke & Barthlott, 2005). In addition, various abiotic levels such as topography, soil types and geologic formations also significantly contribute to species richness (Braun et al., 2002). The tropical forests account for the most diverse plant communities around the Earth with up to 473 trees in single hectare of land due to which these forests display a unique patterns of plant species richness (Phillips et al., 1994; Condit et al., 1996). However, there exists a threat on tree species due to global changes (Boonman et al., 2024). The recent conservation effort lacks information on threat exposure and its intensity on tree species (Zhu et al., 2023).

According to Acharya et al. (2008), after the nationalization of all forests by the government of Nepal in 1957, there was a concern on sustainable forest resources management which led to the formulation of legal documents such as Forest Act (1993); Forest Regulation (1995); Land Revenue Act (1977); Land Act (1962). From 1976 to 2021, the dynamics of Nepal’s forest management system has changed as the private forest nationalization act (1957), forest act (2061) and special forest act laws (1967) took away power from local communities who were involved in traditionally managing the forests on their own for generations, which created the disconnection between government controls and the local people’s expectation ultimately resulting in creating problems in forest governance (Ojha and Hall, 2021). The possible forest management regimes in Nepal have been categorized into two types namely; private forest and national forest. Within the national forests, there are five sub-categories namely; government managed forest, protected forest, community forest, leasehold forest and the religious forest (HMG/N, 1993).

The Chure region, recognized as the youngest mountain range in the world (DFRS, 2014) has a climate varying from tropical to sub-tropical (DFRS, 2015). It is fragile and vulnerable due to both natural and human-induced levels (FRA/DFRS, 2014). The Chure region of Nepal has been reported to provide rich biodiversity (Chaudhary and Subedi, 2019) with 14 forest ecosystem types (Uprety et al., 2023). Deforestation and forest degradation in Nepal’s lower belt have contributed to an annual deforestation rate of 0.44% between 2001 and 2010 (DFRS, 2014). Also, the forest fire has been reported as one of the main disturbance in forests of Chure region of Nepal (Mishra et al., 2023). These environmental threats pose significant risks (Schweik et al., 1997) in the forests of Chure. Along with this, the accelerated deforestation (Bhatta et al., 2007) and unmanaged forests activities in the upper Chure region is one of the major problem (Shah et al., 2024).

1.1.1 Tree diversity

According to Dobremez (1980), vegetation of Nepal has been broadly categorized into six bio- climatic zones namely: Nival (>5000m), Alpine (4000-5000m), Sub-alpine (3000-4000m), Temperate (2000-3000m), Sub- tropical (1000-2000m) and Tropical (<1000m). The geography of Nepal ranges from Tarai to Himalaya where variation in species richness is evident. The peak species richness of plants is found in the range of

1500 and 2500 m whereas the peak species richness of endemic plants is found in between 3800 to 4200 m (Grytnes and Vetaas, 2002; Tiwari et al., 2019).

Based on the geographical ranges, the variability of all life forms occurs within species, between species and ecosystems which is described as biodiversity (Glowka et al., 1994). The diversity generally comprises two components, namely: species richness and evenness. Species richness is the number of species per unit area and evenness is the abundance distribution of species in a community (Vasilevich, 2009). Species evenness is used to define and differentiate different ecological communities and both the components are influenced by natural and anthropogenic disturbance (Magurran, 2004). So, species diversity is affected by various environmental levels like slopes, elevation, temperature and water availability (Zeng et al., 2014; Rai et al., 2016; Brown, 2001).

Therefore, estimation of species diversity is an important task in order to characterize the community. Various indices such as: Shannon- wiener's index (Shannon and Wiener, 1963), Simpson's index (Simpson, 1949) and Margalef's index (Margalef, 1958) are used for estimating tree diversity. The Shannon-Wiener's diversity index provides much balanced assessment of diversity because it accounts for both species richness and evenness while Simpson's index accounts for dominance (Nagendra, 2002). The Shannon-Wiener's index is reported to be more affected by the addition of rare species while the Simpson's index stabilizes at low sample sizes (Gimaret-Carpentier et al., 1998). The value of Shannon-Wiener's index can be classified based on Magurran's (2004) classification, which signifies low diversity at 0-2, moderate diversity at 2-3 and high diversity at >3. Similarly, the value of Simpson's index ranges 0-1 (Simpson, 1949) where a value close to 1 indicates high diversity. The Margalef's index is considered a measure of richness of species that accounts both the total number of individuals in the sample and the number of different species. Its high value indicates that the sample area is rich with different tree species (Margalef's, 1958). The Importance Value Index (IVI) shows the overall scenario of ecological importance of the species in a community and indicates dominant species based on its relative density, relative frequency and relative basal area (Kunwar and Sharma, 2004). It ranges from 0 to 300 and species having higher IVI value within the given range indicates its importance in a community (Curtis and McIntosh, 1951; Zobel et al., 1987).

1.1.2 Regeneration

Regeneration is considered a key process due to which a species continues its existence and a successful regeneration of a species requires an adequate number of seedlings and saplings within a forest (Tripathi and Khan, 2007). Regeneration is the process by which trees sprout from fallen seeds and their *in-situ* germination (Harmer, 2001). Plant species maintain and increase their population in a community throughout time and space by a process known as natural regeneration (Acharya and Shrestha, 2011), which is the regrowth or reproduction of plants through their young to old (Bharali et al., 2012). Good regeneration patterns with appropriate age-gradation and increasing stock are considered characteristics of sustainable forests (Subedi, 2011).

Regeneration determines the composition and structure of the forest and is monitored to ascertain whether it meets the goals of sustainable forest management, including maintaining the forest's biological variety and productive potential (Lutze et al., 2004). Regeneration is demonstrated by the appearance of an enough population of seedlings, saplings and young trees of variable age groups (Chauhan et al., 2008). A population with a reasonable number of seedlings and saplings portrays agreeable regeneration behavior, while a scarce number of seedlings and saplings signifies poor regeneration (Tripathi and Khan, 2007).

A key symbol of the community's development trend, species composition, potential for productivity, and future dynamics of the forest is the potential regenerative status of tree species (Bose et al., 2016). These are also regarded as important elements of stable forests (Awasthi et al., 2015). In the case of Nepal, the community forestry inventory guideline mentions that if a forest has more than 5,000 seedlings and 2000 saplings per hectare, its regeneration condition is deemed 'good'. Similarly, if the number of seedlings and saplings occurs between 2000 to 5000 and 800 to 2000, the regeneration is 'medium' whereas the regeneration is considered 'poor' if the number of seedlings and saplings occurs below 2000 and 800 respectively (MFSC, 2002).

Another widely used parameter for the study of regeneration status is the Density-Diameter (D-D) class distribution curve. In this parameter, the 'reversed J-shaped curve' indicates strong potential for forest regeneration for which, the distribution class shows higher concentration of individuals at seedlings state and subsequently decreases to sapling state and lowest to the adult state (Chauhan et al., 2008). The regeneration status of individual tree species can be ascertained ‘good’, ‘fair’, ‘poor’, ‘none’, and ‘new’ on the basis of number of seedlings, saplings and trees per hectare (Shankar, 2001).

1.1.3 Disturbance

Forest’s ecological services can be enhanced or diminished by different disturbances processes (Sagar and Singh, 2005). Forest dynamics and tree diversity are impacted at both local and regional levels by natural and human disturbances. The structural characteristics of forests have often been explained by human individual disturbance factors, such as selective logging (Sapkota et al., 2009 a). Disturbances such as logging, browsing, fire, fuel wood, and fodder collection have been disregarded in explanations of post-disturbance changes in forest ecosystems, although several factors impact ecosystem functioning simultaneously (Sapkota et al., 2010). The deforestation is a widespread occurrence in the Tarai and Siwalik regions of Nepal because of the illegal forest cutting for agricultural and government resettlement schemes, illegal harvest of forest products, overgrazing and ambiguous policy (Chaudhary et al., 2016).

In general, there are several factors contributing to deforestation in the country that includes conversion of forest lands for farming and resettlement, the need for wood and fuel, the need for fodder for animals, local unemployment, and a lack of government management (Joshi et al., 2000). There are multiple ways to quantify the disturbances in forest ecosystems, out of which the disturbance index (DI %) based on cut stumps is widely used to know and quantify anthropogenic disturbance (Malik et al., 2016). Disturbances like timber harvesting, fuel wood and fodder collection are common in Sal dominated forest (Timilsina et al., 2007; Sapkota et al., 2009); therefore, threats from disturbances need to be studied for the proper management of the forest.

1.1.4 Carbon stock

Forests and other wooded land together cover 44.74 % of the total land area of Nepal (DFRS, 2015). The Chure region of Nepal covers 12.78 % extending 800km in length from east to west (Subedi et al., 2021). Forests provide extremely important provisioning services such as fodder, fuel wood, and food while also contributing to economic growth and improving livelihoods (Stainton, 1972). Beyond these, forests play a crucial role in mitigating global challenges like climate change, rising temperatures, and the adverse effects of increased greenhouse gas (GHG) emissions motivated by industrialization and human activities (Le Quéré et al., 2015). The growing trees provides a way to minimize the amount of carbon dioxide (CO_2) in the atmosphere by accumulating it in the form of biomass (Chavan and Rasal, 2010). Among GHGs, CO_2 is the most abundant, with emissions increasing by 2.2% between 2000 and 2010. As a result, the average global temperature rose by 0.85°C between 1880 and 2012 (Pachauri et al., 2014). To address this issue, the Intergovernmental Panel on Climate Change (IPCC) set a target to limit global warming to 1.5°C before 2025 (Fyson et al., 2023).

Carbon stock refers to the total amount of carbon stored in an ecosystem, mainly within living biomass and soil, but also in dead wood and litter (Mukul et al., 2016). The balance between carbon gain through Net Primary Productivity (NPP) and carbon loss by way of decomposition and heterotrophic respiration determines the total ecosystem carbon stock (Mukul et al., 2021). These stocks fluctuate due to environmental factors that influence key carbon fluxes, including photosynthesis, decomposition, and both autotrophic and heterotrophic respiration. In recent years, the rising levels of carbon dioxide emissions and the challenge of mitigating them have become global concerns (Baul et al., 2021). Given their capacity to store some one-fourth of the world's terrestrial carbon, tropical forests play a crucial role in sequestering atmospheric carbon dioxide, highlighting their importance in climate change mitigation (Mitchard, 2018).

Forests play a vital role in achieving this goal by acting as natural carbon sinks, storing vast amounts of carbon in their vegetation (McMahon, 2010). Forests can act as both carbon sinks and sources which depends on how the forest is managed (Pradhan et al., 2019). Through photosynthesis, trees absorb CO_2 from the atmosphere, then converting it into biomass and effectively sequestering carbon (Jana et al., 2009). Shockingly, deforestation is responsible for about 20% of global GHG_s emissions (Gullison et al., 2007), making forest conservation as one of the priority, especially in countries like Nepal, where green forest cover is considerable.

Understanding the importance of forest conservation, the 13th Conference of the Parties (COP) in 2007 introduced the concept of 'carbon payments' to financially compensate countries for their role in carbon sequestration process. This initiative enhanced further with the launch of REDD+ following the 14^{th} COP held in Poland in 2008 (Adhikari and Prasain, 2009). The carbon stock assessment helps to deduce the role of different vegetation types in mitigating GHG emissions (Liu et al., 2018) and helps in monitoring and evaluating how well the forest-based strategies work to reduce carbon emissions (Pandey et al., 2014). The CO_2 sequestration in the forest is determined by the forest type, species composition and stand age (Huy and Anh, 2008).

1.2 Rationale of the study

Human reliance on forest resources and the area's precarious natural setting both have an impact on the forests of the Chure region (Acharya et al., 2019). Comprehending the diversity of tree species, their regeneration status, the extent of disturbances (such as logging), and the carbon store is essential for evaluating the stress placed on these forests (Uprety et al., 2025). Since monitoring species regeneration and disturbances provide insights required for conservation and sustainable forest management, such research is essential for guiding forest management methods (Kaushal et al., 2021). Furthermore, the data on carbon stocks is necessary for programs like REDD+, which provides financial rewards to nations like Nepal that protect their natural carbon sinks and thereby advance national development. The objective of this study is to evaluate the tree species diversity, regeneration status, and disturbance levels and carbon stock in the Chure region of Madhesh Province. Complement to previous research of Uprety et al. (2023), who reported moderate to high forest regeneration throughout the Chure region, this study will be able of shade a light on diversity, regeneration and carbon stock focused on the Chure region of Madhesh Province. In Nepal, tree diversity, regeneration, and carbon stock were studied in different parts and very limited studies were done in the Chure region of Madhesh Province. This study provides the first hand information on tree diversity, regeneration and carbon stock in the forests of Chure region, Madhesh Province, Nepal.

1.3 Hypothesis

Disturbance significantly lowers tree diversity in the forests of Chure region, Madhesh Province, Nepal.

1.4 Objectives

General objective:

- To study tree diversity, regeneration and carbon stock in the forests of Chure region, Madhesh Province, Nepal.

Specific objectives:

- To calculate tree diversity indices along the Chure forest of Madhesh Province.
- To assess the regeneration status of important tree species.
- To assess regeneration and disturbance levels in three forest management types and three forest management regimes.
- To measure the carbon stock in three forest types and forest management regimes.

1.5 Limitations

- Only trees were considered for diversity indices, regeneration and carbon stock while herbs and shrubs were not considered.
- Sampling sites with steep terrains were avoided.

2 Literature Review

2.1 Tree diversity

Mutke and Barthlott (2005) studied patterns of vascular plants diversity and concluded that higher vascular plants diversity exists in between tropical to temperate belts. Kier et al. (2005) studied the patterns of species diversity throughout the world and concluded that high species diversity occurs in between temperate and tropical region. Pausas and Austin (2001) had studied the species richness pattern and found that species richness increases with temperature and water availability. Prasad et al. (2009) studied the species diversity and regeneration in seasonally dried Sal forests and concluded that forests gaps help in maintaining species diversity of the forest. Wang et al. (2020) studied the soil moisture and species diversity and found that the soil moisture found in 20-60 cm has significant role in maintaining species diversity.

Yadav et al. (2023) studied the regional assessment and distribution of native tree species in south Asia and reported that Nepal holds 4th position in south Asia for native tree diversity by country's land area and has 604 tree species. Previously, DFRS (2015) reported 443 tree species in Nepal that belongs to 239 genera and 99 families with Fabaceae being the largest family followed by Lauraceae. However, a recent study conducted by Pandey (2024) reported 700 taxa of tree species that belongs to 90 families, 300 genera and 688 species with Lauraceae being the largest family followed by Fabaceae in Nepal.

Chure, the water towers for lower region of Tarai, is considered a hotspot for biological diversity and in-situ conservation of flora and fauna (DFRS, 2014) has become vulnerable due to abrupt high unpredictable rainfall, deforestation, unplanned road construction, cultivation in steep slopes and land use land cover changes (SAWTEE, 2016). Recently, 14 forest types have been reported by Uprety et al. (2023) in Chure region. Few ecological studies have been done regarding forest, grassland and wetland ecosystems. Till date, Pokhrel (2012), studied the conservation of Chure forest in Nepal and stated that, farmers of the Chure range have considered the forest as an integrated part of the farming system for long. Pandey (2007) studied tree species diversity in the forests of mid-hills, Nepal and found that the community forests and national park had the highest tree species richness with better diversity than that of the government managed forests. Pokhrel and Sherpa (2020) studied the relationship, distribution of tree species diversity and above ground biomass in Chitwan-Annapurna landscape, Nepal and found that the Shannon diversity index for the study area was 2.75 which varied due to changing elevation.

The Shannon-Weiner's diversity index of tropical Sal forest in eastern Nepal was 1.66 (Mandal, 1999) indicating moderate diversity which was due to the dominance of single *Shorea robusta* species. Tropical dry evergreen forest of India had the Shannon-Weiner's diversity index ranging 1.24-2.2 (Pragasan and Parthasarathy, 2010) indicating moderate diversity of trees which was due to selective timber harvesting that acted as human induced disturbance in the forest areas. The tropical wet forest in Western Ghats of India had the Shannon-Weiner's diversity index ranging 2.01-3.7 (Swamy et al., 2010) indicating moderate diversity which was due to the indiscriminate logging activity by human and also attributed by microclimate and topographic effect that had direct impact on the spatial diversity of vegetation. Likewise, the tropical moist forest of eastern Nepal had 3.08 Shannon-Weiner's diversity index (Gautam and Mandal, 2018) indicating high diversity of trees which was attributed by microclimate, soil nutrient availability and high annual precipitation. The tropical wet evergreen forest of Bangladesh was high (3.37) (Feroz et al., 2013) which was due to high expected species richness value and moderate distribution of individuals among species. The Simpson diversity index value emphasize slightly more on species evenness and the common trend in diversity along altitudinal gradients is reported as steep increase until 1500 m (Pandey, 2016). However, with increase in altitude, the diversity declines due to the low species richness (Veetas and Grytnes, 2002).

2.2 Regeneration

Jayakumar and Nair (2013) conducted species diversity and trees regeneration status in tropical forests of India and found that the tree regeneration was higher in species rich vegetation type with no sign of human disturbances and change in regeneration status was more frequent in disturbed forest types. Khadka et al. (2024) assessed the regeneration status of tree species in the subtropical hills of Lamjung District and found that the Kirtipur community forest had the best regeneration among four community forest under study with seedlings 58,438 individuals/ha and saplings 3500 individuals/ha and trees 969 individuals/ha. Among the recorded species, 6 had good regeneration, 2 had fair regeneration, 4 had poor regeneration, 5 had new regeneration and 6 had no regeneration. The current population structure and its growth rate can predict the success the regeneration (Guedje et al., 2003) and various types of regeneration patterns were recorded till date in the world. Sarkar and Devi (2014) recorded inverse J- shaped with 'Good regeneration status' with seedlings > saplings > trees in Assam, Northeast India and Central Himalaya, India with density of seedlings and adults > saplings (Pandey et al., 2014).

The forest structure is determined by various factors such as geography, environmental conditions, anthropogenic factors (Poudel and Devkota, 2021), light environment and seed germination (Chikanbanjar et al., 2020). Giri et al. (1999) studied the composition of vegetation, the production of biomass, and the regeneration of *Shorea robusta* forests within Bardiya national park and concluded that the forest was in youthful and actively undergoing regeneration stage due to inverse J-shaped regeneration pattern. Poudel and Devkota (2021) studied the regeneration status of Sal forest in community managed forests and concluded that the size class distribution of the trees that resembled inversed J-shaped curve indicated 'Good regenerating capacities' of the forests. Joshi et al. (2021) studied the regeneration status and carbon accumulation potential in community managed Sal forest in far western Nepal and found the reversed J-shaped curve with seedlings 19583 individuals/ha to 37500 individuals/ha > saplings 2533 individuals/ha to 4000 individuals/ha.

2.3 Disturbance

Sapkota et al. (2009 a) had investigated the spatial distribution, advanced regeneration and stand structure of five Sal dominated forests and their result concluded that the simultaneously occurring frequent and fluctuating moderate disturbances are majorly responsible for higher stem density in the forests. Disturbances are driven by various factors and in Chure region of Madhesh Province, it is driven due to the economy. Mahat et al. (1986) concluded that the economic sources of the rural poor of the Chure indicated that more than one-fifth income of the poor, crucial for subsistence living, comes from the common resources such as forest and other available natural resources which led forests to their degradation and destruction.

Bhattarai and Mandal (2016) studied soil characteristics and concluded that Bulk densities, water holding capacities and soil moisture is higher in the soil of Tarai Sal

Forest. Gautam and Mandal (2016a) studied the effect of disturbance on biomass, production and carbon dynamics also litter dynamics (Gautam and Mandal, 2016b) in moist tropical forest of eastern Nepal. They concluded that disturbance activities give rise to the loss in stand biomass, net primary productivity and carbon sequestration capacity. Also, in disturbed and undisturbed forest, nutrient stocks in litter mass as N>K>P order. Malik et al. (2016) investigated anthropogenic disturbances and their impact on western Himalaya, India and found that disturbance index based on cut stumps (53.19±1.98 %) of trees are highly associated with anthropogenic disturbances.

Sapkota et al. (2010) assessed tree species diversity and dominance across a disturbance gradient in Nepalese Sal Forest and stated that with increasing disturbance, the diversity of *Shorea robusta* forests decline which directly favors the dominance of *S. robusta* species and recommended to enhance diversity to gain multiple use forest management objectives. Sapkota et al. (2009 b) stated that the advanced regeneration of important tree species such as *S. robusta*, *T. alata*, *S. cumini*, *E. operculata*, and *C. fistula* shows strong regeneration performance in forests with moderate disturbance. Another factor that strongly governs regeneration beside the disturbance factors, of tropical climax species *S. robusta* are seed viability, moisture availability and disease like Die-back disease (Kaushal et al., 2021). Over-exploitation of tree species, for timber, fodder, fuel-wood and non-timber forest products by local people, and extreme browsing, trampling and uprooting by herbivores, may lower their regeneration ability in heavily disturbed sites. Similar result was suggested by Gautam et al. (2016) who studied the pattern of diversity and regeneration in the Siwalik's Himalaya of India stated that disturbance with moderate intensities benefits species diversity and regeneration.

2.4 Carbon stock

Different environmental factors like slope, aspect, topography, soil affects the forest composition (Shank and Noorie, 1950). The carbon stocks in forest ecosystem varies with age structure (Clark *et al.,* 2004), climate, disturbances, stand age and soil (Somogyi et al., 2007) and forest type (Zhang et al., 2013). A study done by Dar et al. (2019) in the Central India's religious forests had found an average value of 97 Mg per ha of carbon stock and found the positive correlation between trees carbon stock and tree basal area. Luyssaert et al. (2008) also found that the carbon sequestration is faster in regenerating, young forest stands whereas it is higher in the mature and older forest stand. Forests offers a crucial role in carbon cycle which depends on the management activities and can play a role of both sources and sinks for carbon (IPCC, 2000).

Kaushal and Baishya (2021) concluded that higher biomass and carbon content were contributed by huge trees up to 65% of the growing carbon stock in the primary forest types of Central Himalaya. According to DFRS (2015), the total air dried biomass of the living tree with DBH ≥ 5cm is 387.96 million tons out of which the forests has 340.05 million tons in central Nepal. The context of carbon sequestration in the Sal forests of Chitwan valley (Chure) was recorded as 2.06 Mg C per ha/year by Bhattarai et al. (2012). Due to different micro-climatic and topographic conditions, the forest types in Nepal differs which plays a crucial role carbon sequestration. Shrestha (2009) found 101.66 t C/ha in the Sal forests of Palpa District. Likewise, Pandey et al. (2014) had studied the carbon stock of three Districts i.e., Chitwan, Gorkha and Dolakha and concluded that carbon storage was highest in the pine dominated dense forests (24 Mg C/ha) which was followed by *Schima-Castanopsis* forests (20 Mg C/ha), Mixed broad leaved forests (18.9 Mg C/ha) and Sal forests (16.9 Mg C/ha). In the Chure region, a research done by Sharma and Kakchapati (2018) reported 76.67 t C/ha which seems to be lower than that of the temperate protected forests. Sharma (2022) studied the above ground tree biomass of temperate forest of Nepalese Himalaya and reported 164±8 t C/ha which was greater than the carbon stock of unprotected forest (114±5 t/ha). Thus, above literatures have concluded that carbon stock may vary depending upon the forest types, management regimes and management duration (Thapa-Magar and Shrestha, 2015). Also, the basal area is regarded as one of the key determinant of carbon stock (Uprety et al., 2025; Balderas Torres and Lovett, 2013) Moreover, the findings of Borah et al. (2015) in tropical forest explained that higher tree biomass and carbon stock is due to old growth matured forest with big trees with greater tree diversity.

There exist multiple models given by different literatures to estimate the above ground biomass which includes the use of GIS and remote sensing (Lal, 2004) and the field measurements. Field measurements include harvesting method (Montes et al., 2000) and non- harvesting method (Chave et al., 2005). For non- harvesting technique, allometric regression model serves as simple and scientific way to find the above ground dry biomass and for this, tree height (m), diameter at breast height (DBH) and specific wood density of each tree species (MacDicken, 1997).

2.5 Research gap

Few studies have been conducted in the field of forest characterization in Chure hills. Recently, Uprety et al. (2023) conducted research on forest characterization of Chure hill of Nepal and 14 forest ecosystem types have been discovered. Chaudhary and Subedi (2019) reported that there is a great human disturbance impact in Chure region because majority of the peoples that live in the periphery of Chure hills are highly dependent on Chure forest resources either for their income or for their farming purposes as reported by Pokhrel (2012). According to DFRS (2014), over the past 15 years from 1995 to 2010, the area of forest cover found to be decreased due to deforestation in 27 Districts (Nawalparasi, Dang, Sindhuli, Surkhet, Makawanpur, Kailali, Udayapur, Rautahat, Dhanusa, Siraha, Dadeldhura, Rupandehi, Palpa, Salyan, Bardiya, Parsa, Bara, Kanchanpur, Sarlahi, Mahottari, Doti, Lalitpur, Jhapa, Tanahu, Saptari, Kavrepalanchowk and Bhojpur). Among these 27 Districts, 8 Districts are from Madhesh Province namely; Parsa, Bara, Rautahat, Sarlahi, Mahottari, Dhanusha, Siraha and Saptari. Various studies have been done such as, soil characteristics (Bhattarai and Mandal, 2016), forest biomass and carbon dynamics (Gautam and Mandal, 2016a), litter dynamics (Gautam and Mandal, 2016b), soil nutrients (Gautam and Mandal, 2016 a, b), Nitrogen mineralization in Chure (Mandal, 2011) but not specifically in the forests of Chure region, Madhesh Province. Therefore, this study is focused on fulfilling that gap by providing the tree diversity and the current disturbance and regeneration status and carbon stock in three forest types namely: Riverine forest (RF), Mixed forest (MF) & Sal forest (SF) and three forest management regimes namely; Government forest (NF), Community forest (CF) and protected forest (PNP) in the forests of Chure region, Madhesh Province, Nepal.

3 Materials and Methods

3.1 Study area

This study was conducted in the forests of Chure region, Madhesh Province accommodating eight Districts (Figure 1). Madhesh Province lies between 84^0 27′ & 86^0 54'30" East longitude and 26^0 23'38" & 27^0 28'17" North latitude. It has an area of 9,661 sq.km and that is 6.56% of the total area of the country. Out of which 27.29% land is covered by forest. It is bordered by India in the south, Makawanpur and Sindhuli Districts of Bagmati Province and Udayapur of Koshi Province in the north and Chitwan District of Bagmati Province in the west (DRFS, 2015).

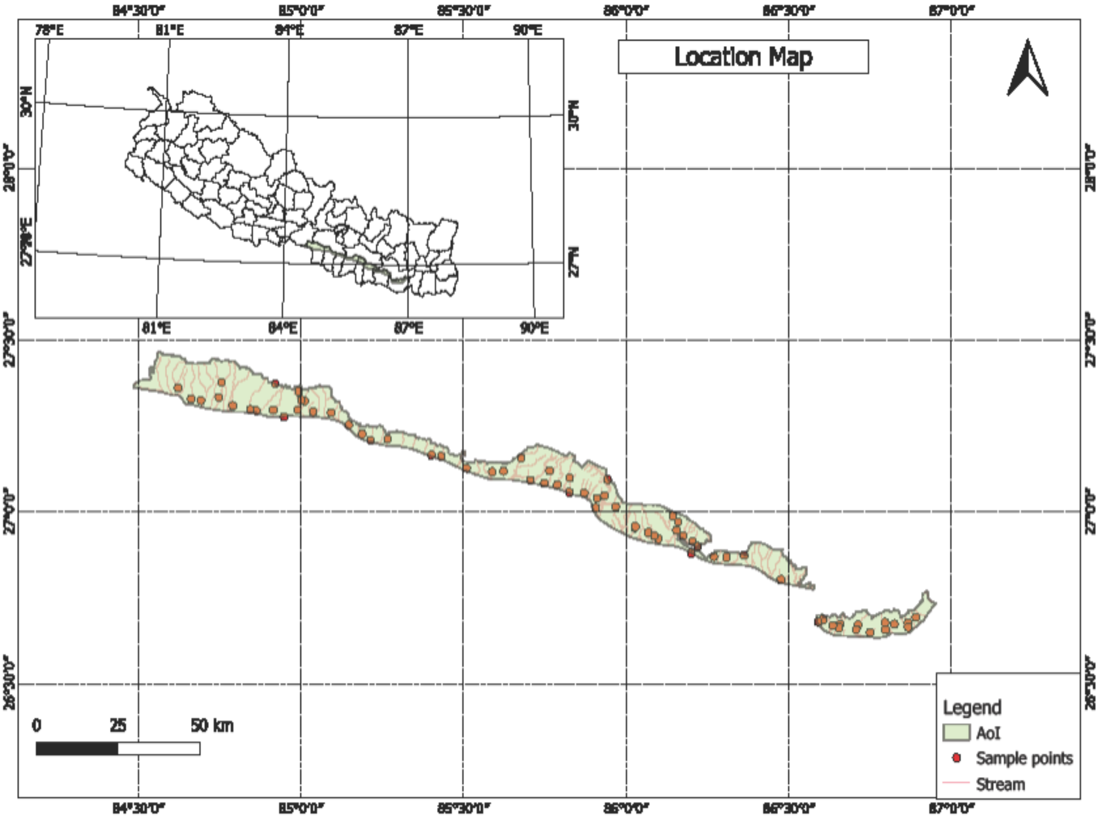


Figure 1: Chure region of Madhesh Province with sampling points

Topographically, the Province can be divided into four main regions starting from the North namely: (1) The Chure Region, (2) The valley basin or Dun (3) The Inner Tarai or the Bhavar region and (4) The Low plain region –Tarai. Chure region occupies 1, 52,339 ha (15.88%) of the total Province's area. This is a mountainous region far south to the high Himalayas, bordering the country in the north (GoN- RCTM, 2017). The Chure region is made up of soft and easily eroded sediments due to which gullies can be commonly seen. These hills were formed over the last 40 million years from the materials carried down as the Himalayas began to rise. It is considered fragile and geologically young areas that are made up of loose, unconsolidated substances that come from soft rocks like sandstone siltstone, shale and mudstone (Singh, 2017).

3.1.1 Climate

The highest average maximum temperature is found to be 34.84 ℃, with May being the hottest month, and the average minimum temperature is found to be 8.43 ℃, with January being the coldest one. June to September had the maximum rainfall with July being the rainiest month receiving 458.83 mm average precipitation (Figure 2).

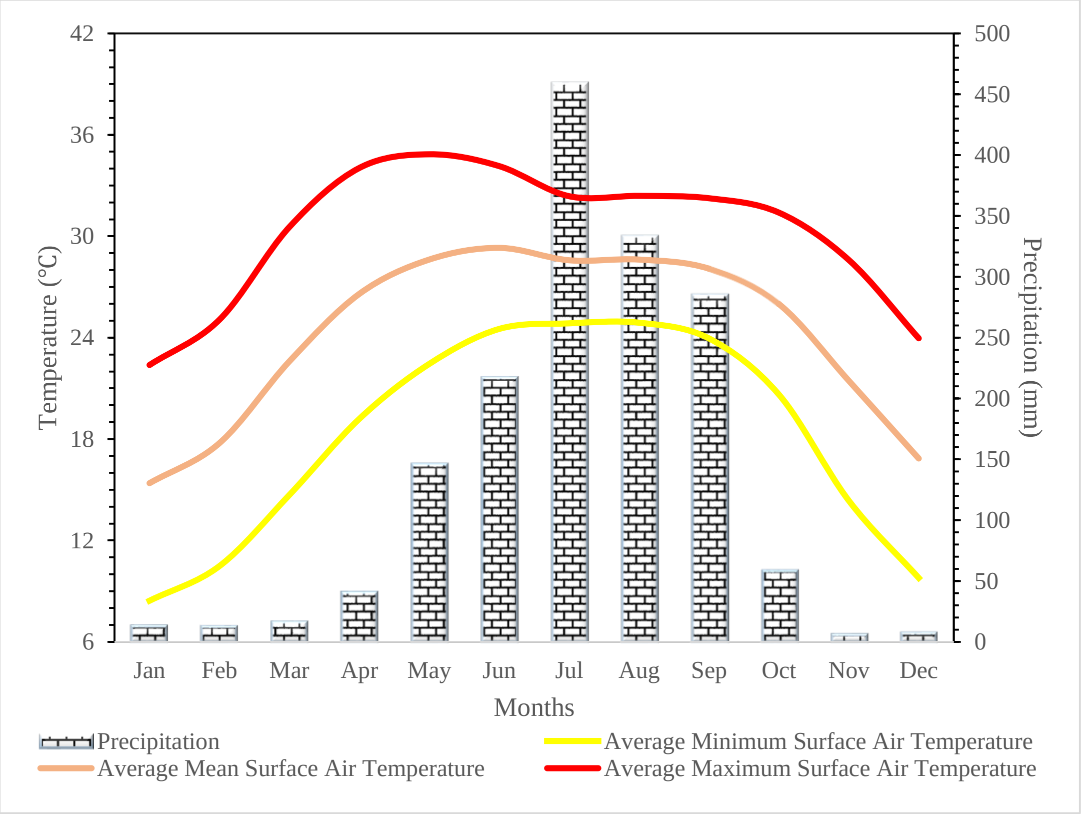
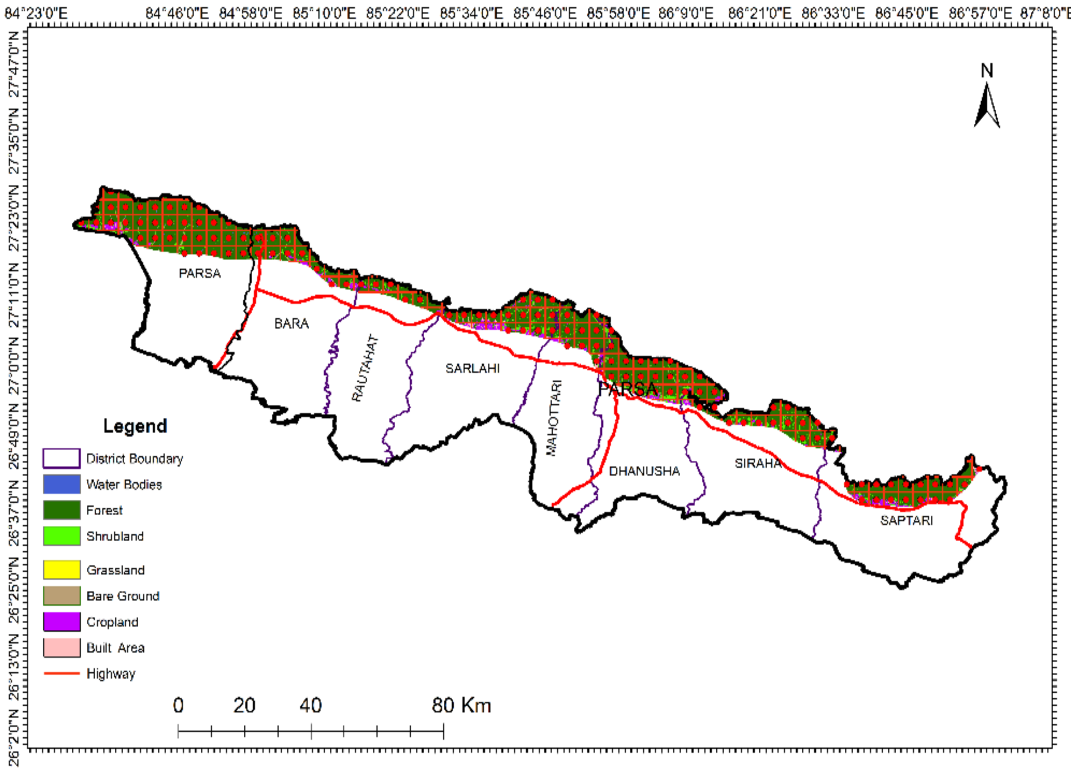
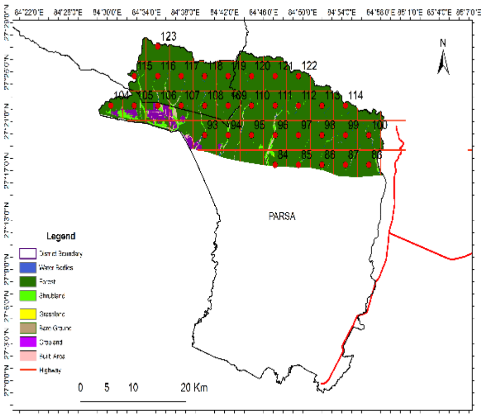


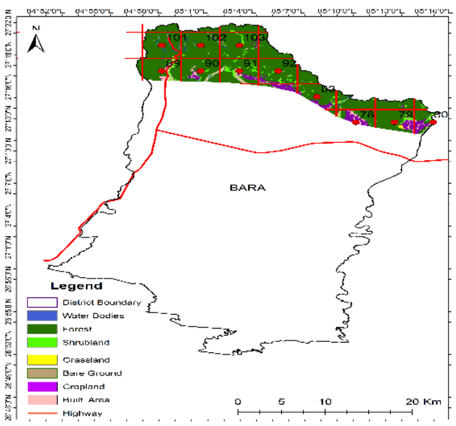
Figure 2: Average monthly temperature and precipitation of the past 30 years (1991-2022) AD (Data from the climate knowledge portal retrieved on January 25, 2025).

3.2 Sampling design

The two-phase systematic sampling was adopted. In the first- phase sampling, a 4 km × 4 km grid was super-imposed on a high-resolution Rapid Eye (5m × 5m) satellite image covering the entire country with the help of Google Earth images and topographic maps to create clusters (grid cells), each of which consisted of concentric circular sampling plot. The sampling plot in the clusters that lie in the Chure physiographic region was visually interpreted using standardized procedures (FRA Nepal, 2010). Those clusters and sub plots that falls in the Chure forest were only considered for sampling following the stratified systematic cluster sampling technique (Figure 3).







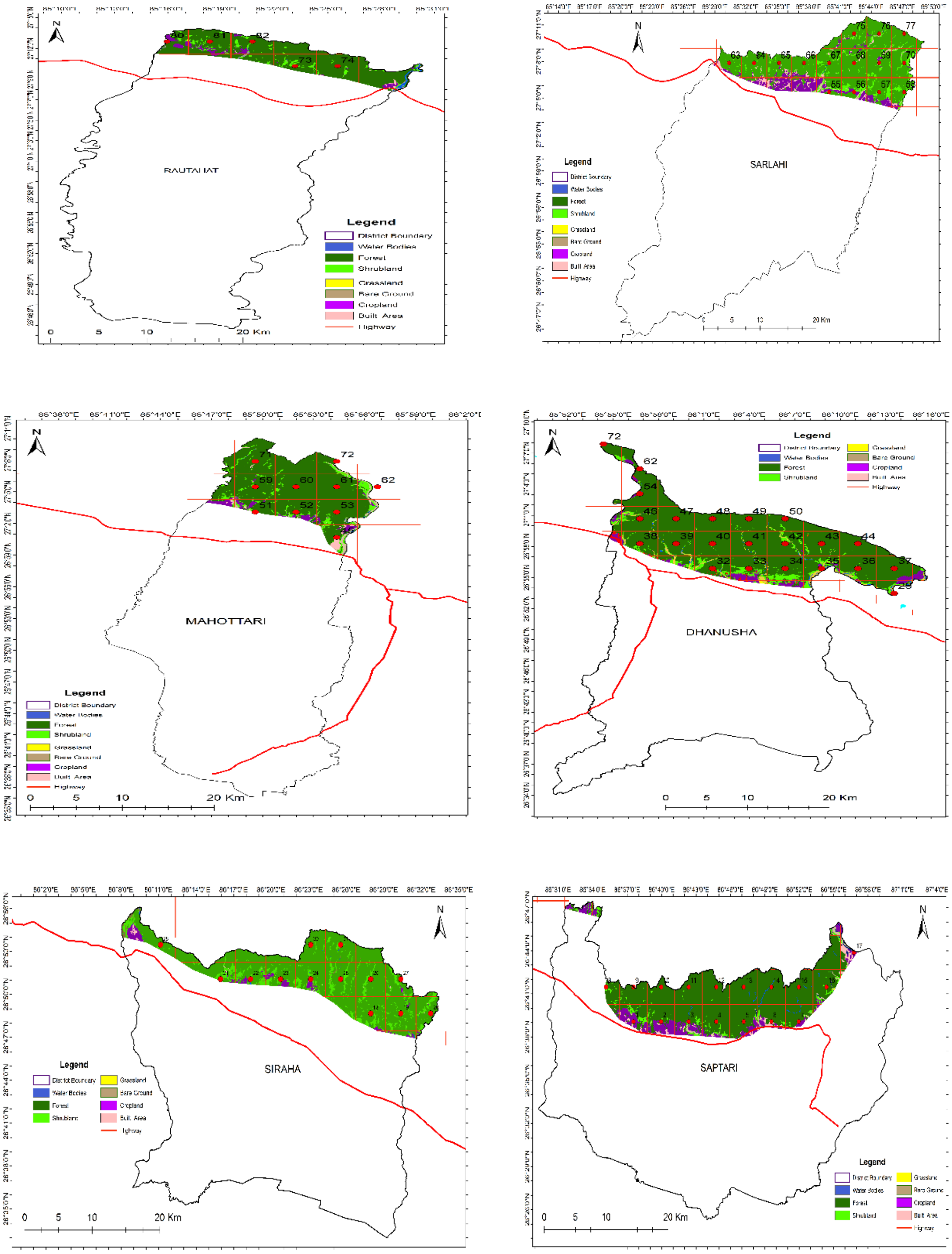


Figure 3: Sampling point in each 4km×4km grid cells in Chure region of each District of Madhesh Province

3.2.1 Sampling point

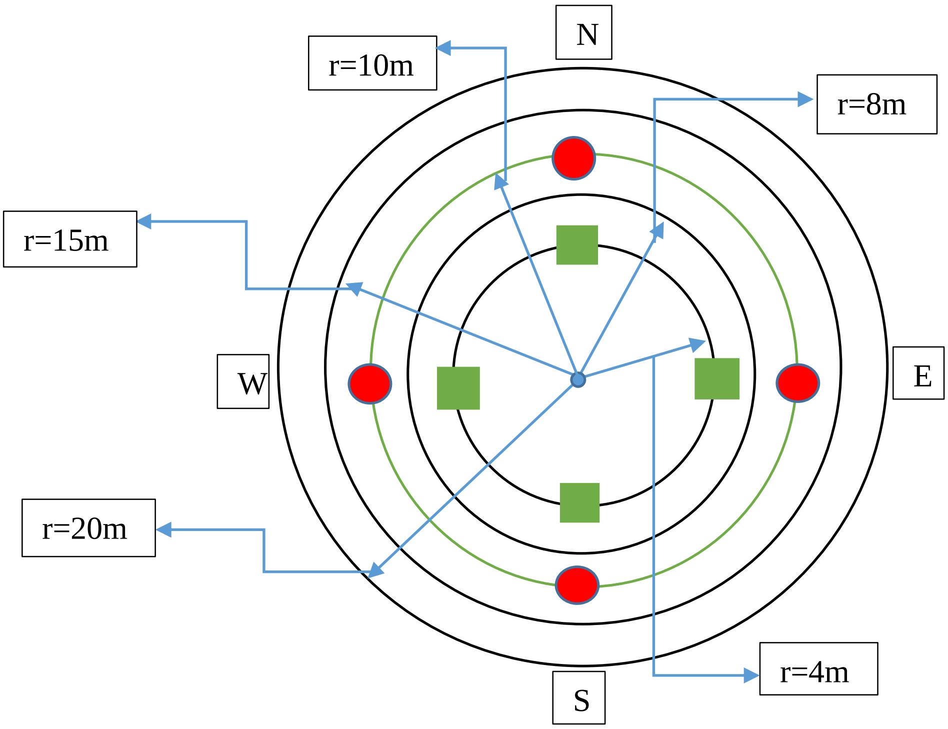


Figure 4: A concentric circular sampling plot (CCSP) design

In this study, a concentric circular sampling plot design was used to assess different vegetation categories based on their size and growth stage. Seedlings (SE) were sampled within a 1 m × 1 m square sub-plot, while saplings (SA) were assessed within a 2 m radius circular sub-plot. For trees, the sampling radius varied according to their diameter at breast height (DBH): trees with DBH < 10 cm were sampled within a 4 m radius, those with DBH between 10 cm and 20 cm within an 8 m radius, and trees with DBH ranging from 20 cm to 30 cm within a 15 m radius. Larger trees with DBH ≥ 30 cm were measured within a 20 m radius. Additionally, invasive alien plant species (IAPS) and cut stumps were recorded within the CCSP to account for disturbances (Figure 4). The height of the individual trees was determined using Clinometer, the diameter at breast height was measured by using DBH tape and the tree canopy was measured using Densiometer. Among 123 sampling points, a total of 69 points were sampled. Rest of the sampling points were skipped because some of the sampling points within the grid cells were present in the agricultural land and steep terrains. The sampling points that were distributed throughout the Chure forest of Madhesh Province is shown in Figure 3. The sampling was done within 24 days of intense field work starting form 5th of September to 16th of September in 2023, while the second field work was conducted from 8th of January to 19th of January, 2024.

3.3 Forest categorization

Three types of forests namely: Sal forest, Riverine forest and Mixed forest were categorized following DFRS (2014). *Shorea robusta* (Sal) forests were categorized based on basal area of *Shorea robusta* which is > 60% of the total basal area and associated with species like *Adina cordifolia*, *Terminalia chebula*, *Terminalia elliptica*, *Terminalia bellirica*, *Lagerstroemia parviflora* and *Schleichera oleosa*. Riverine forests were categorized based on the presence of species such as *Senegalia catechu*, *Bombax ceiba, Dalbergia sissoo, Croton persimilis, Holarrhena pubescens, Falconeria insignis* and *Terminalia anogeissiana* found on the riverbanks. Mixed forests were categorized based on the presence of species such as *Shorea robusta*, *Terminalia* species, *Lagerstroemia parviflora, Mallotus philippensis, Dillenia indica, Adina cordifolia*, *Schleichera oleosa* and *Kydia calycina*. The forests were classified into government forest, protected forest and community forest based on management regimes following Forests Act (2019).

3.4 Data analysis

The field data was used to calculate frequency, density, basal area and Importance Value Index (IVI) of plant species following the method described by Zobel et al. (1987).

3.4.1 Frequency and relative frequency

Frequency (F) simply means the number of sampling units where, a species occurs and it is represented in percentage. It also indicates the dispersion of species in a natural community. Frequency (F) was calculated using the following equation:

$$\text{Frequency (F)} = \frac{\text{Number of sampling units in which tree species occurred}}{\text{Total number of sampling units studied}} \times 100\%$$

The relative frequency (RF_r) is defined as the frequency of a particular individual species in relation to the total frequency of all the species occurred in that community. Relative frequency was calculated using the following equation:

$$\text{Relative frequency (RFr)} = \frac{\text{Frequency of individual tree species}}{\text{Total frequency of all tree species}} \times 100\%$$

3.4.2 Density and relative density

Density (D) simply means the number of individual species per unit area and it is the numerical strength of a species in a particular community. Density (D) was calculated using the following equation:

$$\text{Density (D)}=\frac{\text{Total number of individual tree species}}{\text{Total number of sampling units studied}\times\text{Area of a sampling unit}}$$

The relative density (RD) is defined as the density of a particular species in relation to the total density of all the species occurring in that community. Relative density (RD) was calculated using the following equation:

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

3.4.3 Basal area and relative basal area

Basal area (BA) simply means the ground area that is penetrated by the tree and it is regarded as a character that signifies the dominance of that tree species in a community. Basal area (BA) was calculated using the following formula:

$$\text{Basal area (BA)}=\frac{\pi d^2}{4}$$

Where,

d = diameter at breast height

The relative basal area (RBA) is defined as the basal area of a particular species in relation to the total basal area of all the species occurring in that community. Relative basal area (RBA) was calculated using the following equation:

$$\text{Relative basal area (RBA)}=\frac{\text{Basal area of individual tree species}}{\text{Total basal area of all tree species}}\times 100\%$$

3.4.4 Importance value index (IVI)

Importance value index (IVI) offers the overall importance of each species that resides in a community. It was calculated by the sum of relative values of frequency, density and basal area as indicated by the following formula:

$$\text{Importance value index (IVI)}=\text{RD (\%)}+\text{RF}_r\text{ (\%)}+\text{RBA (\%)}$$

3.4.5 Shannon-Wiener's diversity index

The Shannon-Wiener's diversity index is one of the frequently used methods for the estimation of species diversity. It considers both species richness and species evenness. Generally, the Shannon-Wiener's diversity index (H') is calculated using following equation (Shannon and Wiener, 1963):

$$\text{Shannon-Wiener's diversity index } (H') = -\sum P_i \times \ln P_i$$

Where,

P_i = proportion of the species

$P_i = n_i / N$

n_i = number of individual species

N = total number of species

3.4.6 Simpson diversity index

The Simpson diversity index was calculated using the following equation (Simpson, 1949):

$$\text{Simpson diversity index } (1\text{-D}) = 1 - \sum \{n_i \times (n_i - 1) / N\,(N - 1)\}$$

Where,

n_i = number of individual species

N = total number of species

The value of D ranges from 0 to 1, in which 0 represents the infinite diversity and 1 represents low diversity. In a community, if the value of D increases, the diversity decreases. Hence, Simpson's diversity index is expressed as 1-D.

3.4.7 Margalef's richness index

Margalef's richness index is the mean number of species per sample. Higher value indicates higher species richness and is calculated using the following equation (Margalef, 1958):

$$\text{Margalef's richness index} = \frac{S-1}{\ln(N)}$$

Where,

S = Tree species richness count

N = Total number of individuals

3.4.8 Regeneration

For seedlings and saplings, the number of each species was counted and converted in per hectare. All the trees were divided into different size classes based on Diameter at Breast Height (DBH) of 10 cm intervals. Then, the density of each species in the diameter class was converted to per hectare. Then, the following criteria were used to ascertain the status of regeneration of individual tree species (Shankar, 2001):

'Good' = if seedling > sapling > tree

'Fair' = if seedling > sapling ≤ tree

'Poor' = if a species survives in only the sapling stage but not as a seedling

'None' = if a species is absent in both sapling and seedling stages

'New' = if a species has no adults but only saplings or seedlings or both.

3.4.9 Disturbance

Disturbance level was assessed by calculating the disturbance index (DI), using the basal area of alive, fallen and cut trees (Murali et al., 1996).

$$(\text{DI }\%)= \frac{\text{Basal area (BA)of cut stumps}}{\text{Basal area (BA)(of alive tress+fallen trees+cut stumps)}}\times 100\%$$

The assessment of regeneration and disturbances status on the forest was done by adopting mixed approach of qualitative and quantitative method for calculating regeneration and disturbance scores within the CCSP. For this, the number of seedlings and saplings was counted from 1m × 1m sub- plot and 2 m radius sub-plots in North, South, East, and West direction respectively. The regeneration status of the forest was expressed with categorical variables, *i.e.*, low = 1 (less than 20 individuals of seedlings and saplings), moderate = 2 (greater than 20 and less than 60 individuals) and high = 3 (greater than 60 individuals) following the method described by Ballabha et al. (2013).

The disturbances like natural and human induced such as forest encroachment and deforestation were noted based on presence and absence of 14 evidences such as grazing, logging, dead trees, looping, animal activities, trail pass, fire, NTFP collection, landslide, resin tapping, litter collection, bush removal, plastic pollution and Invasive alien plant species (IAPS). Then, the disturbance scores were given from 0 to 4 as ‘0’ = no disturbance with no any evidences, ‘1’ = low disturbance with 1 evidence, ‘2’ = moderate disturbance with 2 evidences, ‘3’ = high disturbance with 3 evidences and ‘4’ = very high disturbance with greater than 3 evidences following the method described by DFRS (2014). Based on the obtained scores of regeneration and disturbance, the disturbed forests were identified.

3.4.10 Carbon stock

To estimate carbon stock, the above ground tree biomass (AGTB) was calculated by following an allometric equation method given by Chave et al. (2005). This allometric equation for biomass requires diameter at breast height (DBH) in cm, tree height in meter and specific wood density in g/cm^3 (Zanne et al., 2009).

The AGTB was calculated using the following allometric equation:

$$\text{AGTB}= \left(0.059 \times \text{Wood specific density} \times \text{DBH}^2 \times \text{H}\right)$$

Where,

DBH = Diameter at breast height (cm)

H = Height of tree (m)

Below ground tree biomass was calculated as 15% of the AGTB (Mac Dicken, 1997).

The total amount of carbon stored in the stem of a tree is its carbon stock and it was calculated by determining above ground tree biomass and below ground tree biomass at first. Then by adding them, the total tree biomass was calculated and by multiplying it with the carbon fraction 0.47 recommended by IPCC (2006) guideline, the total carbon stock for individual species was calculated.

$$\text{Total carbon stock (kg)} = \text{Total tree biomass of individual of a species} \times 0.47$$

$$\text{Total carbon stock (ton/ha)} = (\text{Total carbon stock (kg)} \times 0.001)/\text{Plot area (ha)}$$

3.4.11 Ordination

The ordination is used to summarize species composition pattern where similar species and samples are presented nearby while the dissimilar species and samples are presented farther away (Reft, 1980). Gauch (1982) explained that the main goal of ordination is to accurately capture and reflect the relationships between samples and species in a simplified low-dimensional space. According to Kent and Coker (1992), canonical correspondence analysis (CCA) is a direct gradient analysis that uses environmental data and samples which shows the variation of species data with respect to the contained environmental variables.

3.4.12 Plant collection, herbarium preparation and identification

During the field sampling, the plant specimens were collected only from the sampling points. Field notes containing date and time of collection, latitude, longitude, locality and elevation were noted. The most important characteristics of the vegetative and reproductive flower that are not possible to preserve after herbarium preparation such as; flower, color, smell of the flower, hair or trichomes, leaf character, fruit type etc. were also noted. Then, after the preparation of herbarium, the specimens were identified following standard literatures such as Flora of China (Wu et al., 2011), Flowering plants of Nepal-Vol. II (Rajbhandari et al., 2019), Flora of Bhutan (Grierson et al., 2001), and Plants of Nepal (Shrestha et al., 2022). Some specimens that couldn't be identified through standard literature and characters were identified with the help of experts and by comparing the herbarium specimens from Tribhuvan University Central Herbarium (TUCH) and National Herbarium and Plant Laboratories (KATH). The nomenclatures of the plants were adopted by following the online source database of Plants of the World Online (www.powo.science.kew.org).

3.4.13 Statistical data analysis

Shannon-Weiner's diversity index, Simpson diversity index, Margalef's richness index, Importance value index (IVI %) and Carbon stock were calculated in Microsoft excel, 2013. The IBM statistics SPSS version 25.0 and R version 4.3.3, R core team, 2024 were used to perform further analysis.

The ordination was performed to assess the species distribution relationship with disturbances and environmental variables. For this detrended correspondence analysis (DCA) was performed at first which gave the Eigen value (> 0.5) and axis length (>2.5). Thus, canonical correspondence analysis (CCA) was performed. Also, the data of plot wise Shannon- Weiner's diversity index, Simpson index and Disturbance index according to three forest management regimes were subjected to normality test, which revealed that the data was normally distributed, Shapiro-Wilk test ($p>0.05$). Therefore, a parametric test was performed *i.e.*, one-way ANOVA.

The carbon stock (ton/ha) data was also assessed for normality test using the Kolmogorov-Smirnov and Shapiro-Wilk tests for each forest type. For mixed forest, the result significantly deviated from the normality; Kolmogorov-Smirnov test ($p = 0.001$) and Shapiro-Wilk test ($p = 0.002$). Similarly, Sal Forest (SF) also deviated from normality; Kolmogorov-Smirnov test ($p = 0.045$) and Shapiro-Wilk test ($p = 0.002$). But, the Riverine forest had normal data; Kolmogorov-Smirnov test ($p = 0.200$) and Shapiro-Wilk test ($p = 0.864$). However, majority of the data was not normally distributed. So, non-parametric test was applied for further analysis.

The non- parametric Kruskal-Wallis H test showed statistically significant difference between the carbon stocks in three forest types, H = (14.978), df (2), $p = 0.001 > 0.05$. Therefore, post hoc Mann-Whitney U test with Bonferroni correction ($\alpha=0.0167$) was used to compare the forest types to identify the exact forest type that differed from other forest types in terms of carbon stock. Likewise, the carbon stock (ton/ha) data was assessed for normality test using the Kolmogorov-Smirnov and Shapiro-Wilk tests for each forest management regimes. Since the data was not normally distributed, the Kruskal-Wallis H test followed by the post hoc Mann-Whitney U test with Bonferroni correction were performed.

4 Results

4.1 Tree diversity

Altogether 67 tree species belonging to 57 genera and 29 families were enumerated from the study area (Figure 5). The most abundant species were from Fabaceae family with the highest number of tree species i.e., 12 that was followed by Malvaceae (5), Combretaceae (4), Rubiaceae (4) and Phyllanthaceae (4).

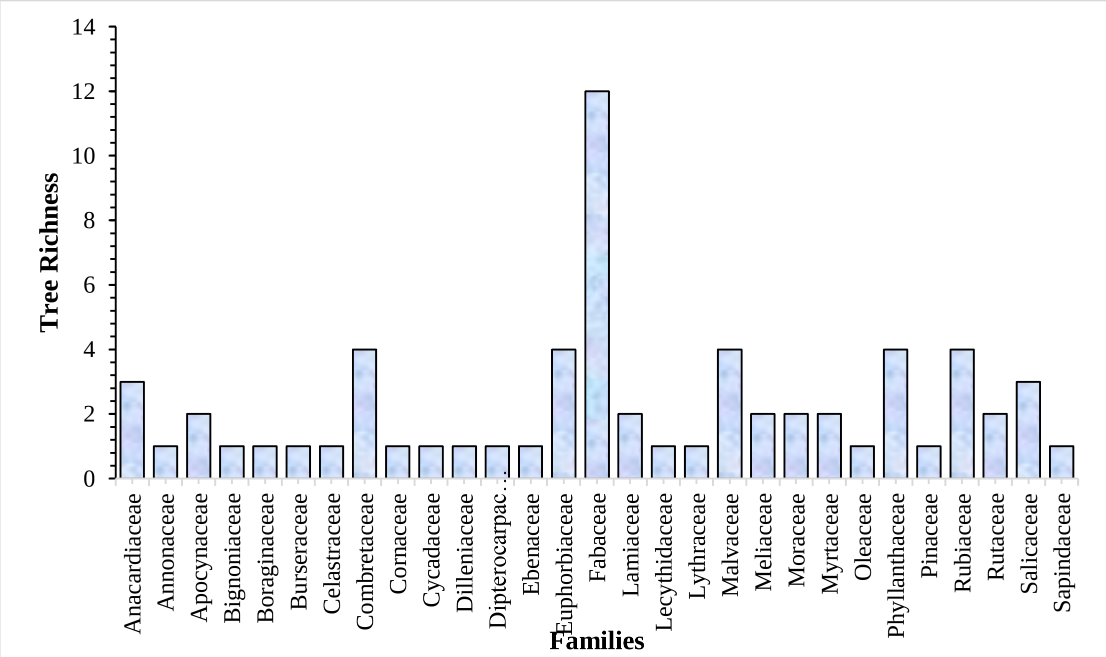


Figure 5: Tree richness with their respective family in the Chure region of Madhesh Province

The overall Shannon-Wiener's diversity index (H') of Chure region of Madhesh Province was high and found to be 3.0. Likewise, the overall Simpson diversity index (D) was found to be 0.89 and the overall Margalef's richness index was found to be 9.06. The Shannon-Wiener's diversity index in eight Districts of Chure region of Madhesh Province was found in the range of 1.12 to 2.91. This means, the highest diversity was found in Saptari District that is followed by Dhanusha, Parsa, Rautahat, Siraha, Bara, Sarlahi and Mahottari Districts respectively (Figure 6). The Simpson diversity index was in the range of 0.46 to 0.92 which suggested that, Saptari District had the highest diversity and Mahottari District with lowest diversity. The Margalef's richness index was in the range of 3.19 to 6.61 where, Saptari District had highest tree species richness that is followed by Dhanusha, Parsa, Bara, Siraha, Rautahat, Sarlahi and Mahottari Districts respectively.

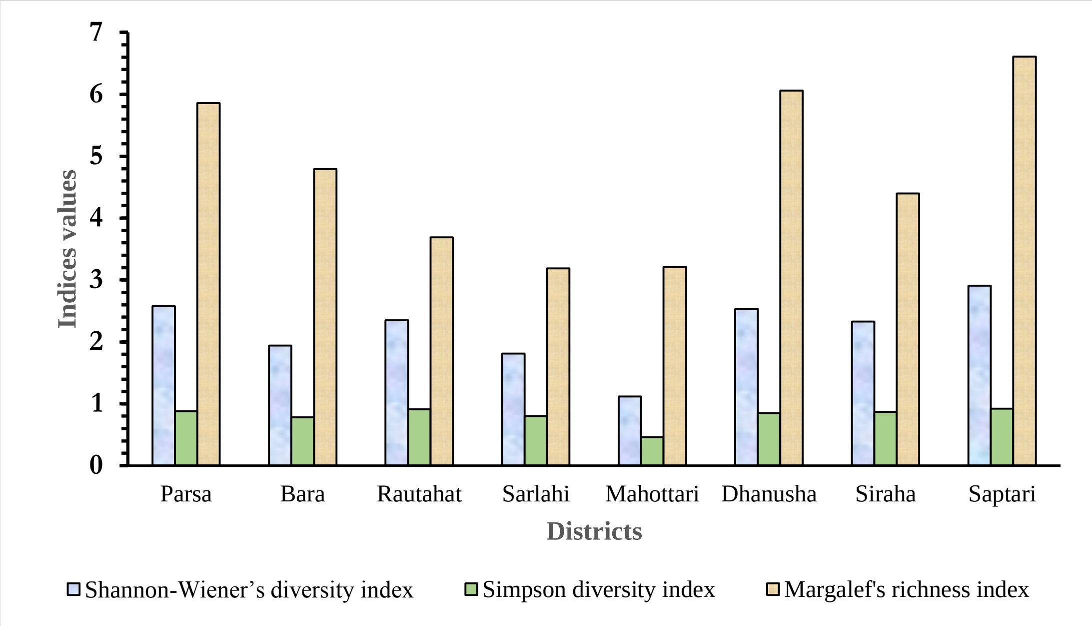


Figure 6: District wise diversity index and Margalef's richness index in the Chure region of Madhesh Province

The ordination included detrended correspondence analysis (DCA) with DCA1 axis Eigen value was > 0.5 and the axis length was >2.5 which indicated a strong gradient existence (Table 1).

Table 1: Detrended correspondence analysis (DCA) summary

DCA summary	**DCA1**	**DCA2**	**DCA3**	**DCA4**
Eigen values	**0.9457**	0.7313	0.5317	0.4598
Additive Eigen values	0.9457	0.7297	0.5247	0.4559
Decorana values	0.9846	0.738	0.622	0.5099
Axis lengths	**6.6356**	4.4883	3.5539	4.3123

Therefore, canonical correspondence analysis (CCA) ordination was performed to explore the relationship between tree species density, environmental variables and disturbances (Figure 7). The overall CCA model was statistically significant which indicates that the variation in the trees species density is collectively explained by existing environmental variables and disturbances.

Table 2: Canonical correspondence analysis (CCA) significance testing

Source	df	Chi-square	F	Pr(>F)
Model	10	2.5784	1.5194	**0.009 ****
Residual	58	9.8424		

The CCA ordination biplot revealed that highly disturbed forest area had *Shorea robusta, Syzygium nervosum, Syzygium cumini, Albizia odorattisima, Dalbergia latifolia* and *Semecarpus anacardium*. The tree species such as *Millettia glaucescens, Albizia lucida, Bombax ceiba, Alangium salviifolium*, and *Falconeria insignis* were riverine tree species that were abundantly distributed near water bodies. Tree canopy was a key environmental variable that shaped the community structure of *Aporosa octandra, Careya arborea, Garuga pinnata, Flacourtia jangomas* and *Piliostigma malabaricum*. In lower elevation, *Bombax ceiba, Cassia fistula,* Alangium salviifolium, *Mallotus philippensis and Azadirachta indica* were present as represented in CCA1 axis. Tree species such as *Piliostigma malabaricum, Falconeria jangomas, Aporosa octandra* and *Careya arboreya* were found abundantly in high tree canopy forest areas. Tree species such as *Senegalia catechu, Aegle marmelos, Terminalia anogeissiana, Bauhinia purpurea* and *Grewia eriocarpa* occurred in steep, fire prone areas that were far from the motorable road. Forest area with greater slope that were far from motorable roads were closely associated with fire as represented in CCA2 axis. These environmental variables and disturbance collectively shaped the community structure of tree species such as *Firmania fulgens, Bridelia retusa, Grewia eriocarpa, Terminalia anoegessiana, Buchaniana cochichinensis, Senegalia catechu, Aegle marmelos*, and *Bauhinia purpurea.*

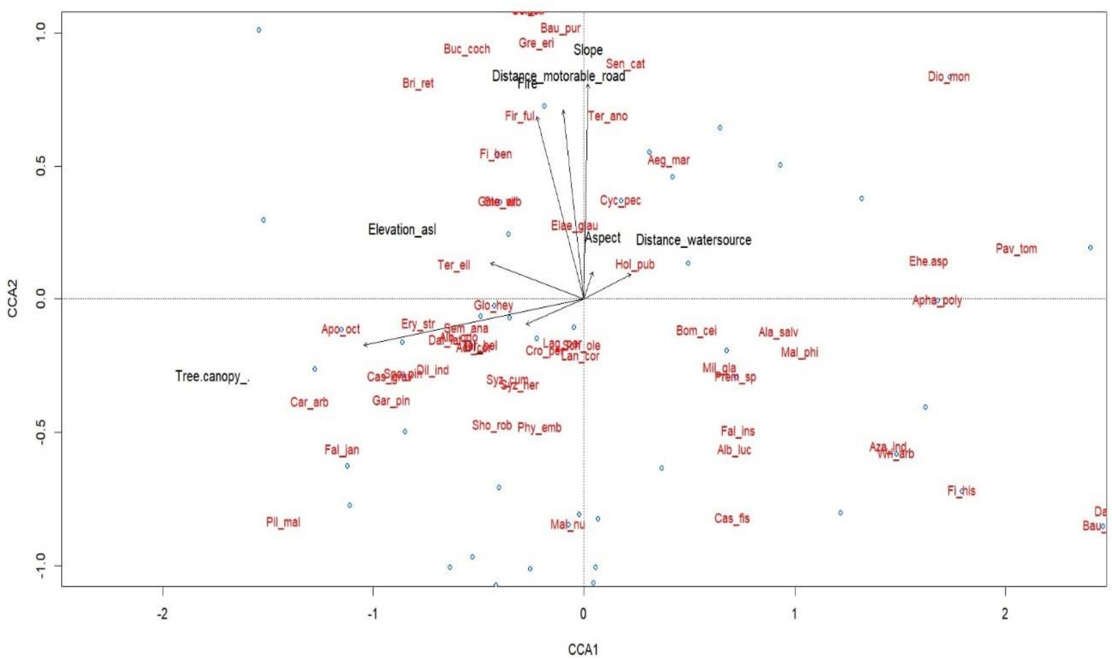


Figure 7: Canonical Correspondence Analysis biplot

The relative values of frequency, density and basal area (Figure 8) demonstrates the species with greater importance in the Chure region of Madhesh province. It showed that *Shorea robusta* C.F. Gaertn. was the most important species in the entire study area with highest IVI value of 80.63 % indicating its ecological dominance, followed by *Lagerstroemia parviflora* Roxb., *Mallotus philippensis* (Lam.) Müll.Arg.

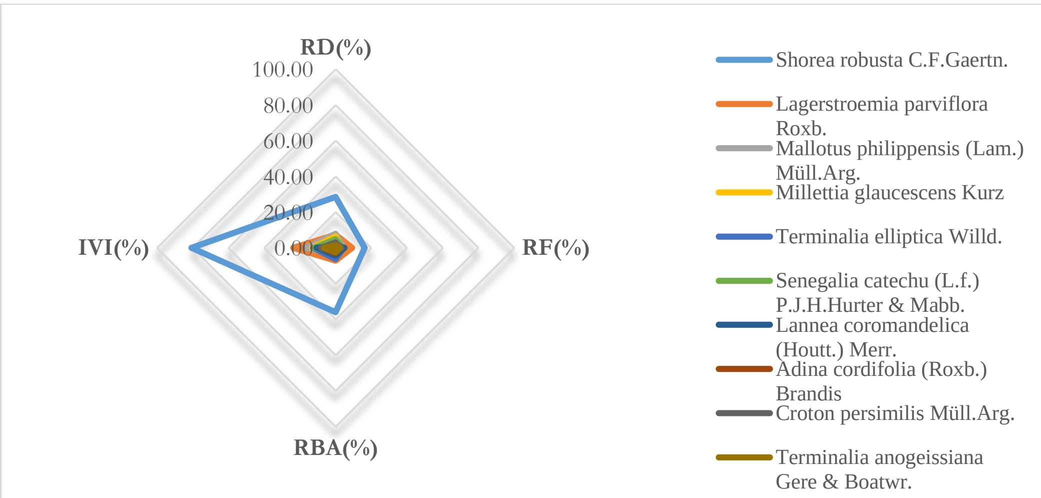
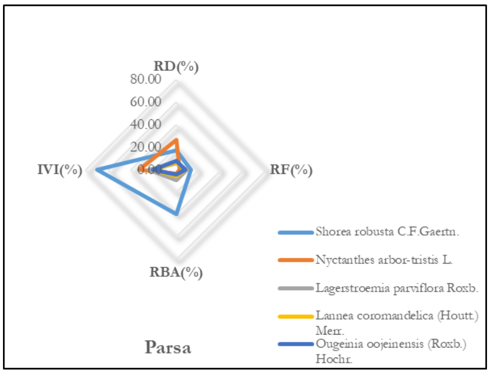
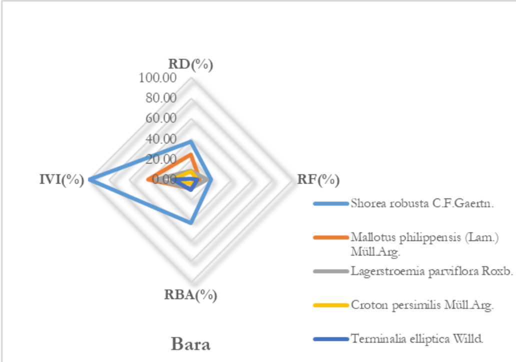
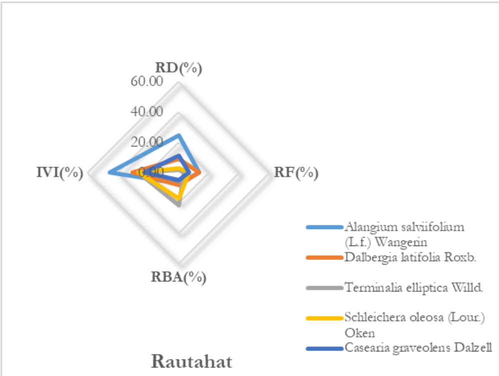


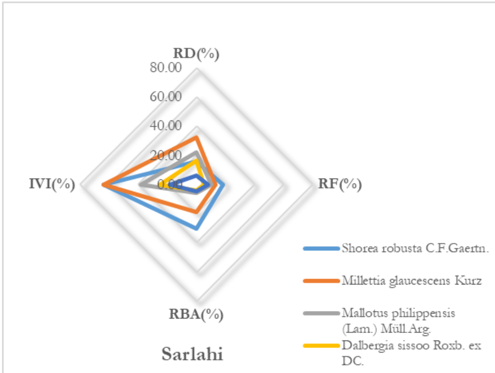
Figure 8: IVI (%) of ten important tree species with highest values in Chure region of Madhesh Province

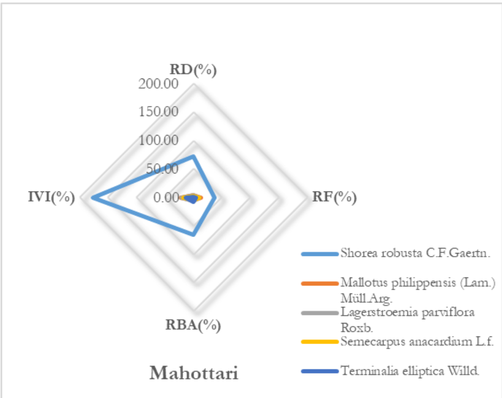
The importance value index (IVI) in Chure region of eight Districts in Madhesh province showed that, *Shorea robusta* had the highest IVI value in Parsa, Bara, Sarlahi, Mahottari, Dhanusha and Saptari Districts whereas, *Alangium salviifolium* (L.f.) Wangerin had the highest IVI value in Rautahat District and the *Senegalia catechu* (L.f.) P.J.H.Hurter & Mabb. in Siraha District. The tree species with the highest IVI values and other associated species had been plotted in IVI graphs of each District (Figure 9).

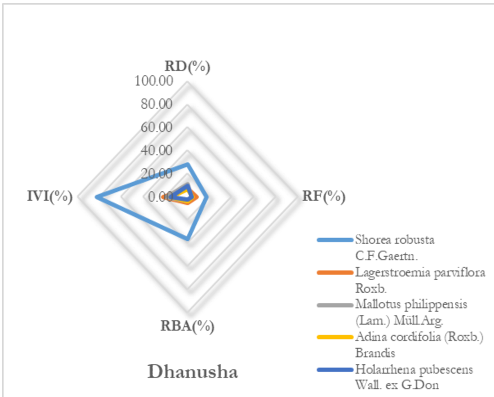


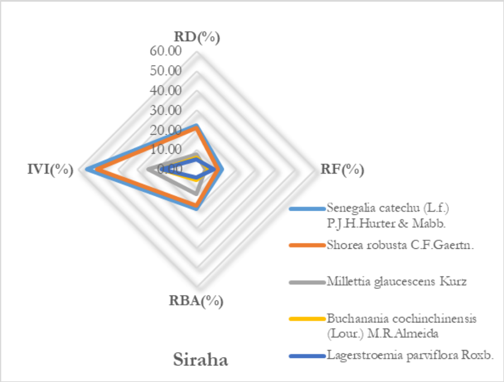












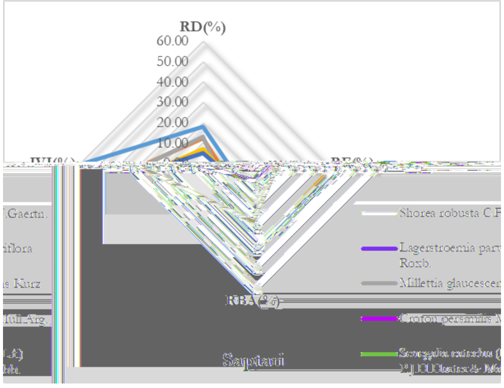


Figure 9: District wise IVI (%) in the Chure region of Madhesh Province

4.2 Regeneration

The overall regeneration status of the forest was 'Good' as indicated by SE/ha >SA/ha > Trees/ha (*i.e.*, 211014.4928 > 2766.805 > 856.9) respectively. A total of 1450 tree individuals were recorded with different DBH (cm) classes. These classes had the tree individuals from (more than10 cm to 140-145 cm) DBH. The highest tree individual per hectare was found in DBH class more than 10 cm and gradually decreases up to the DBH class of 140-145 cm reflecting an inverse J- shaped curve (Figure 10).

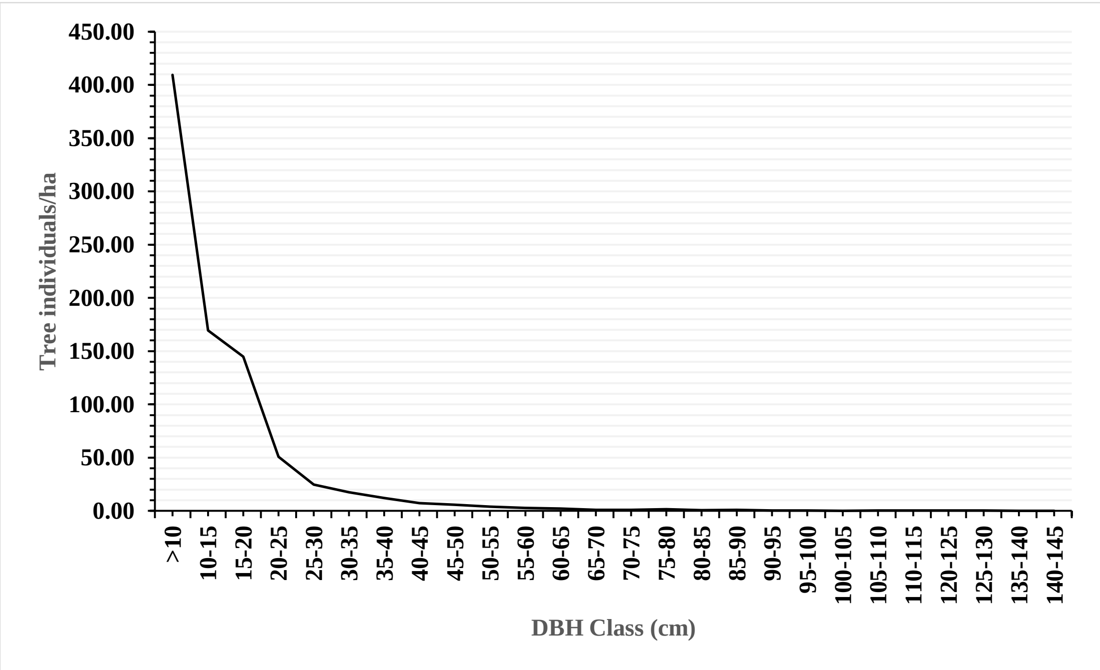


Figure 10: Inverse J-shaped distribution of tree individuals per hectare in different DBH classes

The 10 important species on the basis of IVI values were analyzed for their regeneration status by calculating seedlings (SE) individuals per hectare, saplings (SA) individuals per hectare and trees individuals per hectare (Table 3). The graphical representation of seedlings per hectare (SE/ha), saplings per hectare (SA/ha) and trees per hectare (Trees/ha) with regeneration status showed that the regeneration status was "Good" for seven species (*Shorea robusta*, *Lagerstroemia parviflora*, *Terminalia elliptica*, *Mallotus philippensis*, *Millettia glaucescens*, *Croton persimilis* and *Schleichera oleosa)* while "Fair" for 3 species *(Lannea coromandelica, Senegalia catechu* and *Adina cordifolia).*

Table 3: Regeneration status of ten important tree species

Tree species	**SE/ha**	**SA/ha**	**Trees/ha**	**Regeneration status**
Shorea robusta C.F.Gaertn.	6421	1003	248	Good
Lagerstroemia parviflora Roxb.	311	202	65	Good
Terminalia elliptica Willd.	231	150	16	Good
Mallotus philippensis (Lam.) Müll.Arg.	836	294	70	Good
Lannea coromandelica (Houtt.) Merr.	17	6	11	Fair
Millettia glaucescens Kurz	173	124	56	Good
Senegalia catechu (L.f.) P.J.H.Hurter & Mabb.	84	20	43	Fair
Adina cordifolia (Roxb.) Brandis	32	0	22	Fair
Croton persimilis Müll.Arg.	2591	392	27	Good
Schleichera oleosa (Lour.) Oken	236	43	4	Good

4.3 Disturbance

The assessment of disturbance levels in three forest types (Figure 11) showed that regeneration was moderate with scores ranged from 2 to 3 in all three forest types but riverine forest was the most threatened forest type with lowest regeneration score ranging from 2 to 2.5 and highest disturbance score ranging from 3 to 3.5, that was followed by Sal forest and mixed forest with disturbance score ranging from 2.5 to 3.

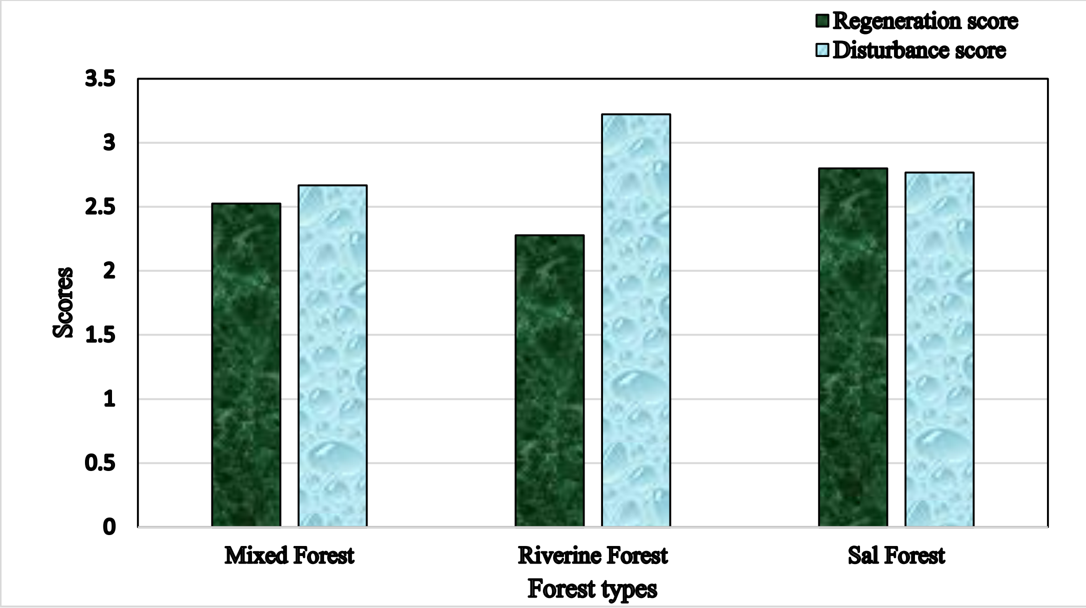


Figure 11: Regeneration and disturbance score in three forest types

Similarly, the assessment on disturbance levels in three forest management regimes (Figure 12) showed that the regeneration was moderate in all three forest management regimes ranging from 2.5 to 3, but the government forest had experienced greater disturbance impact with disturbance score ranging from 3 to 3.5, followed by community managed forest with disturbance score 3 and protected forest had experienced minimal disturbance impact with disturbance score 1.5.

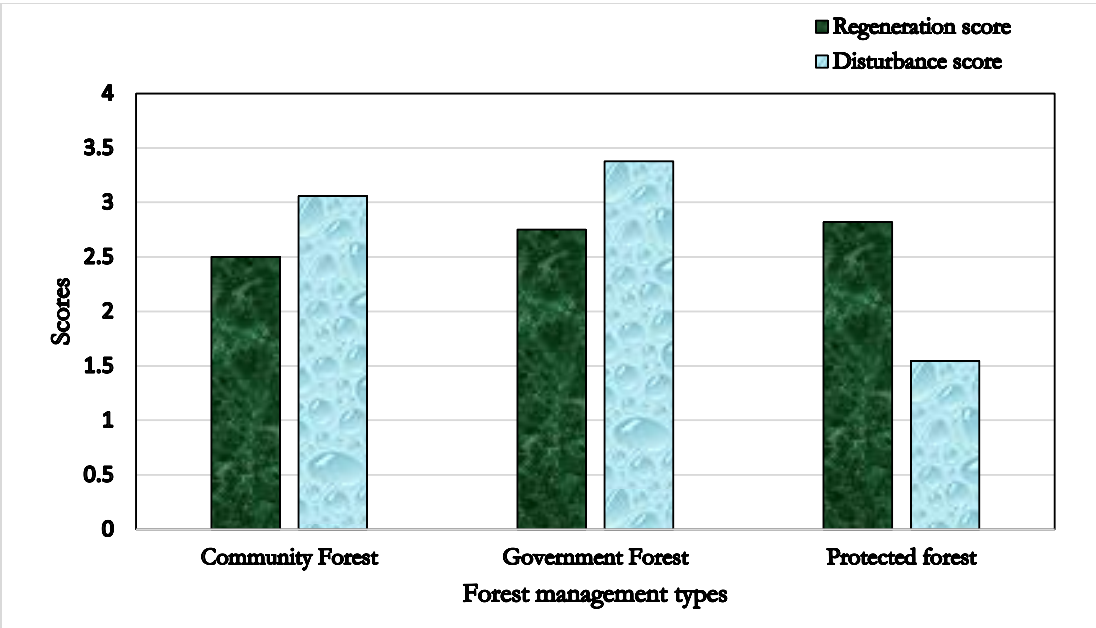


Figure 12: Regeneration and disturbance score in three forest management regimes

The one way ANOVA (Table 4) was performed for Shannon-Weiner’s diversity index, Simpson diversity index and the disturbance index (DI %) which revealed that disturbance significantly exerted its impact on tree species diversity.

Table 4: One-way ANOVA between the diversity indices and the disturbance index

One-way ANOVA							
Diversity indices		Sum of Squares	df	Mean Square	F	Sig.	Result
Shannon-Weiner's diversity index	Between CF, NF & PNP	2.04	2	1.02	2.91	0.061	Near significant
	Within CF, NF & PNP	23.16	66	0.351			
	Total	25.21	68				
Simpson diversity index	Between CF, NF & PNP	0.37	2	0.19	2.66	0.077	Near significant
	Within CF, NF & PNP	4.66	66	0.071			
	Total	5.044	68				
DI (%)	Between CF, NF & PNP	340.32	2	170.16	3.21	**0.047^{**}**	Highly significant
	Within CF, NF & PNP	3494.26	66	52.94			
	Total	3834.59	68				

The descriptive summary revealed that the Shannon-Weiner’s diversity of tree species was found to be highest in PNP, followed by NF and CF. Likewise, the Simpson diversity of trees was found to be highest in CF, followed by NF and PNP. The disturbance index was found highest in NF followed by CF and PNP (Table 5).

Table 5: Descriptive summary on diversity indices and disturbance index

Descriptive summary							
Diversity indices	**Forest Management regimes**	**N**	**Mean**	**Std. Deviation**	**Std. Error**	**95% Confidence Interval for Mean**	
						Lower Bound	Upper Bound
Shannon weiner's diversity index	CF	50	**1.04**	0.64	0.09	0.86	1.23
	NF	8	**1.33**	0.32	0.11	1.06	1.60
	PNP	11	**1.48**	0.46	0.14	1.18	1.79
	Total	69	1.15	0.61	0.07	1.00	1.29
Simpson diversity index	CF	50	**0.50**	0.30	0.04	0.41	0.58
	NF	8	**0.36**	0.14	0.05	0.24	0.48
	PNP	11	**0.32**	0.15	0.05	0.21	0.42
	Total	69	0.45	0.27	0.03	0.39	0.52
DI (%)	CF	50	4.67	6.72	0.95	2.76	6.58
	NF	8	**9.15**	13.35	4.72	-2.01	20.31
	PNP	11	0.62	1.78	0.54	-0.58	1.81
	Total	69	4.54	7.51	0.90	2.74	6.35

4.4 Carbon stock

The average carbon stock was found to be 127.76 ton/ha in the Chure region of Madhesh Province. Among the three forest types, the carbon stock was found to be highest in Sal forest *i.e.,* average 161.39 ton/ha, which was followed by Mixed forest *i.e.*, average 131.227 ton/ha and Riverine forest *i.e*., average 67.66 ton/ha. Among the three forest management regimes, the protected forest (PNP) had the highest carbon stock *i.e.,* average 228.42 ton/ha which was followed by community forest (CF) *i.e.,* 109.74 ton/ha and government forest (NF) *i.e.,* average 101.98 ton/ha (Figure 13).

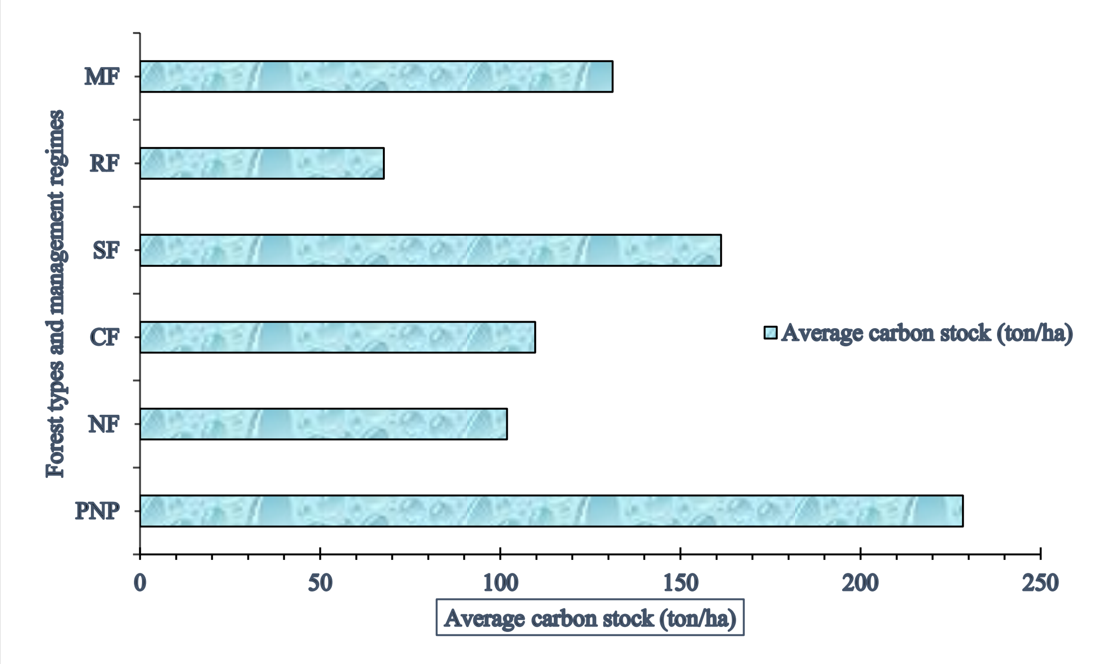


Figure 13: Average carbon stock in three forest types and management regimes in the Chure region of Madhesh Province

This Kruskal-Wallis H test showed that there is a statistically significant difference between the carbon stocks in three forest types, H = (14.978), df (2), $p = 0.001 < 0.05$. Therefore, post hoc Mann-Whitney U test was used to compare the forest types to identify the exact forest type that differ.

Table 6: Pair wise comparisons using the Post-hoc Mann-Whitney U test with Bonferroni correction (adjusted $\alpha = 0.0167$): C-stock vs. Forest types

Pairwise Comparison between forest types	Mann-Whitney U: Carbon stock (ton/ha)	p-value	Bonferroni-Corrected α	Significance after Bonferroni (2-tailed) p-value
MF vs RF	133	0.115	0.0167	0.115
MF vs SF	223	0.078	0.0167	0.078
RF vs SF	81	0.001	0.0167	**0.001 < 0.0167***

In the first comparison between Mixed forest (MF) and Riverine forest (RF), no significant difference was found (U = 133.000, Z = -1.578, $p = 0.115 > 0.0167$) suggesting similar carbon storage capacities. The second comparison, between Mixed forest (MF) and Sal forest (SF), also showed no statistically significant difference at 0.05 level, but indicated an increasing trend (U = 223.000, Z = -1.761, p = 0.078 >

0.0167). However, the third comparison between Riverine forest (RF) and Sal forest (SF), showed a highly significant difference in carbon stocks (U = 81.000, Z = -4.025, p < 0.0167), suggesting that the carbon stock was highest in SF and lowest in RF.

This Kruskal-Wallis H test showed that there is a statistically significant difference between the carbon stocks in three forest management regimes, H= 9.728, df (2), p=0.008 < 0.05. Therefore, post hoc Mann-Whitney U test was used to compare the forest management regimes to identify the exact forest management regime that differ.

Table 7: Pair wise comparisons using the Post-hoc Mann-Whitney U test with Bonferroni correction (adjusted α = 0.0167): C-stock vs. Forest management regimes

Pairwise Comparison between forest management regimes	**Mann-Whitney U: Carbon stock (ton/ha)**	**p-value**	**Bonferroni-Corrected α**	**Significance after Bonferroni (2-tailed) p-value**
CF vs NF	191	0.839	0.0167	0.839
PNP vs CF	111	0.002	0.0167	**0.002 < 0.0167***
NF vs PNP	18	0.032	0.0167	0.032

In the first comparison between community forest (CF) and government forest (NF), no significant difference was found (U = 191, Z = -0.203, p = 0.839 > 0.0167) even after the Bonferroni correction (adjusted α = 0.0167), suggesting similar carbon storage capacity. The second comparison between protected forest (PNP) and community forest (CF), showed statistically significant difference at 0.05 level (U = 111, Z = -3.077, p = 0.002 < 0.0167) after the correction. But, the third comparison between government forest (NF) and protected forest (PNP), didn’t show statistically significant difference in carbon stock (U = 18, Z = -2.147, p = 0.032 > 0.0167) suggesting the similar carbon storage capacity. These results suggest that the forest management regimes influence carbon stock, with PNP differing in carbon stock in comparison to CF and NF.

5 Discussion

5.1 Tree diversity

The Chure region of Madhesh Province covers only a portion of Nepal's Chure and also the Chure in this part is considered disturbed but still the number of trees is high. This could be caused by both geographic factors and the structure of the forest. According to Press et al. (2000), there were 281 tree species in the whole Chure region of Nepal and 164 tree species are found in the Bhavar and Tarai Madhesh region (FRA/DFRS, 2014) out of which, 67 tree species were found inside the sampling plots of this study. The most abundant family was Fabaceae with 12 tree species (Figure 5). The tropical rain forest has Fabaceae family with other dicot families such as Melastomataceae and Myrtaceae (Ghazoul & Sheil, 2010) and tropical dry forests also features Fabaceae as the dominant family (Gillespie et al., 2000). The ecto-mycorrhizal associations might be the reason for the abundance of this family, since in the plant microbe interactions, the carbon fixed by the plants are transferred to the heterotrophic fungus which in turn increases root surface area for the absorption of Nitrogen, Phosphorus, Potassium, Calcium and other ions that are limited in the tropical soils (Gallery, 2014). Previous studies done in the tropical forests of Nepal has also reported the presence of Fabaceae family as the dominant family along with Rubiaceae, Malvaceae, Phyllanthaceae, Moraceae and Dipterocarpaceae (Sharma et al., 2025).

The species diversity is considered a most commonly used approach in measuring the ecological diversity that is assessed through diversity indices and species richness (Goncalves et al., 2017). The study area had high tree species diversity as indicated by Shannon-Wiener's diversity index *i.e.,* 3.0 and Simpson diversity index *i.e.,* 0.89 and had species richness *i.e.,* 9.06 indicating great species richness in the study area. In the present study, the diversity of trees is comparable to other tropical forests around the world. The Shannon-Weiner's diversity index of Tropical wet forest in Western Ghats of India had 2.01-3.7 (Swamy et al., 2010), Tropical wet evergreen forest of Bangladesh had 3.37 (Feroz et al., 2013), Tropical dry evergreen forest of India had 1.24-2.2 (Pragasan and Parthasarathy, 2010), and Tropical moist forest of eastern Nepal had 3.08 (Gautam and Mandal, 2016d). This difference in diversity might've been attributed by climatic suitability as the study area has tropical and sub-tropical bioclimatic regions (Chaudhary and Subedi, 2019; Uprety et al., 2023), more water availability and greater levels of soil organic matter and nitrogen content (Ghimire et al., 2018). The structure and density of plant communities are greatly influenced by water availability for plants (Kuntiel and Lavee, 1999), which could be the cause of the greater diversity of tree species. In general, highest diversity has been recorded in broad leaved forest (Peng et al., 2012) and the study area had forest stands of having broad leaves as well (Miehe et al., 2015).

Upon inspecting the Shannon-Weiner's diversity index values in the Chure forests of eight individual Districts, the Parsa District exhibited moderate tree diversity (2.59) which is in reference to Magurran's (2004) classification, that might be due to sustainable forest management practices as all the plots were under the national park management. Rautahat (2.36), Dhanusha (2.53), Siraha (2.33) and Saptari (2.91) Districts also had moderate tree diversity which might be due to the successful community forest management strategy. The sustainable management practices adopted by community forest management approach and preservation of plants residing under national park applies sustainable land management methods and practices that are favorable for regional bio-physical and socio-economic conditions focused on management, conservation and sustainable use of natural resources (Raison et al., 2001). Also, some of the samplings plots were inside the buffer zone of Parsa national park and being the protected area itself, human interventions are limited due to stricter regulations that might have caused higher diversity in Parsa District and similar type of result was reported by Uprety et al. (2025) in the buffer zones of western Tarai arc landscape of Nepal. Likewise, Bara (1.94), Sarlahi (1.82) and Mahottari (1.13) Districts had low tree diversity which is also in reference to Magurran's (2004) classification, which might be due to high disturbances in riverine forests and governement forests. Also, the forests that were currently under community forest management in these Districts might've been exploited heavenly in the past when these forests were government forests.

The Margalef's richness index value 9.06 showed that the study area had varieties of tree species. It is comparable to the species richness found in the tropical wet evergreen forests of Western Ghats, India *i.e.,* 7.9-12.7 (Swamy et al., 2010). The species richness of this study is similar to the findings of Gautam and Mandal, (2016d) in the moist tropical forest of eastern Nepal with species richness of 6.78-9.11. The species richness of this study is quite higher when compared to the matured Plateau Sal forest of eastern

Siwaliks, Nepal *i.e.*, 1.57 (Mandal, 1999). The high species richness might be due to higher soil moisture contents as well as nutrient contents (Kuntiel and Lavee, 1999; Ghimire et al., 2018). This higher species richness might be attributed to higher annual precipitation as well. Some of the previous studies done by DFRS (2015); Chapagai et al. (2021) however, found that the diversity and richness both are low in Sal dominated forests as the forest floor contains acidic to neutral soil with low carbon content of 0.11% to 1.8%.

The CCA ordination biplot (Figure 7) revealed that *Shorea robusta*, *Syzygium nervosum, Syzygium cumini*, *Dalbergia latifolia* and *Semecarpus anacardium* were found in highly disturbed forest area as these tree species are widely used for timber production (Webb 2003). Therefore, these tree species should be focused on protection in the Chure region of Madhesh Province. The tree species such as *Millettia glaucescens*, *Albizia lucida*, *Bombax ceiba*, *Alangium salviifolium*, *Mallotus philippensis* and *Falconeria insignis* were riverine tree species that were abundantly distributed near water bodies and it is also previously reported by DFRS (2014). Tree canopy was a key environmental variable that shaped the community structure of *Aporosa octandra*, *Careya arborea*, *Flacourtia jangomas* and *Piliostigma malabaricum*. These tree species were found abundantly in high tree canopy forest areas. Tree species such as *Firmania fulgens, Bridelia retusa, Grewia eriocarpa, Terminalia anoegessiana, Buchaniana cochichinensis, Senegalia catechu*, *Aegle marmelos*, and *Bauhinia purpurea* occurred in steep, fire prone areas that were far from the motorable road.

The IVI (%) value signifies the ecological succession and dominance of any species with single value. The species with highest IVI is considered the dominant in a community (Razali et al., 2014). In this study, *Shorea robusta* had the highest IVI (%) value followed by other species like *Lagerstroemia parviflora*, *Terminalia elliptica* (Figure 8) which is supported by previous studies done in tropical forests of Nepal (Pokhrel et al., 2024; Ayer et al., 2024; Khadka et al., 2024). The reason for its dominance might be due to the availability and suitability of micro-climatic condition that favors the rapid growth and regeneration of its seedlings. Various studies have found that the climatic suitability for *S. robusta* seedlings growth is the increasing day length and temperature which induces leafing and flowering of *S. robusta* (Kumar and Chopra, 2018) and such kind of climatic condition is well suited and found in the study area that might have led to single tree species dominance. Also, due to the sharing of great portion of resources by few species only (Swamy et al., 2010) might've caused the dominance of *S. robusta*. It is able to re-sprout vigorously from root suckers after a short period of disturbances (Gautam and Devoe, 2006; Sapkota et al., 2009). It has been more vigorous in growth than other competitors with its tolerance to forest fires and other factors through the die-back mechanism (Champion and Seth, 1968). Also, due to high light demanding nature of Sal, disturbance mediated light availability promotes its seedling recruitment process (Sapkota et al., 2009). Repeated harvesting of fodder and fuel- wood species, on the other hand, results in single species dominance in the forest (Sapkota et al., 2010). Moreover, the restriction and prohibitions led by the policies on cutting down the threatened timber species might also have led to its dominance.

Due to increasing clearance of trees from the forest, many gaps might have been created which facilitated light penetration onto the forest floor that influenced the sprouting of *S. robusta* seedlings with many other tree species seedlings and this might be the cause of greater tree species diversity and richness in the study area. Barik et al. (1992) also stated that the tree species diversity and richness varies in the gapped areas due to the availability of light and moisture regimes which influences in the sprouting of different shade tolerant species in the forest that affects the overall diversity of the forests. Sal trees provides multiple resources to people to support their daily livelihood such as timbers, resin, leaves for plates and thatching due to which, focused active management efforts to such valuable plant might have led to its dominant status in the forest ecosystem. Also, *Shorea robusta* is a protected tree species in Nepal and this might have caused it to experience low human disturbances such as cutting and felling, in the forests (Paudyal, 2016).

The Rautahat District had *Alangium salviifolium* and Siraha District had *Senegalia catechu* as the dominant species whereas Parsa, Bara, Sarlahi, Mahottari, Dhanusha and Saptari had *Shorea robusta* as the dominant species (Figure 9). *Alangium salvifolium* is a riverine forest component (Jain, 2005) and its well adaptive characteristics in such disturbed habitat might attributed its dominance in that region. On the other hand, the *Senegalia catechu* dominance in Siraha District might be due to the successful conservation of IUCN threatened tree species (Plummer, 2021). The restriction on transport, use and trade of such species might have facilitated to increase the dominance of this species in Siraha District.

5.2 Regeneration

The present study showed good regeneration status since the seedlings per hectare > saplings per hectare > trees per hectare. The result showed a high number of individuals in the lower DBH class and low number of individuals in the upper DBH class which is similar to the findings of Khamyong et al. (2003); Chauhan et al. (2008); Poudel and Devkota (2021); Joshi et al. (2021). High number of individuals in lower DBH class indicates good regenerating forest (Sarkar and Devi, 2014). The inverse J- shaped regeneration pattern of tree species indicates good regenerating forests exist in the study area (Figure 10). A similar pattern of regeneration was found by Uprety et al. (2025) in western Tarai arc landscape. This type of regeneration ensures the proper resource utilization, long term carbon storage and biodiversity sustainability (Li et al., 2024; Uprety et al., 2025).

Regeneration of tree species (Table 3) is affected by various factors that include species behavior, micro-climatic conditions, and edaphic factors (Scholl and Taylor, 2006). In the present study, the regeneration of *Shorea robusta, Lagerstroemia parviflora, Terminalia elliptica, Mallotus philippensis, Millettia glaucescens, Croton persimilis* and *Schleichera oleosa* was ‘Good’ as indicated by the number of seedlings (SE) > saplings (SA) > trees per hectare. Other tree species *Lannea coromandelica, Senegalia catechu* and *Adina cordifolia* had ‘Fair’ regeneration as indicated by saplings (SA) > seedlings (SE) > trees per hectare.

There are multiple factors that affects the plant regeneration in the forest including seed germination, survival and establishment of seedlings (Muller- dombios et al., 1980). Even after the successful establishment of seedlings, there exists a competition for nutrients and space between the seedlings as well as other sub canopy species, herbs as well as shrubs (Lorimer et al., 1994), which also affects the regeneration of plant species in the forest. Napit (2005) stated that the viability of seeds and its dispersal, reproductive and vegetative growth also affects plant regeneration in the forests. Manna and Mishra (2017) found that the reason for low regeneration in a forest with low number of seedlings in comparison to saplings and trees occurs due to low productivity of the forest, human disturbances and unfavorable environmental conditions. However, the forest of the Chure region of Madhesh Province had 'Good' and 'Fair' regeneration status of tree species that were assessed**.** This might be due to current forest management practices and people's awareness as well.

Uprety et al. (2023) and DFRS (2014) also reported that Sal forest and tropical mixed broad leaved forest of Chure region had 'Good' regeneration upon inspecting higher number of seedlings of tree species while *Senegalia catechu* forest had 'Poor' natural regeneration due to less number of seedlings per plot. They mentioned that the cause for low number of seedlings might be due to high disturbances such as deforestation, grazing and fire. In contrast, this study showed that *Senegalia catechu* in riverine forest had 'Fair' regeneration status with good number of saplings and increasing seedlings per hectare, which was 'Poor' as mentioned in the previous study of Uprety et al. (2023) in the Chure forests and Chhetri et al. (2023) in a Tarai community forest of Kapilvastu District. This study showed high regeneration of *Shorea robusta* with a greater number of seedlings per hectare than saplings per hectare and trees per hectare which is similar and consistent with the findings of Joshi et al. (2019); Chhetri et al. (2023); Uprety et al. (2023). The improvement in regeneration status reflected the improving environmental conditions. Since, greater number of seedlings per hectare than saplings per hectare and trees per hectare indicated 'Good' regeneration status, it might be due to the availability of appropriate micro-climatic and environmental attributes required for the establishment of seedlings.

The 'Fair' regeneration of *Lannea coromandelica*, *Senegalia catechu* and *Adina cordifolia* (Table 3) might have various causes. The forest areas other than plot sampling area might have experienced a greater impact of human disturbance as many people were observed to have harvested forest products like firewood, fodder, logs and tree trunks from the northern parts of the Chure forest. Similar disturbances were reported by previous studies conducted by DFRS (2014); Chaudhary et al. (2019); Uprety et al. (2023). Those forests were in the process of being incorporated into community management practices due to which people were heavenly involved in harvesting forest products in comparison to the forests that were under their community management. People were engaged in harvesting forest products in excess from the government managed forest (Acharya et al., 2008) rather than the community forest that might be due to unlimited access to forest products and fearlessness of law enforcement to act upon them as nobody were present from the government to monitor their activities inside the Chure forest managed under the government forest.

5.3 Disturbance

The regeneration and disturbance scores for mixed forest (MF), riverine forest (RF) and Sal forest (SF) indicate that the riverine forest had experienced greater disturbances in comparison to mixed forest and Sal forest. The river that were present in between the forest land seems to serve as a comfortable pathway for the people to roam around the desired destination within the Chure forest which might be the cause for higher disturbance in the riverine forest. A previous study conducted by Uprety et al. (2023) also reported that *Senegalia catechu* forest had experienced greater disturbance than that of the Sal forest and it is extremely rare find the forest of *Senegalia catechu* due to illegal felling of this tree species in Chure region. This might be due to the human encroachment on matured trees of Senegalia *catechu* found in those areas.

Moreover, due to the fragile landscape, it is hard to transport forest resources via Chure hill. So, people rather use river channels to transport their domestic cattle's in and out of the forest. The direct observation during the field also led us to know that people become more cautious upon cutting down the trees from the community forest which led to the increase in cutting down of trees in northern part of Chure forest. Chaudhary and Subedi (2019) concluded that due to human activities, the forest of Chure Tarai Madhesh landscape had experienced destruction and deforestation, which posed a great threat to biodiversity conservation as well. The firewood collection, fodder collection and timber collection were the activities that were observed throughout the shallow rivers and streams flowing from in-between the forest areas. Chaudhary et al. (2016) have mentioned that the cause of deforestation beside natural factors was majorly due to different anthropogenic activities like illegal timber harvesting and clearance of forested land for agricultural purposes in Chure area. Hence, similar to previous studies of DFRS (2014); Chaudhary et al. (2016); Gautam and Mandal (2016 a, b); Chaudhary and Subedi (2019), this study also concludes that tree cutting is the major disturbance (

Table ***5***) experienced by the Chure forests of Madhesh Province. The major cause for higher disturbance in riverine forest and mixed forest might be due to the people's dependency on forest resources for daily livelihood which caused deforestation activities to accelerate. FRISP (1994) also mentioned that the forest destruction and degradation in Chure forest is mainly caused due to human activities, either for forest resources or for the clearance of forest floor for agricultural purposes (Gurung and Khanal 1986).

The regeneration and disturbance scores for Community forest (CF), Government forest (NF) and protected forest (PNP) revealed that the protected area (national park) had greater regeneration with minimal disturbance, followed by the community forest while the government forest was found highly disturbed by human activities (Figure 12). The Chure forests present in the northern part of the Madhesh Province were mainly government-regulated forests, due to which, a lack of monitoring and people's awareness towards importance of tree species might have led to the massive clearance of tree species in those areas. The reason for higher disturbance in government forests might be due to selective logging, as it is responsible for 51% of disturbances in tropical forests (Hosonuma et al., 2012). Tree species like *Senegalia catechu Adina cordifolia, Shorea robusta*, *Schleichera oleosa* and *Kydia calycina* were observed to be used as fodder, firewood and medicinal purposes in the study area. This might have created logging of such tree species from the government forest due to the prohibition of their use in protected forest and community forest. The grazing areas as well as fodder collection for cattle were also seen noticeably in the random areas of the forest mainly in the southern part of Chure forest near settlements. Chhetri et al. (2023) concluded that the disturbances in the form of resource utilization by the community are seen higher in near human settlements and lesser away from the settlement area.

Pokhrel (2012) also mentioned that most of the local people's families in Chure extract firewood, timber and fodder from the nearby government forest. This might be the reason for higher disturbance in the government forest**.** The one-way ANOVA result (Table 4) showed high disturbance in the government forest which could be the cause for low tree species diversity in government forest areas. Therefore, these forest should be focused on conservation through community forest management approach because disturbance experienced by community forests is lower than that of the disturbance experienced by government forests (Table 5). Also, the protected forest (PNP) had the lowest disturbance and had highest tree species diversity which might be due to the prohibition of human encroachment activities inside the protected areas.

5.4 Carbon stock

While looking at the carbon stock within three forest types namely, Sal forest (SF), Mixed forest (MF) and Riverine forest (RF), the Kruskal-Wallis H test showed that the carbon stock varies between the three forest types (Figure 13). It revealed that the carbon stock was significantly different in between the Sal forest and the Riverine forest while there was no any significant difference in the carbon stock between Sal forest and mixed forest and also between mixed forest and Riverine forest (Table 6). The reason for higher carbon stock in Sal forest might be due to the dominance of single species (McNicol et al., 2018) *i.e., Shorea robusta* and also the greater tree size (DBH) along with greater height. Mandal et al. (2013) reported that carbon stock and species richness have a weak and negative correlation and carbon stock doesn't vary with species diversification in the forests. Therefore, greater tree diversity in a forest doesn't necessarily mean higher carbon stock. Despite this, many studies including Ghimire et al. (2018) and Mandal et al. (2013) have reported that forest with a single dominant species has high carbon stock in them.

According to MoFSC (2015), the carbon storage capacity of Nepal's forest is estimated at 176.95 ton/ha. The DFRS (2015) reported that the average carbon stock of Chure forest is estimated as 116.94 ton/ha. With reference to this data, the current study findings showed a slightly higher value as average carbon stock *i.e.*, 127.76 ton/ha. This increased value of carbon stock might be due to the sampling focused only in Chure forest of Madhesh Province, while the previous study was focused to whole Chure forest of Nepal. Another reason for the higher value might be due to an increase in stem volume and biomass that occurred due to the increase in diameter and height of individual trees from 2015 to 2023. The volume of the tree stem matters when calculating carbon stocks because the majority of the carbon is stored in the stem section of a tree (Sharma and Kakchapati, 2018). Therefore, an increase in individual tree size might have resulted in an increment in biomass that caused carbon stock of that individual tree to increase (Borah et al., 2015).

Ali et al. (2023) mentioned that carbon sequestration in forests is affected by growing conditions, plant growth, disturbances and wood density. Sharma et al. (2011) and

Brown (2002) mentioned that carbon stock per unit area might vary based on different factors which include tree density, DBH, canopy, geographical locations and forest management regimes. Subedi et al. (2022) showed that the above ground carbon stock had increased from 2012 to 2017 in the Chure forests of Nepal with average annual carbon sequestration rate of 7.90 t CO_2 ha^{-1} yr^{-1}. Pandey et al. (2014) have suggested that the species which is dominant in any kind of forest determines the forest types and also contributes to a vital role in the greater carbon sink. Ghimire et al. (2018) studied the tree carbon stock in a Sal dominated community forest and Pine dominated community forest in Makawanpur District and found that *Shorea robusta* was the dominant species with greater contribution to carbon stock of the forest. Another study done by Mandal et al. (2013) studied the tree carbon stock in three Sal dominated forest in Mahottari District and reported that *Shorea robusta* was the major dominant and contributor of carbon stock in the forests. This study also showed that *Shorea robusta* was the ecologically dominant species with the highest IVI value in the entire Chure forest of Madhesh Province due to which Sal forest exhibited highest carbon stock among the forest types. Ecologically dominant species exhibits a major role in terms of carbon storage in a forest (Gebeyehu et al., 2019; Padmakumar et al., 2018). Moreover, the management duration and community forest management strategies also help to sequester carbon in the forest as the protected forest had highest carbon stock among the three forest management regimes (Thapa-Magar and Shrestha, 2015; Uprety et al., 2025).

6 Conclusion and Recommendations

6.1 Conclusion

This study attempted to study tree diversity, regeneration and carbon stock in the forest of Chure region, Madhesh Province, Nepal. The Chure forest in Madhesh Province had Fabaceae as the most abundant tree family. The diversity and richness of tree species in the entire Chure forests were found high. *Shorea robusta* served as the ecologically important tree species in whole Chure forest with highest IVI value with ‘Good’ regeneration status. The regeneration and disturbance scores revealed that the riverine forest had experienced greater disturbance, which caused lower regeneration of trees in comparison to the mixed forest and Sal forest. Whereas the disturbances were greater in government forest in comparison to community managed forest and protected forest, due to which the regeneration of trees was also lower in the government forest. The assessment of carbon stock in three forest types revealed that the average carbon stock of Sal forest was found to be highest among three forest types followed by the mixed forest and then riverine forest. The protected forest had the highest amount of carbon sequestered followed by community forests while least in the government forest among the management regimes. It can be concluded that, the important *Shorea robusta* tree played vital role in carbon sequestration in Sal forest. Therefore, understanding tree diversity, regeneration and carbon stock is the foundation for implementing sustainable management and conservation of forest resources.

6.2 Recommendations

The following recommendations have been suggested based on the results of the present study.

1. Similar to the current study, other research work should be conducted in other forest types of the Chure region of Madhesh Province as well.
2. Illegal tree cuttings are seen to be the major human disturbance in the Chure forest of Madhesh Province. Therefore, it should be stopped, and the government should actively monitor such kind of activities.

7 References

Acharya, K. P., Adhikari, J., & Khanal, D. R. 2008. Forest tenure regimes and their impact on livelihoods in Nepal. *Journal of Forest and Livelihood*, 7(1), 6–18.

Acharya, R. P., Maraseni, T. N., & Cockfield, G. 2019. Local Users and Other Stakeholders' Perceptions of the Identification and Prioritization of Ecosystem Services in Fragile Mountains: A Case Study of Chure Region of Nepal. *Forests*, 10(5). https://doi.org/10.3390/f10050421

Acharya, R., & Shrestha, B. B. 2011. Vegetation structure, natural regeneration and management of Parroha community forest in Rupandehi District, Nepal. *Scientific World*, 9(9), 70-81.

Adhikari, A., & Prasain, S. 2009. Reducing emissions from Nepal's community managed forests: Discussion for COP 14 in Poznan. *Journal of Forest and Livelihood*, 8(1).

Ali, S., Khan, S. M., Ahmad, Z., Siddiq, Z., Ullah, A., Yoo, S., & Raposo, A. 2023. Carbon sequestration potential of different forest types in Pakistan and its role in regulating services for public health. *Frontiers in Public Health*, 10, 1064586.

Allen, A. P., Brown, J. H., & Gillooly, J. F. 2002. Global biodiversity, biochemical kinetics, and the energetic-equivalence rule. *Science*, 297(5586), 1545–1548.

Anbarashan, M., & Parthasarathy, N. 2013. Tree diversity of tropical dry evergreen forests dominated by single or mixed species on the Coromandel coast of India. *Tropical Ecology*, 54(2), 179–190.

Arul Pragasan, L., & Parthasarathy, N. 2010. Landscape-level tree diversity assessment in tropical forests of southern Eastern Ghats, India. Flora - Morphology, Distribution, *Functional Ecology of Plants*, 205(11), 728–737.

Awasthi, N., Bhandari, S. K., & Khanal, Y. 2015. Does scientific forest management promote plant species diversity and regeneration in Sal (*Shorea robusta*) forest? A case study from Lumbini collaborative forest, Rupandehi, Nepal. *Banko Janakari*, 25(1), 20-29.

Ayer, S., Bhatta, K. P., Timilsina, S., Khamcha, R., Airee, J., Chaudhary, P., & Adhikari, H. 2024. Ecological impact and community perception of Phoenix acaulis (Roxb.) management in *Shorea robusta* Garten. F. forest of Udayapur District, Nepal. *Trees, Forests and People*, 18, 100736.

Balderas Torres, A., & Lovett, J. C. 2013. Using basal area to estimate aboveground carbon stocks in forests: La Primavera Biosphere's Reserve, Mexico. *Forestry*, 86(2), 267-281.

Ballabha, R., Tiwari, J. K., & Tiwari, P. 2013. Regeneration of tree species in the sub-tropical forest of Alaknanda Valley, Garhwal Himalaya, India. *Forest Science and Practice*, 15, 89-97.

Barik, S. K., Pandey, H. N., Tripathi, R. S., & Rao, P. 1992. Microenvironmental variability and species diversity in treefall gaps in a sub-tropical broadleaved forest. *Vegetatio*, 103(1), 31–40.

Barthlott, W., Mutke, J., Rafiqpoor, D., Kier, G., & Kreft, H. 2005. Global centers of vascular plant diversity. *Nova Acta Leopoldina*, 92(342), 61–83.

Baul, T. K., Chakraborty, A., Nandi, R., & others. 2021. Effects of tree species diversity and stand structure on carbon stocks of homestead forests in Maheshkhali Island, Southern Bangladesh. *Carbon Balance and Management,* 16(11). https://doi.org/10.1186/s13021-021-00175-6

Bharali, S., Paul, A., Khan, M., & Singha, L. 2012. Impact of Altitude on Population Structure and Regeneration Status of Two Rhododendron Species in a Temperate Broad Leaved Forest of Arunachal Pradesh, India. *International Journal of Ecosystem,* 2(1), 19–27.

Bhatta, B., Karna, A. L., Dev, O. P., & Springate-Baginski, O. 2007. Forests, people and power: the political ecology of reform in south Asia. In: *Participatory forest management in the Nepalese Tarai: policy, practice and impacts*. S. B. Oliver & B. Piers, (eds.). Taylor & Francis Ltd. Pp. 177-220.

Bhattarai, K. P., & Mandal, T. N. 2016. Effect of altitudinal variation on the soil characteristics in Sal (*Shorea robusta* Gaertn.) forests of eastern Nepal. *Our Nature*, 14(1), 30-38.

Bhattarai, T., Skutsch, M., Midmore, D., & Rana, E. B. 2012. The carbon sequestration potential of community based forest management in Nepal. *International journal of climate change*, 3(2), 233-254.

Boonman, C. C., Serra-Diaz, J. M., Hoeks, S., Guo, W. Y., Enquist, B. J., Maitner, B., & Svenning, J. C. 2024. More than 17,000 tree species are at risk from rapid global change. Nature Communications, 15(1), 166.

Borah, M., Das, D., Kalita, J., Boruah, H. P. D., Phukan, B., & Neog, B. 2015. Tree species composition, biomass and carbon stocks in two tropical forest of Assam. *biomass and bioenergy*, 78, 25-35. doi.org/10.1016/j.biombioe.2015.04.007

Bose, A. K., Weiskittel, A., Wagner, R. G., & Kuehne, C. 2016. Assessing the factors influencing natural regeneration patterns in the diverse, multi- cohort, and managed forests of Maine, USA. *Journal of Vegetation Science*, 27(6), 1140-1150.

Braun, G., Mutke, J., Reder, A., & Barthlott, W. 2002. Mountain biodiversity: A global assessment. In: *Biotope patterns, phytodiversity and forestline in the Andes, based on GIS and remote sensing data*. C. Körner & E. M. Spehn (eds.). Parthenon Publishing Ltd. Pp. 75–89.

Brown, J. H. 1990. Analytical biogeography: An integrated approach to the study of animal and plant distributions. In: *Species diversity*. A. A. Myers & P. S. Giller (eds.). Springer. Pp. 57–58.

Brown, J. H. 2001. Mammals on mountainsides: elevational patterns of diversity. *Global Ecology and Biogeography*, 10(1), 101-109.

Brown, S. 2002. Measuring carbon in forests: current status and future challenges. *Environmental pollution*, 116(3), 363-372.

Champion, S. H. G., & Seth, S. K. 1968. A Revised Survey of the Forest Types of India. In: *Moist tropical forests*. Manager of Publications. Pp. 57–174.

Chapagai, T. B., Khadka, D., Bhuju, D. R., Khanal, N. R., Shi, S. H. I., & Dafang, C. U. I. 2021. Composition and regeneration of trees in the community Forests of Lamjung District, Nepal. *Journal of Resources and Ecology*, 12(5), 658-668.

Chaudhary, R. P., & Sah, J. P. 2016. Plant diversity and environmental flow in the Koshi Basin. In: *Connecting flow and ecology in Nepal: A collation of current knowledge.* T. M. Doody, S. M. Cuddy, & L. D. Bhatta (eds.). Sustainable Development Investment Portfolio (SDIP) project, CSIRO, Australia. Pp. 43–69.

Chaudhary, R. P., & Subedi, C. K. 2019. Chure-tarai madhesh landscape, Nepal from biodiversity research perspective. *Plant Arch,* 19(2), 351-359.

Chaudhary, R. P., Uprety, Y., & Rimal, S. K. 2016. Deforestation in Nepal: Causes, consequences and responses. *Biological and environmental hazards, risks, and disasters*, 12, 335-372.

Chauhan, P. S., Negi, J. D. S., Singh, L and Manhas, R. K. 2008. Regeneration status of Sal forests of Doon valley. *Annals of Forestry,* 16(2), 178-182.

Chave, J., Andalo, C., Brown, S., Cairns, M. A., Chambers, J. Q., Eamus, D., & Yamakura, T. 2005. Tree allometry and improved estimation of carbon stocks and balance in tropical forests. *Oecologia*, 145, 87-99.

Chhetri, P., Chandra, A., & Sharma, G. 2023. Tree species richness, population structure, and regeneration status along the disturbance gradient in tropical forests of South Territorial Division, Sikkim, and Eastern Himalaya. *Environment & Conservation,* 29, S231–S238.

Chhetri, V. T., Shrestha, S., Parajuli, S., & Jha, P. 2023. Regeneration status and population structure in Terai community forest: evidence from Kalyankot Community Forest, Kapilvastu District, Nepal. *International Journal of Environment*, 12(1), 12-29.

Chikanbanjar, R., Baniya, B., & Dhamala, M. K. 2020. An assessment of forest structure, regeneration status and the impact of human disturbance in Panchase protected forest, Nepal. *Forestry: Journal of Institute of Forestry*, Nepal, 17, 42-66.

Clark, K. L., Gholz, H. L., & Castro, M. S. 2004. Carbon dynamics along a chronosequence of slash pine plantations in north Florida. *Ecological Applications*, 14(4), 1154-1171.

Condit, R., Hubbell, S. P., Lafrankie, J. V., Sukumar, R., Manokaran, N., Foster, R. B., & Ashton, P. S. 1996. Species-area and species-individual relationships for tropical trees: a comparison of three 50-ha plots. *Journal of ecology*, 549-562. https://doi.org/10.2307/2261477

Curtis, J. T., & McIntosh, R. P. 1951. An upland forest continuum in the prairie-forest border region of Wisconsin. *Ecology*, 32(3), 476-496.

Dar, J. A., Subashree, K., Raha, D., Kumar, A., Khare, P. K., & Khan, M. L. 2019. Tree diversity, biomass and carbon storage in sacred groves of Central India. *Environmental Science and Pollution Research*, 26(36), 37212-37227.

Department of Forest Research and Survey (DFRS), & Forest Resource Information System Project (FRISP). 1999. *Forest resource of Nepal (1987-1998)*. Department of Forest Research and Survey (DFRS), Ministry of Forests and Soil Conservation, Forest Resource Information System Project (FRISP), The Government of Finland.

DFRS. 2014. Chure Forests of Nepal; Forest Resource Assessment (FRA), Department of Forest\ Research and Survey (DFRS), Ministry of Forest and Soil Conservation (MoFSC), Government of Nepal. Kathmandu, Nepal.

DFRS. 2015. State of Nepal's Forests. Forest Resource Assessment (FRA) Nepal, Department of Forest Research and Survey (DFRS). Kathmandu, Nepal.

Dobremez, J.-F & Shrestha, T.-B. 1980. Carte écologique du Népal Jumla-Saipal (1/250 000). *Cahiers Népalais*, Documents (No. 9), 55 p. C.N.R.S., Paris.

Feroz, S. M., Alam, M. R., Das, P., & Al Mamun, A. 2014. Community ecology and spatial distribution of trees in a tropical wet evergreen forest in Kaptai national park in Chittagong Hill Tracts, Bangladesh. *Journal of Forestry Research*, 25, 311-318.

Forest Research & Training Center (FRTC). 2022. Field manual: Remeasurement of permanent sample plot. In: *Forest resource assessment (FRA)*, Forest Research & Training Center (FRTC), Nepal.

Forest Resource Assessment/Department of Forest Research and Survey (FRA/DFRS). 2014. Churia forests of Nepal (2011–2013). In: *Forest resource assessment Nepal/project*. Department of Forest Research and Survey (FRA/DFRS), Babarmahal, Kathmandu, Nepal.

Francis, A. P., & Currie, D. J. 2003. A globally consistent richness-climate relationship for angiosperms. *The American Naturalist*, 161(4), 523-536.

Fremout, T., Thomas, E., Gaisberger, H., Van Meerbeek, K., Muenchow, J., Briers, S., Gutierrez-Miranda, C.E., Marcelo-Peña, J.L., Kindt, R., Atkinson, R., & Cabrera, O. 2020. Mapping tree species vulnerability to multiple threats as a guide to restoration and conservation of tropical dry forests. Global Change Biology, 26(6), 3552-3568.

Fyson, C., Grant, N., Das, N., Maxwell, V., Reynolds, C., Rogelj, J., Schleußner, C.-F., & Waterton, O. 2023. When will global emissions peak? *Climate Analytics*.

Gallery, R. E. 2014. Ecology of tropical rain forests. Ecology and the Environment, 1-22. doi.10.1007/978-1-4614-7612-2_4-1

Gauch Jr & Hugh. G. 1982. Noise reduction by eigenvector ordinations. *Ecology*, 63(6), 1643-1649.

Gautam, K. H., & Devoe, N. N. 2006. Ecological and anthropogenic niches of sal (*Shorea robusta* Gaertn. f.) forest and prospects for multiple-product forest management–a review. *Forestry*, 79(1), 81-101.

Gautam, M. K., Manhas, R. K., & Tripathi, A. K. 2016. Patterns of diversity and regeneration in unmanaged moist deciduous forests in response to disturbance in Shiwalik Himalayas, India. *Journal of Asia-Pacific Biodiversity*, 9(2), 144-151.

Gautam, T. P., & Mandal, T. N. 2016 a. Effect of disturbance on litter dynamics in moist tropical forest of eastern Nepal. *Our Nature*, 14(1), 1-12.

Gautam, T. P., & Mandal, T. N. 2016 b. Effect of disturbance on biomass, production and carbon dynamics in moist tropical forest of eastern Nepal. *Forest Ecosystems*, 3, 1-10.

Gautam, T. P., & Mandal, T. N. 2016. Effect of disturbance on biomass, production and carbon dynamics in moist tropical forest of eastern Nepal. *Forest Ecosystems*, 3, 1-10.

Gautam, T. P., & Mandal, T. N. 2018. Effect of disturbance on plant species diversity in moist tropical forest of eastern Nepal. *Our Nature*, 16(1), 1-7.

Gebeyehu, G., Soromessa, T., Bekele, T., & Teketay, D. 2019. Carbon stocks and factors affecting their storage in dry Afromontane forests of Awi Zone, northwestern Ethiopia. *Journal of Ecology and Environment*, 43, 1-18.

Ghazoul J & Sheil D. 2010. Tropical rain forest ecology, diversity, and conservation. Oxford University Press, Oxford, UK.

Ghimire, P., Bhatta, B., Pokhrel, B., & Shrestha, I. 2018. Assessment of soil quality for different land uses in the Chure region of Central Nepal. *Journal of Agriculture and Natural Resources*, 1(1), 32-42.

Ghimire, S. K., Higaki, D., & Bhattarai, T. P. 2013. Estimation of soil erosion rates and eroded sediment in a degraded catchment of the Siwalik Hills, Nepal. *Land*, 2(3), 370-391.

Gillespie, T. W., Grijalva, A., & Farris, C. N. 2000. Diversity, composition, and structure of tropical dry forests in Central America. *Plant ecology*, 147, 37-47.

Gimaret- Carpentier, C., Pélissier, R., Pascal, J. P., & Houllier, F. 1998. Sampling strategies for the assessment of tree species diversity. *Journal of Vegetation Science*, 9(2), 161-172.

Giri, A., Aryal, B., Bhattarai, B., Ghimire, S. K., Shrestha, K. K., & Jha, P. K. 1999. Vegetation composition, biomass production and regeneration in Shorea robusta forests in the Royal Bardia National Park, Nepal. Nepal *Journal of Science and technology*, 1(1).

Glowka, L., Burhenne-Guilmin, F., Synge, H., McNeely, J. A., & Gündling, L. 1994. A guide to the Convention on Biological Diversity, IUCN: International Union for Conservation of Nature. IUCN Environmental Law Centre (ELC), IUCN, Biodiversity Programme.

Gonçalves, F. M., Revermann, R., Gomes, A. L., Aidar, M. P., Finckh, M., & Juergens, N. 2017. Tree species diversity and composition of miombo woodlands in south- central Angola: a chronosequence of forest recovery after shifting cultivation. *International Journal of Forestry Research*, 2017(1), 6202093.

GoN-RCTM. 2017. President Chure-Tarai Madhesh Conservation and Management Master Plan. In: *President Chure-Taraimadhesh Conservation Development Board*, Khumaltar, Lalitpur, Nepal.

Grierson, A.J.K., & Long, D.G. 1983-2001. *Flora of Bhutan.* Vol. 1 and 2. Royal Botanical Garden, Edinburgh and Royal Government of Bhutan.

Grytnes, J. A., & Vetaas, O. R. 2002. Species richness and altitude: a comparison between null models and interpolated plant species richness along the Himalayan altitudinal gradient, Nepal. *The American Naturalist*, 159(3), 294-304.

Guedje, N. M., Lejoly, J., Nkongmeneck, B. A., & Jonkers, W. B. 2003. Population dynamics of Garcinia lucida (Clusiaceae) in Cameroonian Atlantic forests. *Forest Ecology and Management*, 177(1-3), 231-241.

Gullison, R. E., Frumhoff, P. C., Canadell, J. G., Field, C. B., Nepstad, D. C., Hayhoe, K., & Nobre, C. 2007. Tropical forests and climate policy. *Science,* 316(5827), 985-986.

Gurung, H., & Khanal, N. 1986. Landscape processes in the Chure range Central Nepal. *Himalayan Review*, 1-39.

Harmer, R. 2001. The effect of plant competition and simulated summer browsing by deer on tree regeneration. *Journal of Applied Ecology*, 38(5), 1094-1103.

HMG/N. 1993. *Forest Act 1993*. Law Book Management Committee, Government of Nepal.

Hosonuma, N., Herold, M., De Sy, V., De Fries, R. S., Brockhaus, M., Verchot, L., & Romijn, E. 2012. An assessment of deforestation and forest degradation drivers in developing countries. *Environmental research letters*, 7(4), 044009.

Huy, B., & Anh, T. A. 2008. Estimating CO2 sequestration in natural broad-leaved evergreen forest in Vietnam. *Asia–Pacific Agroforestry News (FAO).* 32, 7–10.

IPCC. 2000. Landuse, Land-Use Change and Forestry. Cambridge University Press, New York.

IPCC. 2006. Guidelines for National Greenhouse Gas Inventories. Prepared by the National Greenhouse Gas Inventories Programme. Institute for Global Environmental Strategies, Japan: IGES; 2006.

Jain, A., Katewa, S. S., Galav, P. K., & Sharma, P. 2005. Medicinal plant diversity of Sitamata wildlife sanctuary, Rajasthan, India. *Journal of ethnopharmacology*, 102(2), 143-157.

Jana, B. K., Biswas, S., Majumder, M., Roy, P. K., & Mazumdar, A. 2009. Carbon sequestration rate and aboveground biomass carbon potential of four young species. *Journal of Ecology and Natural Environment*, 1(2), 15-24.

Jayakumar, R., & Nair, K. K. N. 2013. Species diversity and tree regeneration patterns in tropical forests of the Western Ghats, India. *International Scholarly Research Notices*, 2013(1), 890862.

Joshi, A. L., Shrestha, K., & Sigdel, H. 2000. Deforestation and participatory forest management policy in Nepal. In: *underlying causes of deforestation and forest degradation in Asia.* World Rainforest Movement.

Joshi, R., Chhetri, R., & Yadav, K. 2019. Vegetation analysis in community forests of Terai Region, Nepal. *International Journal of Environment*, 8(3), 68-82.

Joshi, R., Pangeni, M., Neupane, S. S., & Yadav, N. P. 2021. Regeneration status and carbon accumulation potential in community managed sal (Shorea robusta) forests of Far-Western Terai Region, Nepal. *European Journal of Ecology*, 7(1), 26-39.

Kaushal, S., Siwach, A., & Baishya, R. 2021. Diversity, regeneration, and anthropogenic disturbance in major Indian Central Himalayan forest types: implications for conservation. *Biodiversity and Conservation*, 30(8), 2451-2480.

Kaushal, S., Siwach, A., & Baishya, R. 2021. Diversity, regeneration, and anthropogenic disturbance in major Indian Central Himalayan forest types: implications for conservation. *Biodiversity and Conservation*, 30(8), 2451-2480.

Kent, M, & P. Coker. 1992. Vegetation Description and Analysis. In: *A practical Approach*. United Kingdom, CRC-Press.

Khadka, D., Bhuju, D. R., Aryal, P. C., & Khanal, N. R. 2024. Tree Regeneration Status in Community Forests of Mid Hills, Nepal. *Journal of Environment Sciences*, 10, 114-124.

Khamyong, S., Lykke, A. M., Seramethakun, D., & Barfod, A. S. 2003. Species composition and vegetation structure of an upper montane forest at the summit of Mt. Doi Inthanon, Thailand. *Nordic Journal of Botany*, 23(1), 83-97.

Kier, G., Mutke, J., Dinerstein, E., Ricketts, T. H., Küper, W., Kreft, H., & Barthlott, W. 2005. Global patterns of plant diversity and floristic knowledge. *Journal of Biogeography*, 32(7), 1107-1116.

Kumar, S., & Chopra, N. 2018. Effect of climate change on sal (*Shorea robusta* Gaertn. f.) Forest of Kumaun Himalaya. *American Journal of Environmental Sciences*, 14(4), 185-194.

Kunwar, R. M., & Sharma, S. P. 2004. Quantitative analysis of tree species in two community forests of Dolpa District, mid-west Nepal. *Himalayan Journal of Sciences*, 2(3), 23-28.

Kutiel, P., & Lavee, H. 1999. Effect of slope aspect on soil and vegetation properties along an aridity transect. *Israel Journal of Plant Sciences*, *47*(3), 169-178.

Lal, R. 2004. Soil carbon sequestration to mitigate climate change. *Geoderma*, 123(1-2), 1-22.

Le Quéré, C., Moriarty, R., Andrew, R. M., Canadell, J. G., Sitch, S., Korsbakken, J. I., & Zeng, N. 2015. Global carbon budget 2015. *Earth System Science Data*, 7(2), 349-396.

Li, Y., Li, J., & Wei, L. 2024. Stable reverse J-shaped diameter distribution occurs in an old-growth karst forest. *Journal of Forestry Research*, 35(1), 107.

Liu, X., Trogisch, S., He, J. S., Niklaus, P. A., Bruelheide, H., Tang, Z., & Ma, K. 2018. Tree species richness increases ecosystem carbon storage in subtropical forests. *Proceedings of the Royal Society B*, 285(1885), 20181240.

Lorimer, C. G., Chapman, J. W., & Lambert, W. D. 1994. Tall understorey vegetation as a factor in the poor development of oak seedlings beneath mature stands. *Journal of Ecology*, 82(2), 227–237.

Lutze, M., Ades, P., & Campbell, R. 2004. Review of measures of site occupancy by regeneration. *Australian Forestry*, 67(3), 164-171.

Luyssaert, S., Schulze, E. D., Börner, A., Knohl, A., Hessenmöller, D., Law, B. E., & Grace, J. 2008. Old-growth forests as global carbon sinks. *Nature*, 455(7210), 213-215.

MacDicken, K. G. 1997. A guide to monitoring carbon storage in forestry and agroforestry projects. *Specialist*, 3, 1–87.

Magurran, A. E. 2004. Measuring biological diversity. In: *An index of diversity*. John Wiley & Sons Ltd. Pp. 100–130

Mahat, T. B. S., Griffin, D. M., & Shepherd, K. R. 1986. Human impact on some forests of the middle hills of Nepal 1. Forestry in the context of the traditional resources of the state. *Mountain research and development*, 6(3), 223-232.

Malik, Z. A., Pandey, R., & Bhatt, A. B. 2016. Anthropogenic disturbances and their impact on vegetation in Western Himalaya, India. *Journal of Mountain Science*, 13(1), 69-82.

Mandal, R. A., Dutta, I. C., Jha, P. K., & Karmacharya, S. 2013. Relationship between carbon stock and plant biodiversity in collaborative forests in Terai, Nepal. *International Scholarly Research Notices*, 2013(1), 625767.

Mandal, T. N. 1999. *Ecological analysis of recovery of landslide damaged Sal forest ecosystem in Nepal Himalaya* (Doctoral dissertation). Banaras Hindu University, Varanasi, India.

Mandal, T. N. 2011. Seasonal variations in available N and N-mineralization in relation to fine roots in landslide damaged sites in the sal forest ecosystem of Nepal Himalaya. *Nepalese Journal of Biosciences*, 1(2011), 114-124.

Manna, S. S., & Mishra, S. P. 2017. Diversity, population structure and regeneration of tree species in Lalgarh forest range of West Bengal, India. *International Journal of Botany Studies*, 2(6), 191-195.

Margalef D. R. 1958. Information theory in ecology. *Genetics and Systematics*, 3:36-71.

McMahon, S. M., Parker, G. G., & Miller, D. R. 2010. Evidence for a recent increase in forest growth. *Proceedings of the National Academy of Sciences*, 107(8), 3611-3615.

McNicol, I. M., Ryan, C. M., Dexter, K. G., Ball, S. M., & Williams, M. 2018. Aboveground carbon storage and its links to stand structure, tree diversity and floristic composition in south-eastern Tanzania. *Ecosystems*, 21, 740-754.

MFSC. 2002. Community Forestry Inventory Guideline. Community Forestry Division, Ministriy of Forest and Soil Conservation, Kathmandu, Nepal.

Miehe, S., Miehe, G., Miehe, S., Böhner, J., Bäumler, R., Ghimire, S. K., & Subedi, M. 2015. Vegetation ecology. In: *Nepal: an introduction to the natural history, ecology and human environment in the Himalayas*. Royal Botanic Garden Edinburgh, Edinburgh, United Kingdom. Pp. 385-472.

Mishra, B., Panthi, S., Poudel, S., & Ghimire, B. R. 2023. Forest fire pattern and vulnerability mapping using deep learning in Nepal. *Fire Ecology*, 19(1), 3.

Mitchard, E. T. 2018. The tropical forest carbon cycle and climate change. *Nature*, 559(7715), 527-534.

MoFE. 2019. Forest Act 2019. Ministry of Forests and Environment (MoFE), Government of Nepal, Kathmandu.

MoFSC. 2015. Development of A Redd+ Forest Reference Level in Nepal. Ministry of Forests and Soil Conservation, Kathmandu, Nepal.

Montes, N., Gauquelin, T., Badri, W., Bertaudiere, V., & Zaoui, E. H. 2000. A non-destructive method for estimating above-ground forest biomass in threatened woodlands. *Forest Ecology and Management*, 130(1-3), 37-46.

Mukul, S. A., Halim, M. A., & Herbohn, J. 2021. Forest carbon stock and fluxes: Distribution, biogeochemical cycles, and measurement techniques. *Life on land, encyclopedia of the UN sustainable development goals,* 365-380. https://doi.org/10.1007/978-3-319-71065-5_23-1

Mukul, S. A., Herbohn, J., & Firn, J. 2016. Tropical secondary forests regenerating after shifting cultivation in the Philippines uplands are important carbon sinks. *Scientific Reports*, 6(1), 22483.

Murali, K. S., Shankar, U., Shaanker, R. U., Ganeshaiah, K. N., & Bawa, K. S. 1996. Extraction of non-timber forest products in the forests of Biligiri Rangan Hills, India. 2. Impact of NTFP extraction on regeneration, population structure, and species composition. *Economic botany*, 50, 252-269.

Mutke, J., & Barthlott, W. 2005. Patterns of vascular plant diversity at continental to global scales. *Biologiske skrifter*, 55(4), 521-531.

Napit, R. 2015. Species diversity, forest community structure and regeneration in Banke National Park. *Nepal Journal of Science and Technology*, 16(1), 17-30.

Neupane, A., Bhandari, U., & Khatiwada, H. 2024. Flowering Plant Diversity of Differentially Disturbed Region of Terai Sal (*Shorea robusta*) Forest in Eastern Nepal. *Adhyayan Journal*, 11(11), 44-60.

O'Brien, E. 1998. Water- energy dynamics, climate, and prediction of woody plant species richness: an interim general model. *Journal of Biogeography*, 25(2), 379-398.

Ogawa, H., Yoda, K., Ogino, K., & Kira, T. 1965. Comparative ecological studies on three main types of forest vegetation in Thailand. II. Plant biomass. *Natural Life in Southeast Asia*, 4, 49–80.

Ojha, H., & Hall, A. 2023. Transformation as system innovation: insights from Nepal's five decades of community forestry development. *Innovation and Development*, 13(1), 109-131.

Pachauri, R. K., Allen, M. R., Barros, V. R., Broome, J., Cramer, W., Christ, R., & van Ypserle, J. P. (eds.). 2014. Climate change 2014. In: *Synthesis report. Contribution of Working Groups I, II and III to the fifth assessment report of the Intergovernmental Panel on Climate Change*, IPCC. Pp.151.

Padmakumar, B., Sreekanth, N. P., Shanthiprabha, V., Paul, J., Sreedharan, K., Augustine, T., & Thomas, A. P. 2018. Tree biomass and carbon density estimation in the tropical dry forest of Southern Western Ghats, India. *iForest-Biogeosciences and Forestry*, 11(4), 534.

Pandey, K. P., Adhikari, Y. P., & Weber, M. 2016. Structure, composition and diversity of forest along the altitudinal gradient in the Himalayas, Nepal. *Applied ecology and environmental research*, 14 (2), 235-251.

Pandey, S. S. 2007. Tree species diversity in existing community based forest management systems in central mid-hills of Nepal. Uppsala, Sweden: Swedish Biodiversity Centre. Swedish University of Agricultural Sciences.

Pandey, S. S., Maraseni, T. N., & Cockfield, G. 2014. Carbon stock dynamics in different vegetation dominated community forests under REDD+: a case from Nepal. *Forest Ecology and Management*, 327, 40-47.

Pandey, T. R. 2024. Tree Diversity in Nepal: An Updated List. *Journal of Plant Resources*, 22(1), 43-63.

Paudyal, B. K. 2016. Regeneration, growth of Hill Sal and plant diversity in community forest: A case study from Pragatisil Community Forest in Kaski District, Western Nepal. *Banko Janakari,* 23(2), 37–43.

Peng, W., Song, T., Zeng, F., Wang, K., Du, H., & Lu, S. 2012. Relationships between woody plants and environmental factors in karst mixed evergreen-deciduous broadleaf forest, southwest China. *Journal of Food, Agriculture & Environment*, 10(1), 890–896.

Phillips, O. L., Hall, P., Gentry, A. H., Sawyer, S. A., & Vásquez, R. 1994. Dynamics and species richness of tropical rain forests. *Proceedings of the National Academy of Sciences*, 91(7), 2805–2809.

Plummer, J. 2021. *Senegalia catechu*. The IUCN Red List of Threatened Species 2021: e.T169300001A169300339.

Pokhrel, K. P. 2012. Conservation of Chure forest in Nepal: Issues, challenges and options. *Economic Journal of Nepal*, 35(4), 262-278.

Pokhrel, N., Timilsina, S., Awasthi, N., Adhikari, A., Adhikari, B., Ayer, S., & Bhatta, K. P. 2024. Implications of irregular shelterwood system on regeneration and species diversity of Sal (*Shorea robusta* Gaertn.F.) forest in Nepal. *Heliyon*, 10(1). doi.org/10.1016/j.heliyon.2023.e23156

Pokhrel, S., & Sherpa, C. 2020. Analyzing the relationship, distribution of tree species diversity, and above-ground biomass on the Chitwan-Annapurna landscape in Nepal. *International Journal of Forestry Research*, 2020(1), 2789753.

Poudel, P., & Devkota, A. 2021. Regeneration status of Sal (*Shorea robusta* Gaertn.) in community managed forests, Tanahun District, Nepal. *Journal of Institute of Science and Technology*, 26(2), 23–30.

Pradhan, A., Ormsby, A. A., & Behera, N. 2019. A comparative assessment of tree diversity, biomass and biomass carbon stock between a protected area and a sacred forest of Western Odisha, India. *Ecoscience*, 26(3), 195-204.

Pragasan LA & Parthasarathy N. 2010. Landscape-level tree diversity assessment in tropical forests of southern Eastern Ghats, India. *Flora – Morphology, Distribution, Functional Ecology of Plants,* 205**:** 728–737.

Press, J. R., Shrestha, K. K., & Sutton, D. A. 2000. *Annotated checklist of the flowering plants of Nepal*. The Natural History Museum, London.

Rai, S. K., Sharma, S., Shrestha, K. K., Gajurel, J. P., Devkota, S., Nobis, M. P., & Scheidegger, C. 2016. Effects of the environment on species richness and composition of vascular plants in Manaslu Conservation Area and Sagarmatha region of Nepalese Himalaya. *Banko Janakari,* 26(1), 3–16.

Raison, R. J., Flinn, D. W., & Brown, A. G. 2001. Application of criteria and indicators to support sustainable forest management: Some key issues. In: *Criteria and indicators for sustainable forest management*. IUFRO/CIFOR/FAO. Pp. 5–18.

Rajbhandari, K. R., Rai, S. K., & Chhetri, R. 2019. *A handbook of the flowering plants of Nepal* (Vol. 2). Government of Nepal, Ministry of Forests and Soil Conservation, Department of Plant Resources.

Razali, N., Kamarudin, N., & Ismail, M. H. 2014. Examining the rate of vegetation diversity under abandoned skid trails in Peninsular Malaysia forest. *Journal of Agricultural and Crop Research,* 2(8), 165–172.

Reft, R. K. (1980). Ordination as a tool for analyzing complex data sets. *Vegetatio*, 42, 171-174.

Richerson, P. J., & Lum, K.-L. 1980. Patterns of plant species diversity in California: Relation to weather and topography. *The American Naturalist*, 116(4), 504–536.

Ricker, M., & Hernández, H. M. 2010. Tree and tree-like species of Mexico: gymnosperms, monocotyledons, and tree ferns. *Revista mexicana de biodiversidad*, 81(1), 27-38.

Sagar, R., & Singh, J. S. 2005. Structure, diversity, and regeneration of tropical dry deciduous forest of northern India. *Biodiversity & Conservation*, 14(4), 935–959.

Sapkota, I. P., Tigabu, M., & Odén, P. C. 2009 a. Species diversity and regeneration of old-growth seasonally dry *Shorea robusta* forests following gap formation. *Journal of Forestry Research*, 20(1), 7–14.

Sapkota, I. P., Tigabu, M., & Odén, P. C. 2009 b. Spatial distribution, advanced regeneration and stand structure of Nepalese Sal (Shorea robusta) forests subject to disturbances of different intensities. *Forest Ecology and Management*, *257*(9), 1966-1975.

Sapkota, I. P., Tigabu, M., & Odén, P. C. 2010. Changes in tree species diversity and dominance across a disturbance gradient in Nepalese Sal (*Shorea robusta* Gaertn. F.) forests. *Journal of Forestry Research*, 21(1), 25–32.

Sarkar, M., & Devi, A. 2014. Assessment of diversity, population structure and regeneration status of tree species in Hollongapar Gibbon Wildlife Sanctuary, Assam, Northeast India. *Tropical plant research*, 1(2), 26-36.

SAWTEE. 2016. *Chure Conservation Area: Lessons for the Management and Use of Natural and Biological Resources in Nepal*. South Asia Watch on Trade, Economics & Environment, Kathmandu.

Scholl, A. E., & Taylor, A. H. 2006. Regeneration patterns in old-growth red fir–western white pine forests in the northern Sierra Nevada, Lake Tahoe, USA. *Forest Ecology and Management,* 235(1), 143–154.

Schweik, C. M., Adhikari, K., & Pandit, K. N. 1997. Land-cover change and forest institutions: A comparison of two sub-basins in the southern Siwalik Hills of Nepal. *Mountain Research and Development*, 17(2), 99–116.

Shah, S., Mishra, A. K. & Aithal, P. S. 2024. Practice of Low-Cost River Training Works on the Bank of Mohana River in Kailari Rural Municipality, Nepal. International Journal of Management, Technology, and Social Sciences (IJMTS), 9(2), 53-76.

Shank R, Noorie E. 1950. Microclimate vegetation in a small valley in eastern Tennessee. *Ecology,* 11, 531–539.

Shankar, U. 2001. A case study of high tree diversity in a Sal (*Shorea robusta*) dominated lowland forest of Eastern Himalaya: Floristic composition, regeneration, and conservation. *Current Science,* 81(7), 776–786.

Shannon, C. E., & Wiener, W. 1963. *The mathematical theory of communication.* University of Illinois Press.

Sharma, C. M., Gairola, S., Baduni, N. P., Ghildiyal, S. K., & Suyal, S. 2011. Variation in carbon stocks on different slope aspects in seven major forest types of temperate region of Garhwal Himalaya, India. *Journal of Biosciences,* 36(4), 701–708.

Sharma, I., & Kakchapati, S. 2018. Linear regression model to identify the factors associated with carbon stock in Chure forest of Nepal. *Scientifica*, 2018(1), 1383482.

Sharma, K., Saikia, A., Thapa, P., & Chettry, B. K. 2022. Aboveground biomass and carbon stock assessment in the Eastern Himalaya foothills along the Indo-Bhutan border. *Australian Geographer,* 53(3), 241–264.

Sharma, L. N., Poudel, Y. B., & Adhikari, B. 2024. Assessment of diversity, rarity and socio-ecological significance of tree species of Jalthal remnant forest in Nepal. *Pleione,* 18(3), 281–305.

Shrestha, K. K., Bhandari, P., & Bhattarai, S. 2022. *Plants of Nepal (gymnosperms and angiosperms)*. Heritage Publishers & Distributors Pvt. Limited.

Simpson, E. H. 1949. Measurement of diversity. *Nature,* 163(4148), 688–688.

Singh, B.K. 2017. Land tenure and conservation in Chure. *Journal of forest and livelihood*, 15(1), 87-102.

Somogyi, Z., Cienciala, E., Mäkipää, R., Muukkonen, P., Lehtonen, A., & Weiss, P. 2007. Indirect methods of large-scale forest biomass estimation. *European Journal of forest research*, *126,* 197-207. Stainton, JDA. 1972. *Forests of Nepal.* Hafner Publishing Company. New York.

Subedi, B., Lamichhane, P., Magar, L. K., & Subedi, T. 2022. Aboveground carbon stocks and sequestration rates of forests under different management regimes in Churia region of Nepal. *Banko Janakari*, 32(1), 15-24.

Subedi, N., Bhattarai, S., Pandey, M. R., Kadariya, R., Thapa, S. K., Gurung, A., & Lamichhane, B. R. 2021. Report on faunal diversity in Chure region of Nepal.

President Chure-Terai Madhesh Conservation Development Board and National Trust for Nature Conservation. doi.org/10.13140/RG.2.2.34164.88967

Subedi, V. R. 2011. Forest management opportunities and challenges in Nepal. *Nepal Journal of Forestry*, 14, 95-110.

Swamy, S. L., Dutt, C. B. S., Murthy, M. S. R., Mishra, A., & Bargali, S. S. 2010. Floristics and dry matter dynamics of tropical wet evergreen forests of Western Ghats, India. *Current Science*, 99(3), 353–364.

Thapa-Magar, K. B., & Shrestha, B. B. 2015. Carbon stock in community managed hill sal (*Shorea robusta*) forests of central Nepal. *Journal of Sustainable forestry*, 34(5), 483-501.

Timilsina, N., Ross, M. S., & Heinen, J. T. 2007. A community analysis of sal (*Shorea robusta*) forests in the western Tarai of Nepal. *Forest Ecology and Management*, 241(1), 223–234.

Tiwari, A., Uprety, Y., & Rana, S. K. 2019. Plant endemism in the Nepal Himalayas and phytogeographical implications. *Plant Diversity*, 41(3), 174-182.

Tripathi R.S., & Khan, M.L. 2007. Regeneration dynamics of natural forests. *Proceedings of the Indian National Science Academy*, 73(3), 167-195.

Upadhaya, K., Pandey, H. N., Law, P. S., & Tripathi, R. S. 2004. Diversity and population characteristics of woody species in a subtropical humid forest exposed to cultural disturbances in Meghalaya, Northeast India. *Tropical Ecology*, 45(2), 303–314.

Uprety, Y., Oli, B. N., Karki, S., Bashyal, B., Rimal, R. K., Subedi, S., & Baral, H. 2025. Tree species diversity and spatial distribution of carbon stock in forests under different management regimes in Nepal's Western Terai Arc Landscape. Trees, Forests and People, 19, 100728. doi.org/10.1016/j.tfp.2024.100728

Uprety, Y., Tiwari, A., Karki, S., Chaudhary, A., Yadav, R. K. P., Giri, S., & Dhakal, M. 2023. Characterization of forest ecosystems in the Chure (Siwalik Hills) landscape of Nepal Himalaya and their conservation need. *Forests*, 14(1), 100.

Vasilevich, V. I. 2009. Species diversity of plants. *Contemporary Problems of Ecology*, 2(4), 297–303.

Vetaas, O. R., & Grytnes, J. A. 2002. Distribution of vascular plant species richness and endemic richness along the Himalayan elevation gradient in Nepal. *Global Ecology and Biogeography*, 11(4), 291–301.

Wang, L., Wang, X., Chen, L., Song, N. P., & Yang, X. G. 2021. Trade-off between soil moisture and species diversity in semi-arid steppes in the Loess Plateau of China. *Science of the Total Environment*, 750, 141646.

Wang, Z., Brown, J. H., Tang, Z., & Fang, J. 2009. Temperature dependence, spatial scale, and tree species diversity in eastern Asia and North America. *Proceedings of the National Academy of Sciences*, 106(32), 13388–13392.

Webb, E. L., & Sah, R. N. 2003. Structure and diversity of natural and managed sal (*Shorea robusta* Gaertn. f.) forest in the Terai of Nepal. *Forest Ecology and Management*, 176(1-3), 337-353.

World Bank. 2025. Climate Knowledge Portal. Retrieved January 25, 2025, from https://climateknowledgeportal.worldbank.org/

Wu Z.Y. and Raven P.H. 1994-2000. *Flora of China, Vol. 4, 15, 16, 17, 18 & 24.* Science Press, Beijing, and Missouri Botanical Garden Press, St. Louis.

Yadav, H., Phartyal, S. S., Iwachido, Y., & Sasaki, T. 2023. Regional assessment of diversity and distribution of native tree species in South Asia. Biodiversity and Conservation, 33, 379-396.

Zanne, A. E., Lopez-Gonzalez, G., Coomes, D. A., Ilic, J., Jansen, S., Lewis, S. L., & Chave, J. 2009. Data from: Towards a worldwide wood economics spectrum. *Dryad.* doi.org/10.5061/dryad.234

Zeng, X. H., Zhang, W. J., Song, Y. G., & Shen, H. T. 2014. Slope aspect and slope position have effects on plant diversity and spatial distribution in the hilly region of Mount Taihang, North China. *Journal of Food, Agriculture & Environment,* 12(1), 391-397.

Zhang, Y., Gu, F., Liu, S., Liu, Y., & Li, C. 2013. Variations of carbon stock with forest types in subalpine region of southwestern China. *Forest Ecology and Management*, 300, 88–95.

Zhu, Y., Xu, X., Xi, Z., & Liu, J. 2023. Conservation priorities for endangered trees facing multiple threats around the world. Conservation Biology, 37(6).

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

Appendices

Appendix 1: IVI (%) of individual tree species in the whole Chure forest of Madhesh Province

SN	Tree species	RD_%	RF_%	RBA_%	IVI_%
1	*Adina cordifolia* (Roxb.) Brandis	2.52	2.63	2.99	8.13
2	*Aegle marmelos* (L.) Corrêa	1.25	2.01	1.09	4.34
3	*Alangium salviifolium* (L.f.) Wangerin	0.82	1.39	0.60	2.80
4	*Albizia lucida* (Jacques) Benth.	0.20	0.77	0.69	1.66
5	*Albizia odoratissima* (L.f.) Benth.	0.04	0.31	0.18	0.53
6	*Aphanamixis polystachya* (Wall.) R.Parker	0.01	0.15	0.24	0.41
7	*Aporosa octandra* (Buch.-Ham. ex D.Don) Vickery	0.66	0.15	0.17	0.99
8	*Azadirachta indica* A.Juss.	0.72	0.62	0.21	1.55
9	*Bauhinia purpurea* L.	0.10	0.31	0.20	0.60
10	*Bauhinia variegata* L.	0.02	0.15	0.04	0.22
11	*Bombax ceiba* L.	0.16	0.93	0.97	2.07
12	*Bridelia retusa* (L.) A.Juss.	0.88	1.70	0.68	3.26
13	*Buchanania cochinchinensis* (Lour.) M.R.Almeida	1.76	2.94	1.43	6.12
14	*Careya arborea* Roxb.	0.40	1.39	0.83	2.62
15	*Casearia graveolens* Dalzell	2.20	1.39	0.58	4.17
16	*Casearia tomentosa* Roxb.	0.02	0.15	0.04	0.22
17	*Cassia fistula* L.	0.88	0.93	0.71	2.52
18	Celastraceae	0.02	0.15	0.04	0.22
19	*Ceriscoides turgida* (Roxb.) Tirveng.	0.66	0.15	0.37	1.18
20	*Croton persimilis* Müll.Arg.	3.06	3.25	1.76	8.07
21	*Cycas pectinata* Buch.-Ham.	0.02	0.15	0.03	0.21
22	*Dalbergia latifolia* Roxb.	1.53	1.85	0.86	4.24
23	*Dalbergia sissoo* Roxb. ex DC.	1.41	0.31	0.28	2.00
24	*Dillenia indica* L.	0.65	1.55	0.85	3.05
25	*Diospyros montana* Roxb.	0.02	0.15	0.03	0.21
26	*Ehretia aspera* Willd.	2.51	1.55	0.81	4.86
27	*Elaeodendron glaucum* (Rottb.) Pers.	1.09	0.62	0.34	2.05
28	*Erythrina stricta* Roxb.	0.60	1.08	0.64	2.32
29	*Falconeria insignis* Royle	0.03	0.31	0.11	0.45
30	*Ficus benjamina* L.	0.01	0.15	0.14	0.30
31	*Ficus hispida* L.f.	0.08	0.15	0.06	0.30
32	*Firmiana fulgens* (Wall. ex Mast.) K.Schum.	0.85	1.24	0.81	2.90
33	*Flacourtia jangomas* (Lour.) Raeusch.	0.73	0.62	0.46	1.81
34	*Garuga pinnata* Roxb.	0.16	0.46	0.29	0.91
35	*Glochidion heyneanum* (Wight & Arn.) Wight	0.08	0.15	0.03	0.27
36	*Gmelina arborea* Roxb. ex Sm.	0.01	0.15	0.10	0.26
37	*Grewia eriocarpa* Juss.	0.13	0.62	0.21	0.96
38	*Holarrhena pubescens* Wall. ex G.Don	2.99	2.16	0.90	6.05
39	*Hymenodictyon orixense* (Roxb.) Mabb.	0.11	0.46	0.19	0.77

40	*Kydia calycina* Roxb.	0.17	0.15	0.09	0.41
41	*Lagerstroemia parviflora* Roxb.	7.52	9.27	7.00	23.79
42	*Lannea coromandelica* (Houtt.) Merr.	1.32	4.95	4.29	10.56
43	*Mallotus nudiflorus* (L.) Kulju & Welzen	0.02	0.15	0.06	0.24
44	*Mallotus philippensis* (Lam.) Müll.Arg.	8.02	4.48	3.85	16.35
45	*Miliusa velutina* (DC.) Hook.f. & Thomson	1.04	1.24	0.54	2.82
46	*Millettia glaucescens* Kurz	6.46	2.78	4.00	13.24
47	*Nyctanthes arbor-tristis* L.	3.48	0.93	0.93	5.34
48	*Ougeinia oojeinensis* (Roxb.) Hochr.	0.78	1.55	0.97	3.29
49	*Pavetta tomentosa* Roxb. ex Sm.	0.78	0.62	0.26	1.66
50	*Phyllanthus emblica* L.	0.38	0.93	0.26	1.57
51	*Piliostigma malabaricum* (Roxb.) Benth.	0.13	0.31	0.16	0.60
52	*Pinus roxburghii* Sarg.	0.15	0.31	1.08	1.53
53	*Premna* sp.	0.02	0.15	0.03	0.21
54	*Schleichera oleosa* (Lour.) Oken	0.48	2.01	2.83	5.32
55	*Semecarpus anacardium* L.f.	1.01	3.25	1.51	5.77
56	*Senegalia catechu* (L.f.) P.J.H.Hurter & Mabb.	4.95	3.86	3.29	12.11
57	*Shorea robusta* C.F.Gaertn.	28.53	16.23	35.87	80.63
58	*Spondias pinnata* (L.f.) Kurz	0.01	0.15	0.05	0.21
59	*Sterculia villosa* Roxb. ex Sm.	0.07	0.31	0.20	0.58
60	*Stereospermum colais* (Buch.-Ham. ex Dillwyn) Mabb.	1.37	1.24	1.04	3.64
61	*Syzygium cumini* (L.) Skeels	0.08	0.62	0.61	1.30
62	*Syzygium nervosum* DC.	0.31	1.08	0.96	2.36
63	*Terminalia anogeissiana* Gere & Boatwr.	1.46	2.63	2.40	6.49
64	*Terminalia bellirica* (Gaertn.) Roxb.	0.17	0.77	0.33	1.27
65	*Terminalia chebula* Retz.	0.02	0.15	0.11	0.29
66	*Terminalia elliptica* Willd.	1.87	4.48	6.24	12.59
67	*Wrightia arborea* (Dennst.) Mabb.	0.02	0.15	0.04	0.22

Appendix 2: Density-Diameter curve data

DBH class (cm)	Individuals/ha
>10	409.26
10-15	169.32
15-20	144.82
20-25	50.83
25-30	24.80
30-35	17.41
35-40	12.10
40-45	7.15
45-50	5.65

50-55	3.92
55-60	2.65
60-65	2.31
65-70	0.92
70-75	1.04
75-80	1.50
80-85	0.58
85-90	0.92
90-95	0.23
95-100	0.23
100-105	0.12
105-110	0.23
110-115	0.23
120-125	0.23
125-130	0.23
135-140	0.12
140-145	0.12

Appendix 3: Diversity indices in Chure forest of eight District in Madhesh Province

All Districts	**Shannon-Wiener's diversity index**	**Simpson diversity index**	**Margalef's richness index**
Parsa	2.59	0.89	5.86
Bara	1.94	0.78	4.78
Rautahat	2.36	0.92	3.69
Sarlahi	1.82	0.80	3.18
Mahottari	1.13	0.46	3.21
Dhanusha	2.53	0.86	6.05
Siraha	2.33	0.88	4.40
Saptari	2.91	0.92	6.61

Appendix 4: Disturbance index (%) across three forest types

Plot	Forest types	Number of Stumps	Number of Fallen dead trees	BA(m^2) of cut stumps per plot	BA(m^2) fallen dead trees	BA(m^2) of alive trees	DI (%)
1	RF	3	0	0.07	0.00	1.98	3.36
2	RF	3	0	0.08	0.00	1.40	5.25
3	MF	1	0	0.01	0.00	0.98	0.75
4	MF	2	0	0.04	0.00	0.70	5.91
5	SF	0	0	0.00	0.00	1.97	0.00
6	RF	3	1	0.05	0.04	1.80	2.83
7	SF	4	0	0.13	0.00	2.92	4.31
8	MF	6	0	0.08	0.00	1.38	5.65
9	MF	1	0	0.02	0.00	0.26	6.65
10	SF	1	0	0.06	0.00	2.08	2.68
11	MF	0	0	0.00	0.00	0.95	0.00
13	SF	1	0	0.01	0.00	0.80	1.17

14	MF	5	2	0.07	0.05	1.34	4.65
15	SF	6	0	0.28	0.00	1.54	15.27
16	SF	0	0	0.00	0.00	1.42	0.00
18	SF	5	0	0.16	0.00	0.47	25.76
21	RF	2	0	0.03	0.00	0.39	6.72
22	RF	3	0	0.03	0.00	0.54	4.87
23	RF	7	0	0.10	0.00	0.50	16.10
28	RF	0	0	0.00	0.00	1.40	0.00
29	MF	7	1	0.25	0.13	0.88	19.93
32	RF	0	0	0.00	0.00	0.21	0.00
33	RF	2	0	0.02	0.00	0.71	2.82
34	RF	0	0	0.00	0.00	0.16	0.00
35	SF	5	1	0.18	0.11	1.28	11.32
36	SF	3	0	0.04	0.00	2.53	1.62
37	SF	2	2	0.05	0.15	0.81	5.06
40	RF	1	0	0.03	0.00	0.91	3.49
41	RF	0	0	0.00	0.00	0.67	0.00
43	MF	10	3	0.56	0.29	3.12	14.03
44	SF	12	3	1.28	0.14	1.74	40.44
45	SF	0	0	0.00	0.00	0.41	0.00
49	MF	2	0	0.08	0.00	1.49	5.18
51	SF	9	0	0.71	0.00	2.03	25.88
52	SF	4	1	0.04	0.09	2.34	1.60
53	SF	0	0	0.00	0.00	1.87	0.00
54	SF	0	0	0.00	0.00	3.34	0.00
55	SF	3	1	0.03	0.03	2.19	1.32
56	SF	2	1	0.04	0.06	2.11	1.74
57	MF	0	0	0.00	0.00	1.23	0.00
58	MF	0	0	0.00	0.00	1.05	0.00
59	MF	6	0	0.28	0.00	1.86	12.97
62	SF	0	0	0.00	0.00	0.56	0.00
63	RF	7	0	0.21	0.00	1.19	14.74
65	RF	0	0	0.00	0.00	0.09	0.00
66	RF	0	0	0.00	0.00	0.38	0.00
73	RF	0	5	0.00	0.15	1.60	0.00
74	MF	0	0	0.00	0.00	3.45	0.00
78	SF	6	0	0.09	0.00	1.23	7.03
79	SF	0	0	0.00	0.00	2.69	0.00
80	RF	1	0	0.02	0.00	1.60	1.37
83	MF	1	0	0.01	0.00	0.13	6.27
84	MF	0	1	0.00	0.03	1.45	0.00
85	MF	0	0	0.00	0.00	3.85	0.00
86	MF	0	3	0.00	0.15	2.93	0.00
87	SF	0	4	0.00	0.43	2.02	0.00
88	SF	0	5	0.00	0.31	2.14	0.00
89	SF	3	0	0.28	0.00	2.71	9.43
90	SF	0	0	0.00	0.00	2.10	0.00
92	MF	2	0	0.03	0.00	0.86	3.74

93	MF	1	1	0.04	0.02	4.41	0.87
94	MF	0	1	0.00	0.01	5.26	0.00
95	MF	0	3	0.00	0.15	1.06	0.00
101	SF	0	0	0.00	0.00	1.83	0.00
102	SF	2	0	0.02	0.00	3.57	0.64
107	SF	2	1	0.27	0.10	4.19	5.93
110	SF	0	4	0.00	0.47	5.09	0.00
114	SF	0	0	0.00	0.00	1.77	0.00
115	RF	2	0	0.04	0.00	1.94	1.88

Appendix 5: Carbon stock across three forest types

Forest types Carbon stock (ton per hectare)		
SF	MF	RF
117.79	24.57	106.93
123.84	17.80	59.48
100.59	105.47	149.32
54.94	55.83	19.03
75.84	42.74	59.34
134.83	93.02	47.87
56.14	41.90	117.19
73.48	269.79	21.20
187.82	79.31	53.73
71.67	71.07	31.61
126.16	70.60	81.71
66.86	117.78	56.85
175.43	367.81	75.66
245.92	12.06	9.62
162.92	96.31	49.52
250.09	257.16	92.76
161.26	178.50	96.03
174.81	64.47	90.16
69.49	240.20	
97.29	445.07	
330.48	104.29	
124.17		
210.75		
184.16		
122.64		
150.39		
335.84		
349.62		
446.25		
60.30		

Appendix 6: Diversity and richness index of protected forest for Parsa District

Tree species	ni	N	pi	lnpi	pi*lnpi	ni-1	ni*(ni-1)	N-1	N*(N-1)	[{ni*(ni-1)}/{N*(N-1}]	Margalefs richness index
Adina cordifolia (Roxb.) Brandis	1.1272	87.7754	0.0128	-4.3550	-0.0559	0.1272	0.1434	86.7754	7616.7486	0.0000	5.86
Aegle marmelos (L.) Corrêa	0.7205	87.7754	0.0082	-4.8026	-0.0394	-0.2795	-0.2014	86.7754	7616.7486	0.0000	
Alangium salviifolium (L.f.) Wangerin	0.1153	87.7754	0.0013	-6.6351	-0.0087	-0.8847	-0.1020	86.7754	7616.7486	0.0000	
Bridelia retusa (L.) A.Juss.	0.7301	87.7754	0.0083	-4.7893	-0.0398	-0.2699	-0.1970	86.7754	7616.7486	0.0000	
Buchanania cochinchinensis (Lour.) M.R.Almeida	3.8524	87.7754	0.0439	-3.1261	-0.1372	2.8524	10.9885	86.7754	7616.7486	0.0014	
Careya arborea Roxb.	0.3202	87.7754	0.0036	-5.6135	-0.0205	-0.6798	-0.2177	86.7754	7616.7486	0.0000	
Cassia fistula L.	2.8821	87.7754	0.0328	-3.4163	-0.1122	1.8821	5.4243	86.7754	7616.7486	0.0007	
Croton persimilis Müll.Arg.	3.4329	87.7754	0.0391	-3.2414	-0.1268	2.4329	8.3518	86.7754	7616.7486	0.0011	
Dalbergia latifolia Roxb.	1.1304	87.7754	0.0129	-4.3522	-0.0560	0.1304	0.1474	86.7754	7616.7486	0.0000	
Dillenia indica L.	0.5508	87.7754	0.0063	-5.0712	-0.0318	-0.4492	-0.2474	86.7754	7616.7486	0.0000	
Ehretia aspera Willd.	0.2049	87.7754	0.0023	-6.0598	-0.0141	-0.7951	-0.1629	86.7754	7616.7486	0.0000	
Elaeodendron glaucum (Rottb.) Pers.	0.7205	87.7754	0.0082	-4.8026	-0.0394	-0.2795	-0.2014	86.7754	7616.7486	0.0000	
Garuga pinnata Roxb.	0.2049	87.7754	0.0023	-6.0598	-0.0141	-0.7951	-0.1629	86.7754	7616.7486	0.0000	

Glochidion heyneanum (Wight & Arn.) Wight	0.7205	87.7754	0.0082	-4.8026	-0.0394	-0.2795	-0.2014	86.7754	7616.7486	0.0000	
Gmelina arborea Roxb. ex Sm.	0.1153	87.7754	0.0013	-6.6351	-0.0087	-0.8847	-0.1020	86.7754	7616.7486	0.0000	
Holarrhena pubescens Wall. ex G.Don	0.7205	87.7754	0.0082	-4.8026	-0.0394	-0.2795	-0.2014	86.7754	7616.7486	0.0000	
Hymenodictyon orixense (Roxb.) Mabb.	0.1153	87.7754	0.0013	-6.6351	-0.0087	-0.8847	-0.1020	86.7754	7616.7486	0.0000	
Lagerstroemia parviflora Roxb.	4.8003	87.7754	0.0547	-2.9061	-0.1589	3.8003	18.2423	86.7754	7616.7486	0.0024	
Lannea coromandelica (Houtt.) Merr.	5.7450	87.7754	0.0655	-2.7265	-0.1784	4.7450	27.2595	86.7754	7616.7486	0.0036	
Mallotus nudiflorus (L.) Kulju & Welzen	0.2049	87.7754	0.0023	-6.0598	-0.0141	-0.7951	-0.1629	86.7754	7616.7486	0.0000	
Mallotus philippensis (Lam.) Müll.Arg.	6.1901	87.7754	0.0705	-2.6518	-0.1870	5.1901	32.1269	86.7754	7616.7486	0.0042	
Miliusa velutina (DC.) Hook.f. & Thomson	1.7613	87.7754	0.0201	-3.9087	-0.0784	0.7613	1.3408	86.7754	7616.7486	0.0002	
Nyctanthes arbor-tristis L.	23.0567	87.7754	0.2627	-1.3368	-0.3512	22.0567	508.5529	86.7754	7616.7486	0.0668	
Ougeinia oojeinensis (Roxb.) Hochr.	6.7505	87.7754	0.0769	-2.5652	-0.1973	5.7505	38.8185	86.7754	7616.7486	0.0051	
Phyllanthus emblica L.	0.7205	87.7754	0.0082	-4.8026	-0.0394	-0.2795	-0.2014	86.7754	7616.7486	0.0000	
Pinus roxburghii Sarg.	0.5764	87.7754	0.0066	-5.0257	-0.0330	-0.4236	-0.2442	86.7754	7616.7486	0.0000	
Schleichera oleosa (Lour.) Oken	0.2306	87.7754	0.0026	-5.9420	-0.0156	-0.7694	-0.1774	86.7754	7616.7486	0.0000	
Shorea robusta C.F.Gaertn.	15.2046	87.7754	0.1732	-1.7532	-0.3037	14.2046	215.9748	86.7754	7616.7486	0.0284	

Sterculia villosa Roxb. ex Sm.	0.6405	87.7754	0.0073	-4.9203	-0.0359	-0.3595	-0.2303	86.7754	7616.7486	0.0000	
Stereospermum colais (Buch.-Ham. ex Dillwyn) Mabb.	0.1153	87.7754	0.0013	-6.6351	-0.0087	-0.8847	-0.1020	86.7754	7616.7486	0.0000	
Terminalia anogeissiana Gere & Boatwr.	1.2809	87.7754	0.0146	-4.2272	-0.0617	0.2809	0.3598	86.7754	7616.7486	0.0000	
Terminalia bellirica (Gaertn.) Roxb.	0.9255	87.7754	0.0105	-4.5522	-0.0480	-0.0745	-0.0690	86.7754	7616.7486	0.0000	
Terminalia elliptica Willd.	1.9086	87.7754	0.0217	-3.8284	-0.0832	0.9086	1.7341	86.7754	7616.7486	0.0002	
					-2.5871				D	0.11372	
				(H')=	2.5871				(1-D)=	0.8863	

Appendix 7: Diversity and richness index for Bara District

Tree species	ni	N	pi	lnpi	pi*lnpi	ni-1	ni*(ni-1)	N-1	N*(N-1)	[{ni*(ni-1)}/{N*(N-1}]	Margalefs richness index (d)
Adina cordifolia (Roxb.) Brandis	0.4099	94.4779	0.0043	-5.4402	-0.0236	-0.5901	-0.2419	93.4779	8831.5886	0.0000	4.78
Aegle marmelos (L.) Corrêa	0.3202	94.4779	0.0034	-5.6871	-0.0193	-0.6798	-0.2177	93.4779	8831.5886	0.0000	
Alangium salviifolium (L.f.) Wangerin	0.7205	94.4779	0.0076	-4.8761	-0.0372	-0.2795	-0.2014	93.4779	8831.5886	0.0000	
Albizia lucida (Jacques) Benth.	0.5252	94.4779	0.0056	-5.1924	-0.0289	-0.4748	-0.2494	93.4779	8831.5886	0.0000	
Aphanamixis polystachya (Wall.) R.Parker	0.1153	94.4779	0.0012	-6.7087	-0.0082	-0.8847	-0.1020	93.4779	8831.5886	0.0000	
Buchanania cochinchinensis (Lour.) M.R.Almeida	0.1153	94.4779	0.0012	-6.7087	-0.0082	-0.8847	-0.1020	93.4779	8831.5886	0.0000	
Casearia graveolens Dalzell	5.7642	94.4779	0.0610	-2.7967	-0.1706	4.7642	27.4614	93.4779	8831.5886	0.0031	
Cassia fistula L.	1.6716	94.4779	0.0177	-4.0346	-0.0714	0.6716	1.1227	93.4779	8831.5886	0.0001	
Croton persimilis Müll.Arg.	7.8297	94.4779	0.0829	-2.4904	-0.2064	6.8297	53.4739	93.4779	8831.5886	0.0061	
Dillenia indica L.	3.8332	94.4779	0.0406	-3.2047	-0.1300	2.8332	10.8600	93.4779	8831.5886	0.0012	
Ehretia aspera Willd.	0.3202	94.4779	0.0034	-5.6871	-0.0193	-0.6798	-0.2177	93.4779	8831.5886	0.0000	
Falconeria insignis Royle	0.1153	94.4779	0.0012	-6.7087	-0.0082	-0.8847	-0.1020	93.4779	8831.5886	0.0000	
Garuga pinnata Roxb.	0.4611	94.4779	0.0049	-5.3224	-0.0260	-0.5389	-0.2485	93.4779	8831.5886	0.0000	
Grewia eriocarpa Juss.	0.2049	94.4779	0.0022	-6.1334	-0.0133	-0.7951	-0.1629	93.4779	8831.5886	0.0000	
Lagerstroemia parviflora Roxb.	8.6623	94.4779	0.0917	-2.3894	-0.2191	7.6623	66.3725	93.4779	8831.5886	0.0075	
Lannea coromandelica (Houtt.) Merr.	0.5508	94.4779	0.0058	-5.1448	-0.0300	-0.4492	-0.2474	93.4779	8831.5886	0.0000	

Mallotus philippensis (Lam.) Müll.Arg.	23.3961	94.4779	0.2476	-1.3958	-0.3456	22.3961	523.9816	93.4779	8831.5886	0.0593	
Phyllanthus emblica L.	0.2049	94.4779	0.0022	-6.1334	-0.0133	-0.7951	-0.1629	93.4779	8831.5886	0.0000	
Pinus roxburghii Sarg.	0.6917	94.4779	0.0073	-4.9170	-0.0360	-0.3083	-0.2133	93.4779	8831.5886	0.0000	
Semecarpus anacardium L.f.	1.0664	94.4779	0.0113	-4.4841	-0.0506	0.0664	0.0708	93.4779	8831.5886	0.0000	
Shorea robusta C.F.Gaertn.	35.4112	94.4779	0.3748	-0.9813	-0.3678	34.4112	1218.5409	93.4779	8831.5886	0.1380	
Syzygium nervosum DC.	0.2306	94.4779	0.0024	-6.0156	-0.0147	-0.7694	-0.1774	93.4779	8831.5886	0.0000	
Terminalia anogeissiana Gere & Boatwr.	0.1153	94.4779	0.0012	-6.7087	-0.0082	-0.8847	-0.1020	93.4779	8831.5886	0.0000	
Terminalia bellirica (Gaertn.) Roxb.	0.2049	94.4779	0.0022	-6.1334	-0.0133	-0.7951	-0.1629	93.4779	8831.5886	0.0000	
Terminalia chebula Retz.	0.2049	94.4779	0.0022	-6.1334	-0.0133	-0.7951	-0.1629	93.4779	8831.5886	0.0000	
Terminalia elliptica Willd.	1.3322	94.4779	0.0141	-4.2616	-0.0601	0.3322	0.4425	93.4779	8831.5886	0.0001	
Total					-1.9425				D	0.2151	
				H' =	1.9425				1-D =	0.7849	

Appendix 8: Diversity and richness index for Rautahat District

Tree species	ni	N	pi	lnpi	pi*lnpi	ni-1	ni*(ni-1)	N-1	N*(N-1)	[{ni*(ni-1)}/{N*(N-1}]	Margalefs richness index (d)
Aegle marmelos (L.) Corrêa	2.1616	20.7606	0.1041	-2.2622	-0.2355	1.1616	2.5108	19.7606	410.2419	0.0061	3.69
Alangium salviifolium (L.f.) Wangerin	5.1429	20.7606	0.2477	-1.3954	-0.3457	4.1429	21.3067	19.7606	410.2419	0.0519	
Casearia graveolens Dalzell	2.3665	20.7606	0.1140	-2.1716	-0.2475	1.3665	3.2339	19.7606	410.2419	0.0079	
Casearia tomentosa Roxb.	0.2049	20.7606	0.0099	-4.6181	-0.0456	-0.7951	-0.1629	19.7606	410.2419	-0.0004	
Cassia fistula L.	2.8821	20.7606	0.1388	-1.9745	-0.2741	1.8821	5.4243	19.7606	410.2419	0.0132	
Dalbergia latifolia Roxb.	1.8605	20.7606	0.0896	-2.4122	-0.2162	0.8605	1.6011	19.7606	410.2419	0.0039	
Erythrina stricta Roxb.	1.3610	20.7606	0.0656	-2.7248	-0.1786	0.3610	0.4913	19.7606	410.2419	0.0012	
Holarrhena pubescens Wall. ex G.Don	1.1304	20.7606	0.0545	-2.9105	-0.1585	0.1304	0.1474	19.7606	410.2419	0.0004	
Lagerstroemia parviflora Roxb.	0.9223	20.7606	0.0444	-3.1140	-0.1383	-0.0777	-0.0717	19.7606	410.2419	-0.0002	
Lannea coromandelica (Houtt.) Merr.	0.3458	20.7606	0.0167	-4.0948	-0.0682	-0.6542	-0.2262	19.7606	410.2419	-0.0006	
Mallotus philippensis (Lam.) Müll.Arg.	0.3202	20.7606	0.0154	-4.1718	-0.0643	-0.6798	-0.2177	19.7606	410.2419	-0.0005	
Millettia glaucescens Kurz	0.5252	20.7606	0.0253	-3.6771	-0.0930	-0.4748	-0.2494	19.7606	410.2419	-0.0006	
Premna sp.	0.2049	20.7606	0.0099	-4.6181	-0.0456	-0.7951	-0.1629	19.7606	410.2419	-0.0004	
Schleichera oleosa (Lour.) Oken	0.5764	20.7606	0.0278	-3.5840	-0.0995	-0.4236	-0.2442	19.7606	410.2419	-0.0006	
Terminalia anogeissiana Gere & Boatwr.	0.4099	20.7606	0.0197	-3.9249	-0.0775	-0.5901	-0.2419	19.7606	410.2419	-0.0006	
Terminalia elliptica Willd.	0.3458	20.7606	0.0167	-4.0948	-0.0682	-0.6542	-0.2262	19.7606	410.2419	-0.0006	
					-2.3565				D	0.0802	
				H' =	2.3565				1-D =	0.9198	

Appendix 9: Diversity and richness index for Sarlahi District

Tree species	ni	N	pi	lnpi	pi*lnpi	ni-1	ni*(ni-1)	N-1	N*(N-1)	[{ni*(ni-1)}/{N*(N-1}]	Margalefs richness index (d)
Aegle marmelos (L.) Corrêa	1.4410	75.4817	0.0191	-3.9585	-0.0756	0.4410	0.6356	74.4817	5622.0111	0.0001	3.18
Bauhinia variegata L.	0.2049	75.4817	0.0027	-5.9089	-0.0160	-0.7951	-0.1629	74.4817	5622.0111	0.0000	
Bombax ceiba L.	0.6661	75.4817	0.0088	-4.7302	-0.0417	-0.3339	-0.2224	74.4817	5622.0111	0.0000	
Dalbergia sissoo Roxb. ex DC.	12.2489	75.4817	0.1623	-1.8185	-0.2951	11.2489	137.7855	74.4817	5622.0111	0.0245	
Ehretia aspera Willd.	0.2049	75.4817	0.0027	-5.9089	-0.0160	-0.7951	-0.1629	74.4817	5622.0111	0.0000	
Lagerstroemia parviflora Roxb.	0.3458	75.4817	0.0046	-5.3856	-0.0247	-0.6542	-0.2262	74.4817	5622.0111	0.0000	
Lannea coromandelica (Houtt.) Merr.	0.5764	75.4817	0.0076	-4.8748	-0.0372	-0.4236	-0.2442	74.4817	5622.0111	0.0000	
Mallotus philippensis (Lam.) Müll.Arg.	16.7769	75.4817	0.2223	-1.5039	-0.3343	15.7769	264.6882	74.4817	5622.0111	0.0471	
Millettia glaucescens Kurz	24.1871	75.4817	0.3204	-1.1381	-0.3647	23.1871	560.8276	74.4817	5622.0111	0.0998	
Phyllanthus emblica L.	0.7205	75.4817	0.0095	-4.6517	-0.0444	-0.2795	-0.2014	74.4817	5622.0111	0.0000	
Schleichera oleosa (Lour.) Oken	0.1153	75.4817	0.0015	-6.4843	-0.0099	-0.8847	-0.1020	74.4817	5622.0111	0.0000	
Senegalia catechu (L.f.) P.J.H.Hurter & Mabb.	4.4224	75.4817	0.0586	-2.8372	-0.1662	3.4224	15.1352	74.4817	5622.0111	0.0027	
Shorea robusta C.F.Gaertn.	11.9831	75.4817	0.1588	-1.8404	-0.2922	10.9831	131.6106	74.4817	5622.0111	0.0234	
Syzygium nervosum DC.	1.0119	75.4817	0.0134	-4.3120	-0.0578	0.0119	0.0121	74.4817	5622.0111	0.0000	
Terminalia anogeissiana Gere & Boatwr.	0.4611	75.4817	0.0061	-5.0980	-0.0311	-0.5389	-0.2485	74.4817	5622.0111	0.0000	
Terminalia elliptica Willd.	0.1153	75.4817	0.0015	-6.4843	-0.0099	-0.8847	-0.1020	74.4817	5622.0111	0.0000	
					-1.8169				D	0.1973	
				H' =	1.8169				1-D =	0.8027	

Appendix 10: Diversity and richness index for Mahottari District

Tree species	ni	N	pi	lnpi	pi*lnpi	ni-1	ni*(ni-1)	N-1	N*(N-1)	[{ni*(ni-1)}/{N*(N-1}]	Margalefs richness index (d)
Adina cordifolia (Roxb.) Brandis	0.2049	68.1805	0.0030	-5.8072	-0.0175	-0.7951	-0.1629	67.1805	4580.3951	0.0000	3.21
Albizia lucida (Jacques) Benth.	0.1153	68.1805	0.0017	-6.3825	-0.0108	-0.8847	-0.1020	67.1805	4580.3951	0.0000	
Bombax ceiba L.	0.2049	68.1805	0.0030	-5.8072	-0.0175	-0.7951	-0.1629	67.1805	4580.3951	0.0000	
Casearia graveolens Dalzell	0.2049	68.1805	0.0030	-5.8072	-0.0175	-0.7951	-0.1629	67.1805	4580.3951	0.0000	
Dillenia indica L.	0.1153	68.1805	0.0017	-6.3825	-0.0108	-0.8847	-0.1020	67.1805	4580.3951	0.0000	
Ehretia aspera Willd.	2.8821	68.1805	0.0423	-3.1636	-0.1337	1.8821	5.4243	67.1805	4580.3951	0.0012	
Elaeodendron glaucum (Rottb.) Pers.	5.7642	68.1805	0.0845	-2.4705	-0.2089	4.7642	27.4614	67.1805	4580.3951	0.0060	
Lagerstroemia parviflora Roxb.	2.9173	68.1805	0.0428	-3.1515	-0.1348	1.9173	5.5934	67.1805	4580.3951	0.0012	
Mallotus philippensis (Lam.) Müll.Arg.	2.8020	68.1805	0.0411	-3.1918	-0.1312	1.8020	5.0493	67.1805	4580.3951	0.0011	
Millettia glaucescens Kurz	0.7205	68.1805	0.0106	-4.5499	-0.0481	-0.2795	-0.2014	67.1805	4580.3951	0.0000	
Phyllanthus emblica L.	0.2049	68.1805	0.0030	-5.8072	-0.0175	-0.7951	-0.1629	67.1805	4580.3951	0.0000	
Semecarpus anacardium L.f.	1.8862	68.1805	0.0277	-3.5876	-0.0992	0.8862	1.6714	67.1805	4580.3951	0.0004	
Shorea robusta C.F.Gaertn.	49.5814	68.1805	0.7272	-0.3185	-0.2316	48.5814	2408.7363	67.1805	4580.3951	0.5259	
Spondias pinnata (L.f.) Kurz	0.1153	68.1805	0.0017	-6.3825	-0.0108	-0.8847	-0.1020	67.1805	4580.3951	0.0000	
Syzygium cumini (L.) Skeels	0.1153	68.1805	0.0017	-6.3825	-0.0108	-0.8847	-0.1020	67.1805	4580.3951	0.0000	
Terminalia elliptica Willd.	0.3458	68.1805	0.0051	-5.2839	-0.0268	-0.6542	-0.2262	67.1805	4580.3951	0.0000	
	68.1805				-1.1274				D	0.5354	
				H' =	1.1274				1-D =	0.4646	

Appendix 11: Diversity and richness index for Dhanusha District

Tree species	ni	N	pi	lnpi	pi*lnpi	ni-1	ni*(ni-1)	N-1	N*(N-1)	[{ni*(ni-1)}/{N*(N-1}]	Margalefs richness index (d)
Adina cordifolia (Roxb.) Brandis	12.7100	245.9441	0.0517	-2.9627	-0.1531	11.7100	148.8337	244.9441	60242.5593	0.0025	6.057
Aegle marmelos (L.) Corrêa	0.9255	245.9441	0.0038	-5.5826	-0.0210	-0.0745	-0.0690	244.9441	60242.5593	0.0000	
Alangium salviifolium (L.f.) Wangerin	1.1304	245.9441	0.0046	-5.3825	-0.0247	0.1304	0.1474	244.9441	60242.5593	0.0000	
Albizia lucida (Jacques) Benth.	0.7205	245.9441	0.0029	-5.8329	-0.0171	-0.2795	-0.2014	244.9441	60242.5593	0.0000	
Albizia odoratissima (L.f.) Benth.	0.2306	245.9441	0.0009	-6.9723	-0.0065	-0.7694	-0.1774	244.9441	60242.5593	0.0000	
Azadirachta indica A.Juss.	0.2049	245.9441	0.0008	-7.0901	-0.0059	-0.7951	-0.1629	244.9441	60242.5593	0.0000	
Bombax ceiba L.	0.1153	245.9441	0.0005	-7.6655	-0.0036	-0.8847	-0.1020	244.9441	60242.5593	0.0000	
Bridelia retusa (L.) A.Juss.	1.4410	245.9441	0.0059	-5.1397	-0.0301	0.4410	0.6356	244.9441	60242.5593	0.0000	
Buchanania cochinchinensis (Lour.) M.R.Almeida	1.3354	245.9441	0.0054	-5.2159	-0.0283	0.3354	0.4478	244.9441	60242.5593	0.0000	
Careya arborea Roxb.	2.1712	245.9441	0.0088	-4.7298	-0.0418	1.1712	2.5428	244.9441	60242.5593	0.0000	
Casearia graveolens Dalzell	7.9257	245.9441	0.0322	-3.4350	-0.1107	6.9257	54.8914	244.9441	60242.5593	0.0009	
Cassia fistula L.	0.2049	245.9441	0.0008	-7.0901	-0.0059	-0.7951	-0.1629	244.9441	60242.5593	0.0000	
Croton persimilis Müll.Arg.	2.6867	245.9441	0.0109	-4.5168	-0.0493	1.6867	4.5318	244.9441	60242.5593	0.0001	
Dalbergia latifolia Roxb.	9.3668	245.9441	0.0381	-3.2679	-0.1245	8.3668	78.3696	244.9441	60242.5593	0.0013	
Diospyros montana Roxb.	0.2049	245.9441	0.0008	-7.0901	-0.0059	-0.7951	-0.1629	244.9441	60242.5593	0.0000	
Ehretia aspera Willd.	14.5257	245.9441	0.0591	-2.8292	-0.1671	13.5257	196.4701	244.9441	60242.5593	0.0033	
Firmiana fulgens (Wall. ex Mast.) K.Schum.	1.7613	245.9441	0.0072	-4.9391	-0.0354	0.7613	1.3408	244.9441	60242.5593	0.0000	
Flacourtia jangomas (Lour.) Raeusch.	6.3790	245.9441	0.0259	-3.6521	-0.0947	5.3790	34.3127	244.9441	60242.5593	0.0006	
Garuga pinnata Roxb.	0.7205	245.9441	0.0029	-5.8329	-0.0171	-0.2795	-0.2014	244.9441	60242.5593	0.0000	

Holarrhena pubescens Wall. ex G.Don	19.4541	245.9441	0.0791	-2.5370	-0.2007	18.4541	359.0063	244.9441	60242.5593	0.0060	
Lagerstroemia parviflora Roxb.	21.1993	245.9441	0.0862	-2.4511	-0.2113	20.1993	428.2118	244.9441	60242.5593	0.0071	
Lannea coromandelica (Houtt.) Merr.	1.9118	245.9441	0.0078	-4.8571	-0.0378	0.9118	1.7431	244.9441	60242.5593	0.0000	
Mallotus philippensis (Lam.) Müll.Arg.	20.3795	245.9441	0.0829	-2.4906	-0.2064	19.3795	394.9455	244.9441	60242.5593	0.0066	
Miliusa velutina (DC.) Hook.f. & Thomson	0.1153	245.9441	0.0005	-7.6655	-0.0036	-0.8847	-0.1020	244.9441	60242.5593	0.0000	
Pavetta tomentosa Roxb. ex Sm.	6.6000	245.9441	0.0268	-3.6180	-0.0971	5.6000	36.9596	244.9441	60242.5593	0.0006	
Phyllanthus emblica L.	1.4410	245.9441	0.0059	-5.1397	-0.0301	0.4410	0.6356	244.9441	60242.5593	0.0000	
Piliostigma malabaricum (Roxb.) Benth.	1.1304	245.9441	0.0046	-5.3825	-0.0247	0.1304	0.1474	244.9441	60242.5593	0.0000	
Schleichera oleosa (Lour.) Oken	1.9022	245.9441	0.0077	-4.8621	-0.0376	0.9022	1.7161	244.9441	60242.5593	0.0000	
Semecarpus anacardium L.f.	3.4073	245.9441	0.0139	-4.2792	-0.0593	2.4073	8.2022	244.9441	60242.5593	0.0001	
Senegalia catechu (L.f.) P.J.H.Hurter & Mabb.	7.1251	245.9441	0.0290	-3.5415	-0.1026	6.1251	43.6426	244.9441	60242.5593	0.0007	
Shorea robusta C.F.Gaertn.	82.6741	245.9441	0.3362	-1.0902	-0.3665	81.6741	6752.3385	244.9441	60242.5593	0.1121	
Stereospermum colais (Buch.-Ham. ex Dillwyn) Mabb.	0.7557	245.9441	0.0031	-5.7852	-0.0178	-0.2443	-0.1846	244.9441	60242.5593	0.0000	
Syzygium nervosum DC.	0.7205	245.9441	0.0029	-5.8329	-0.0171	-0.2795	-0.2014	244.9441	60242.5593	0.0000	
Terminalia anogeissiana Gere & Boatwr.	2.1327	245.9441	0.0087	-4.7477	-0.0412	1.1327	2.4158	244.9441	60242.5593	0.0000	
Terminalia bellirica (Gaertn.) Roxb.	0.3458	245.9441	0.0014	-6.5669	-0.0092	-0.6542	-0.2262	244.9441	60242.5593	0.0000	
Terminalia elliptica Willd.	9.8887	245.9441	0.0402	-3.2137	-0.1292	8.8887	87.8985	244.9441	60242.5593	0.0015	
	245.9441				-2.5348				D	0.1434	
				H' =	2.5348				1-D =	0.8566	

Appendix 12: Diversity and richness index for Siraha District

Tree species	ni	N	pi	lnpi	pi*lnpi	ni-1	ni*(ni-1)	N-1	N*(N-1)	[{ni*(ni-1)}/{N*(N-1}]	Margalefs richness index (d)
Adina cordifolia (Roxb.) Brandis	0.2049	100.9786	0.0020	-6.1999	-0.0126	-0.7951	-0.1629	99.9786	10095.6916	0.0000	4.40
Aegle marmelos (L.) Corrêa	0.9511	100.9786	0.0094	-4.6651	-0.0439	-0.0489	-0.0465	99.9786	10095.6916	0.0000	
Azadirachta indica A.Juss.	6.0844	100.9786	0.0603	-2.8092	-0.1693	5.0844	30.9355	99.9786	10095.6916	0.0031	
Bauhinia purpurea L.	0.7205	100.9786	0.0071	-4.9427	-0.0353	-0.2795	-0.2014	99.9786	10095.6916	0.0000	
Bombax ceiba L.	0.2306	100.9786	0.0023	-6.0821	-0.0139	-0.7694	-0.1774	99.9786	10095.6916	0.0000	
Buchanania cochinchinensis (Lour.) M.R.Almeida	5.9691	100.9786	0.0591	-2.8283	-0.1672	4.9691	29.6612	99.9786	10095.6916	0.0029	
Celastraceae	0.2049	100.9786	0.0020	-6.1999	-0.0126	-0.7951	-0.1629	99.9786	10095.6916	0.0000	
Ceriscoides turgida (Roxb.) Tirveng.	5.7642	100.9786	0.0571	-2.8632	-0.1634	4.7642	27.4614	99.9786	10095.6916	0.0027	
Ehretia aspera Willd.	0.7205	100.9786	0.0071	-4.9427	-0.0353	-0.2795	-0.2014	99.9786	10095.6916	0.0000	
Falconeria insignis Royle	0.1153	100.9786	0.0011	-6.7753	-0.0077	-0.8847	-0.1020	99.9786	10095.6916	0.0000	
Holarrhena pubescens Wall. ex G.Don	0.9255	100.9786	0.0092	-4.6924	-0.0430	-0.0745	-0.0690	99.9786	10095.6916	0.0000	
Lagerstroemia parviflora Roxb.	4.9380	100.9786	0.0489	-3.0180	-0.1476	3.9380	19.4456	99.9786	10095.6916	0.0019	
Lannea coromandelica (Houtt.) Merr.	0.3458	100.9786	0.0034	-5.6767	-0.0194	-0.6542	-0.2262	99.9786	10095.6916	0.0000	
Millettia glaucescens Kurz	7.8201	100.9786	0.0774	-2.5582	-0.1981	6.8201	53.3331	99.9786	10095.6916	0.0053	
Nyctanthes arbor-tristis L.	7.2052	100.9786	0.0714	-2.6401	-0.1884	6.2052	44.7098	99.9786	10095.6916	0.0044	
Schleichera oleosa (Lour.) Oken	0.1153	100.9786	0.0011	-6.7753	-0.0077	-0.8847	-0.1020	99.9786	10095.6916	0.0000	
Semecarpus anacardium L.f.	0.9511	100.9786	0.0094	-4.6651	-0.0439	-0.0489	-0.0465	99.9786	10095.6916	0.0000	

Senegalia catechu (L.f.) P.J.H.Hurter & Mabb.	22.3714	100.9786	0.2215	-1.5071	-0.3339	21.3714	478.1066	99.9786	10095.6916	0.0474	
Shorea robusta C.F.Gaertn.	21.4459	100.9786	0.2124	-1.5494	-0.3291	20.4459	438.4806	99.9786	10095.6916	0.0434	
Stereospermum colais (Buch.-Ham. ex Dillwyn) Mabb.	10.0873	100.9786	0.0999	-2.3036	-0.2301	9.0873	91.6661	99.9786	10095.6916	0.0091	
Terminalia anogeissiana Gere & Boatwr.	3.6026	100.9786	0.0357	-3.3333	-0.1189	2.6026	9.3761	99.9786	10095.6916	0.0009	
Wrightia arborea (Dennst.) Mabb.	0.2049	100.9786	0.0020	-6.1999	-0.0126	-0.7951	-0.1629	99.9786	10095.6916	0.0000	
	100.9786				-2.3339				D	0.1210	
				H' =	2.3339				1-D =	0.8790	

Appendix 13: Diversity and richness index for Saptari District

Tree species	ni	N	pi	lnpi	pi*lnpi	ni-1	ni*(ni-1)	N-1	N*(N-1)	[{ni*(ni-1)}/{N*(N-1}]	Margalefs richness index (d)
Adina cordifolia (Roxb.) Brandis	7.2404	177.0719	0.0409	-3.1969	-0.1307	6.2404	45.1834	176.0719	31177.4001	0.0014	6.61
Aegle marmelos (L.) Corrêa	4.3231	177.0719	0.0244	-3.7126	-0.0906	3.3231	14.3663	176.0719	31177.4001	0.0005	
Albizia lucida (Jacques) Benth.	0.3458	177.0719	0.0020	-6.2383	-0.0122	-0.6542	-0.2262	176.0719	31177.4001	0.0000	
Albizia odoratissima (L.f.) Benth.	0.1153	177.0719	0.0007	-7.3369	-0.0048	-0.8847	-0.1020	176.0719	31177.4001	0.0000	
Aporosa octandra (Buch.-Ham. ex D.Don) Vickery	5.7642	177.0719	0.0326	-3.4249	-0.1115	4.7642	27.4614	176.0719	31177.4001	0.0009	
Bauhinia purpurea L.	0.1153	177.0719	0.0007	-7.3369	-0.0048	-0.8847	-0.1020	176.0719	31177.4001	0.0000	
Bombax ceiba L.	0.2049	177.0719	0.0012	-6.7616	-0.0078	-0.7951	-0.1629	176.0719	31177.4001	0.0000	
Bridelia retusa (L.) A.Juss.	5.4792	177.0719	0.0309	-3.4756	-0.1075	4.4792	24.5420	176.0719	31177.4001	0.0008	
Buchanania cochinchinensis (Lour.) M.R.Almeida	4.0125	177.0719	0.0227	-3.7871	-0.0858	3.0125	12.0877	176.0719	31177.4001	0.0004	
Careya arborea Roxb.	0.9511	177.0719	0.0054	-5.2267	-0.0281	-0.0489	-0.0465	176.0719	31177.4001	0.0000	
Casearia graveolens Dalzell	2.8821	177.0719	0.0163	-4.1180	-0.0670	1.8821	5.4243	176.0719	31177.4001	0.0002	
Croton persimilis Müll.Arg.	12.6587	177.0719	0.0715	-2.6382	-0.1886	11.6587	147.5851	176.0719	31177.4001	0.0047	
Cycas pectinata Buch.-Ham.	0.2049	177.0719	0.0012	-6.7616	-0.0078	-0.7951	-0.1629	176.0719	31177.4001	0.0000	
Dalbergia latifolia Roxb.	0.9255	177.0719	0.0052	-5.2540	-0.0275	-0.0745	-0.0690	176.0719	31177.4001	0.0000	
Dillenia indica L.	1.1560	177.0719	0.0065	-5.0316	-0.0328	0.1560	0.1804	176.0719	31177.4001	0.0000	
Ehretia aspera Willd.	2.9974	177.0719	0.0169	-4.0788	-0.0690	1.9974	5.9868	176.0719	31177.4001	0.0002	

Elaeodendron glaucum (Rottb.) Pers.	2.9974	177.0719	0.0169	-4.0788	-0.0690	1.9974	5.9868	176.0719	31177.4001	0.0002	
Erythrina stricta Roxb.	3.8332	177.0719	0.0216	-3.8329	-0.0830	2.8332	10.8600	176.0719	31177.4001	0.0003	
Ficus benjamina L.	0.1153	177.0719	0.0007	-7.3369	-0.0048	-0.8847	-0.1020	176.0719	31177.4001	0.0000	
Ficus hispida L.f.	0.7205	177.0719	0.0041	-5.5043	-0.0224	-0.2795	-0.2014	176.0719	31177.4001	0.0000	
Firmiana fulgens (Wall. ex Mast.) K.Schum.	5.6201	177.0719	0.0317	-3.4502	-0.1095	4.6201	25.9650	176.0719	31177.4001	0.0008	
Grewia eriocarpa Juss.	0.9511	177.0719	0.0054	-5.2267	-0.0281	-0.0489	-0.0465	176.0719	31177.4001	0.0000	
Holarrhena pubescens Wall. ex G.Don	3.8076	177.0719	0.0215	-3.8396	-0.0826	2.8076	10.6899	176.0719	31177.4001	0.0003	
Hymenodictyon orixense (Roxb.) Mabb.	0.8198	177.0719	0.0046	-5.3753	-0.0249	-0.1802	-0.1477	176.0719	31177.4001	0.0000	
Kydia calycina Roxb.	1.4410	177.0719	0.0081	-4.8112	-0.0392	0.4410	0.6356	176.0719	31177.4001	0.0000	
Lagerstroemia parviflora Roxb.	21.6701	177.0719	0.1224	-2.1006	-0.2571	20.6701	447.9213	176.0719	31177.4001	0.0144	
Lannea coromandelica (Houtt.) Merr.	2.0271	177.0719	0.0114	-4.4700	-0.0512	1.0271	2.0819	176.0719	31177.4001	0.0001	
Miliusa velutina (DC.) Hook.f. & Thomson	7.2052	177.0719	0.0407	-3.2018	-0.1303	6.2052	44.7098	176.0719	31177.4001	0.0014	
Millettia glaucescens Kurz	22.9670	177.0719	0.1297	-2.0425	-0.2649	21.9670	504.5158	176.0719	31177.4001	0.0162	
Pavetta tomentosa Roxb. ex Sm.	0.2049	177.0719	0.0012	-6.7616	-0.0078	-0.7951	-0.1629	176.0719	31177.4001	0.0000	
Schleichera oleosa (Lour.) Oken	1.2457	177.0719	0.0070	-4.9569	-0.0349	0.2457	0.3061	176.0719	31177.4001	0.0000	
Semecarpus anacardium L.f.	1.5019	177.0719	0.0085	-4.7698	-0.0405	0.5019	0.7538	176.0719	31177.4001	0.0000	
Senegalia catechu (L.f.) P.J.H.Hurter & Mabb.	9.1810	177.0719	0.0518	-2.9594	-0.1534	8.1810	75.1103	176.0719	31177.4001	0.0024	
Shorea robusta C.F.Gaertn.	32.1128	177.0719	0.1814	-1.7073	-0.3096	31.1128	999.1192	176.0719	31177.4001	0.0320	

Stereospermum colais (Buch.-Ham. ex Dillwyn) Mabb.	0.9511	177.0719	0.0054	-5.2267	-0.0281	-0.0489	-0.0465	176.0719	31177.4001	0.0000	
Syzygium cumini (L.) Skeels	0.5764	177.0719	0.0033	-5.7275	-0.0186	-0.4236	-0.2442	176.0719	31177.4001	0.0000	
Syzygium nervosum DC.	0.7205	177.0719	0.0041	-5.5043	-0.0224	-0.2795	-0.2014	176.0719	31177.4001	0.0000	
Terminalia anogeissiana Gere & Boatwr.	4.6882	177.0719	0.0265	-3.6315	-0.0961	3.6882	17.2909	176.0719	31177.4001	0.0006	
Terminalia elliptica Willd.	2.3377	177.0719	0.0132	-4.3274	-0.0571	1.3377	3.1271	176.0719	31177.4001	0.0001	
	177.0719				-2.9121				D	0.0779	
				H' =	2.9121				1-D =	0.9221	

Appendix 14: Diversity and richness index for whole Chure region of Madhesh Province

Tree species	ni	N	pi	lnpi	pi*lnpi	ni-1	ni*(ni-1)	N-1	N*(N-1)	[{ni*(ni-1)}/{N*(N-1}]	Margalefs richness index (d)
Adina cordifolia (Roxb.) Brandis	21.8974	870.6707	0.0252	-3.6829	-0.0926	20.8974	457.5997	869.6707	757196.7817	0.0006	9.0668
Aegle marmelos (L.) Corrêa	10.8430	870.6707	0.0125	-4.3857	-0.0546	9.8430	106.7284	869.6707	757196.7817	0.0001	
Alangium salviifolium (L.f.) Wangerin	7.1091	870.6707	0.0082	-4.8079	-0.0393	6.1091	43.4307	869.6707	757196.7817	0.0001	
Albizia lucida (Jacques) Benth.	1.7068	870.6707	0.0020	-6.2346	-0.0122	0.7068	1.2064	869.6707	757196.7817	0.0000	
Albizia odoratissima (L.f.) Benth.	0.3458	870.6707	0.0004	-7.8310	-0.0031	-0.6542	-0.2262	869.6707	757196.7817	0.0000	
Aphanamixis polystachya (Wall.) R.Parker	0.1153	870.6707	0.0001	-8.9296	-0.0012	-0.8847	-0.1020	869.6707	757196.7817	0.0000	
Aporosa octandra (Buch.-Ham. ex D.Don) Vickery	5.7642	870.6707	0.0066	-5.0176	-0.0332	4.7642	27.4614	869.6707	757196.7817	0.0000	
Azadirachta indica A.Juss.	6.2893	870.6707	0.0072	-4.9304	-0.0356	5.2893	33.2665	869.6707	757196.7817	0.0000	
Bauhinia purpurea L.	0.8358	870.6707	0.0010	-6.9486	-0.0067	-0.1642	-0.1372	869.6707	757196.7817	0.0000	
Bauhinia variegata L.	0.2049	870.6707	0.0002	-8.3543	-0.0020	-0.7951	-0.1629	869.6707	757196.7817	0.0000	
Bombax ceiba L.	1.4218	870.6707	0.0016	-6.4173	-0.0105	0.4218	0.5998	869.6707	757196.7817	0.0000	
Bridelia retusa (L.) A.Juss.	7.6503	870.6707	0.0088	-4.7345	-0.0416	6.6503	50.8772	869.6707	757196.7817	0.0001	

Buchanania cochinchinensis (Lour.) M.R.Almeida	15.2846	870.6707	0.0176	-4.0424	-0.0710	14.2846	218.3357	869.6707	757196.7817	0.0003	
Careya arborea Roxb.	3.4425	870.6707	0.0040	-5.5331	-0.0219	2.4425	8.4082	869.6707	757196.7817	0.0000	
Casearia graveolens Dalzell	19.1434	870.6707	0.0220	-3.8173	-0.0839	18.1434	347.3276	869.6707	757196.7817	0.0005	
Casearia tomentosa Roxb.	0.2049	870.6707	0.0002	-8.3543	-0.0020	-0.7951	-0.1629	869.6707	757196.7817	0.0000	
Cassia fistula L.	7.6407	870.6707	0.0088	-4.7358	-0.0416	6.6407	50.7399	869.6707	757196.7817	0.0001	
Celastraceae	0.2049	870.6707	0.0002	-8.3543	-0.0020	-0.7951	-0.1629	869.6707	757196.7817	0.0000	
Ceriscoides turgida (Roxb.) Tirveng.	5.7642	870.6707	0.0066	-5.0176	-0.0332	4.7642	27.4614	869.6707	757196.7817	0.0000	
Croton persimilis Müll.Arg.	26.6080	870.6707	0.0306	-3.4881	-0.1066	25.6080	681.3790	869.6707	757196.7817	0.0009	
Cycas pectinata Buch.-Ham.	0.2049	870.6707	0.0002	-8.3543	-0.0020	-0.7951	-0.1629	869.6707	757196.7817	0.0000	
Dalbergia latifolia Roxb.	13.2832	870.6707	0.0153	-4.1828	-0.0638	12.2832	163.1601	869.6707	757196.7817	0.0002	
Dalbergia sissoo Roxb. ex DC.	12.2489	870.6707	0.0141	-4.2638	-0.0600	11.2489	137.7855	869.6707	757196.7817	0.0002	
Dillenia indica L.	5.6553	870.6707	0.0065	-5.0367	-0.0327	4.6553	26.3270	869.6707	757196.7817	0.0000	
Diospyros montana Roxb.	0.2049	870.6707	0.0002	-8.3543	-0.0020	-0.7951	-0.1629	869.6707	757196.7817	0.0000	
Ehretia aspera Willd.	21.8558	870.6707	0.0251	-3.6848	-0.0925	20.8558	455.8199	869.6707	757196.7817	0.0006	
Elaeodendron glaucum (Rottb.) Pers.	9.4821	870.6707	0.0109	-4.5199	-0.0492	8.4821	80.4272	869.6707	757196.7817	0.0001	
Erythrina stricta Roxb.	5.1942	870.6707	0.0060	-5.1217	-0.0306	4.1942	21.7851	869.6707	757196.7817	0.0000	
Falconeria insignis Royle	0.2306	870.6707	0.0003	-8.2365	-0.0022	-0.7694	-0.1774	869.6707	757196.7817	0.0000	

Ficus benjamina L.	0.1153	870.6707	0.0001	-8.9296	-0.0012	-0.8847	-0.1020	869.6707	757196.7817	0.0000	
Ficus hispida L.f.	0.7205	870.6707	0.0008	-7.0970	-0.0059	-0.2795	-0.2014	869.6707	757196.7817	0.0000	
Firmiana fulgens (Wall. ex Mast.) K.Schum.	7.3813	870.6707	0.0085	-4.7703	-0.0404	6.3813	47.1027	869.6707	757196.7817	0.0001	
Flacourtia jangomas (Lour.) Raeusch.	6.3790	870.6707	0.0073	-4.9163	-0.0360	5.3790	34.3127	869.6707	757196.7817	0.0000	
Garuga pinnata Roxb.	1.3866	870.6707	0.0016	-6.4424	-0.0103	0.3866	0.5361	869.6707	757196.7817	0.0000	
Glochidion heyneanum (Wight & Arn.) Wight	0.7205	870.6707	0.0008	-7.0970	-0.0059	-0.2795	-0.2014	869.6707	757196.7817	0.0000	
Gmelina arborea Roxb. ex Sm.	0.1153	870.6707	0.0001	-8.9296	-0.0012	-0.8847	-0.1020	869.6707	757196.7817	0.0000	
Grewia eriocarpa Juss.	1.1560	870.6707	0.0013	-6.6243	-0.0088	0.1560	0.1804	869.6707	757196.7817	0.0000	
Holarrhena pubescens Wall. ex G.Don	26.0380	870.6707	0.0299	-3.5097	-0.1050	25.0380	651.9402	869.6707	757196.7817	0.0009	
Hymenodictyon orixense (Roxb.) Mabb.	0.9351	870.6707	0.0011	-6.8364	-0.0073	-0.0649	-0.0607	869.6707	757196.7817	0.0000	
Kydia calycina Roxb.	1.4410	870.6707	0.0017	-6.4039	-0.0106	0.4410	0.6356	869.6707	757196.7817	0.0000	
Lagerstroemia parviflora Roxb.	65.4553	870.6707	0.0752	-2.5879	-0.1946	64.4553	4218.9402	869.6707	757196.7817	0.0056	
Lannea coromandelica (Houtt.) Merr.	11.5027	870.6707	0.0132	-4.3267	-0.0572	10.5027	120.8096	869.6707	757196.7817	0.0002	
Mallotus nudiflorus (L.) Kulju & Welzen	0.2049	870.6707	0.0002	-8.3543	-0.0020	-0.7951	-0.1629	869.6707	757196.7817	0.0000	
Mallotus philippensis (Lam.) Müll.Arg.	69.8649	870.6707	0.0802	-2.5227	-0.2024	68.8649	4811.2367	869.6707	757196.7817	0.0064	
Miliusa velutina (DC.) Hook.f. & Thomson	9.0818	870.6707	0.0104	-4.5630	-0.0476	8.0818	73.3966	869.6707	757196.7817	0.0001	

Millettia glaucescens Kurz	56.2198	870.6707	0.0646	-2.7400	-0.1769	55.2198	3104.4485	869.6707	757196.7817	0.0041	
Nyctanthes arbor-tristis L.	30.2619	870.6707	0.0348	-3.3594	-0.1168	29.2619	885.5187	869.6707	757196.7817	0.0012	
Ougeinia oojeinensis (Roxb.) Hochr.	6.7505	870.6707	0.0078	-4.8597	-0.0377	5.7505	38.8185	869.6707	757196.7817	0.0001	
Pavetta tomentosa Roxb. ex Sm.	6.8049	870.6707	0.0078	-4.8516	-0.0379	5.8049	39.5020	869.6707	757196.7817	0.0001	
Phyllanthus emblica L.	3.2920	870.6707	0.0038	-5.5778	-0.0211	2.2920	7.5451	869.6707	757196.7817	0.0000	
Piliostigma malabaricum (Roxb.) Benth.	1.1304	870.6707	0.0013	-6.6467	-0.0086	0.1304	0.1474	869.6707	757196.7817	0.0000	
Pinus roxburghii Sarg.	1.2681	\	0.0015	-6.5317	-0.0095	0.2681	0.3400	869.6707	757196.7817	0.0000	
Premna sp.	0.2049	870.6707	0.0002	-8.3543	-0.0020	-0.7951	-0.1629	869.6707	757196.7817	0.0000	
Schleichera oleosa (Lour.) Oken	4.1854	870.6707	0.0048	-5.3377	-0.0257	3.1854	13.3323	869.6707	757196.7817	0.0000	
Semecarpus anacardium L.f.	8.8128	870.6707	0.0101	-4.5931	-0.0465	7.8128	68.8521	869.6707	757196.7817	0.0001	
Senegalia catechu (L.f.) P.J.H.Hurter & Mabb.	43.0999	870.6707	0.0495	-3.0057	-0.1488	42.0999	1814.5051	869.6707	757196.7817	0.0024	
Shorea robusta C.F.Gaertn.	248.4131	870.6707	0.2853	-1.2542	-0.3578	247.4131	61460.6478	869.6707	757196.7817	0.0812	
Spondias pinnata (L.f.) Kurz	0.1153	870.6707	0.0001	-8.9296	-0.0012	-0.8847	-0.1020	869.6707	757196.7817	0.0000	
Sterculia villosa Roxb. ex Sm.	0.6405	870.6707	0.0007	-7.2148	-0.0053	-0.3595	-0.2303	869.6707	757196.7817	0.0000	
Stereospermum colais (Buch.-Ham. ex Dillwyn) Mabb.	11.9094	870.6707	0.0137	-4.2919	-0.0587	10.9094	129.9245	869.6707	757196.7817	0.0002	

Syzygium cumini (L.) Skeels	0.6917	870.6707	0.0008	-7.1379	-0.0057	-0.3083	-0.2133	869.6707	757196.7817	0.0000	
Syzygium nervosum DC.	2.6835	870.6707	0.0031	-5.7821	-0.0178	1.6835	4.5178	869.6707	757196.7817	0.0000	
Terminalia anogeissiana Gere & Boatwr.	12.6908	870.6707	0.0146	-4.2284	-0.0616	11.6908	148.3648	869.6707	757196.7817	0.0002	
Terminalia bellirica (Gaertn.) Roxb.	1.4763	870.6707	0.0017	-6.3797	-0.0108	0.4763	0.7031	869.6707	757196.7817	0.0000	
Terminalia chebula Retz.	0.2049	870.6707	0.0002	-8.3543	-0.0020	-0.7951	-0.1629	869.6707	757196.7817	0.0000	
Terminalia elliptica Willd.	16.2742	870.6707	0.0187	-3.9797	-0.0744	15.2742	248.5741	869.6707	757196.7817	0.0003	
Wrightia arborea (Dennst.) Mabb.	0.2049	870.6707	0.0002	-8.3543	-0.0020	-0.7951	-0.1629	869.6707	757196.7817	0.0000	
					-3.00				D	0.1068	
				H' =	3.0				1-D =	0.8932	

Appendix 16: DATASHEET FOR VEGETATION SAMPLING

General Information

Name of person(s) filling this form			
Start time		End time	
Plot ID (as GPS code)		Plot code	Grid: CCSP:
Lat. (N)		Long. (E)	
Waypoint No.		Photo No.	
Location			

Forest

Name of forest		Forest type	
Forest management type	National forest/Community forest/ National park forest		
Outside PA	Name of NF/CF/NP:		
Inside PA			

Tree canopy (Densiometer)

Tree canopy cover (%): open, 1-10, 11-20, 21-30, 31-40, 41-50, 51-60, 61-70, 71-80, 81-90

Disturbances

Sign of grazing (0-3):	
Presence of logging (greater than 10 cm D): Yes/NO Number of stumps: No. of fallen dead trees:	Presence of dead trees (in 10 m): Yes /No No. of standing dead trees:
Presence of lopping (No. of lopped trees and sapling):	
Sign of elephant activities (Yes/No):	Landslide (Yes/No):
Sign of other animal's activities: (Yes/No):	Resin tapping:
Is there any trail passing through plot (Yes/No):	Litter collection (%):
Sign of fire (Yes/No):	Sign of bush removal:
Sign of NTFPs collection:	Plastic pollution:

Seedlings (SE) (from four square 1×1 m sub-plots located to the cardinal points (N, E, S and W) 5 meters apart from the plot center)

S.N.	**Name of species**	**Cover (%)**				**Specimen No.**
		Sub-plot A	**Sub-plot B**	**Sub-plot C**	**Sub-plot D**	
1						
2						

Saplings (SA) (from four sub-plots with the radius of 2 m that are located 10 meters from the center of the plot in the four cardinal directions (N, E, S and W)

S.N.	Name of species	Cover (%)				Specimen No.
		Sub-plot A	Sub-plot B	Sub-plot C	Sub-plot D	
1						
2						

Any interesting observation on site:

Trees (Individuals of tree species having DBH ≥30 cm from the sub-plot with radius of 20 m)

S.N.	Name of species	Distance (tree to observer)	Angle (Tree top) Clinometer	Tree height (m)	DBH (cm)	Herbarium No.
1						
2						

Trees (Individuals of tree species having DBH 20 to <30 from the sub-plot with radius of 15 m)

S.N.	Name of species	Distance (tree to observer)	Angle (Tree top) Clinometer	Tree height (m)	DBH (cm)	Herbarium No.
1						
2						

Trees (Individuals of tree species having DBH 10 to <20 from the sub-plot with radius of 8 m)

S.N.	Name of species	Distance (tree to observer)	Angle (Tree top) Clinometer	Tree height (m)	DBH (cm)	Herbarium No.
1						
2						

Trees (Individuals of tree species having DBH 5 to <10 from the sub-plot with radius of 4 m)

S.N.	Name of species	Distance (tree to observer)	Angle (Tree top) Clinometer	Tree height (m)	DBH (cm)	Herbarium No.
1						
2						

Remarks

Appendix 17: Permission letters

नेपाल सरकार
वन तथा वातावरण मन्त्रालय
वनस्पति विभाग
(..................................शाखा)

☎ ४२६१९६६, ४२६१९६७, ४२५११५९, ५३५११६१

PLANTS FOR LIFE

पत्र संख्याः- ०८०/८१
चलानी नम्बरः- १८०

नेपाल सरकार वन तथा वातावरण मन्त्रालय वनस्पति विभाग

इमेलः info@dpr.gov.np
वनस्पति मार्ग, थापाथली
काठमाडौं

विषय: अनुसन्धान अनुमति सम्बन्धमा ।

मितिः २०८०/०५/१५

डा.नारायण प्रसाद घिमिरे
उप-प्रध्यापक, वनस्पतिशास्त्र केन्द्रीय विभाग, त्रि. वि. ।

प्रस्तुत विषयमा यस विभागको मिति २०८०/०५/१३ को निर्णयानुसार तपाईंलाई देहाय बमोजिमका शर्तहरुमा रही वनस्पति स्रोतको अनुसन्धान कार्यविधि, २०७०(पहिलोसंशोधन,२०७३) बमोजिम अनुसन्धान गर्न निम्नानुसार अनुमति प्रदान गरिएको छ ।

अनुसन्धानकर्ताको नाम	पहिलो	बीचको	थर	
	नारायण	प्रसाद	घिमिरे	
अनुसन्धानकर्ताको ठेगाना	स्थायी:पाल्पा अस्थायी: कीर्तिपुर	ईमेल: -np.ghimire@cdbtu.edu.np	फोन नं. ९८४१६५२९९८	
सम्बद्ध संस्था	संस्थाको नाम: श्री वनस्पति शास्त्र केन्द्रीय विभाग।	ठेगाना: कीर्तिपुर, काठमाडौं ।		
पद	उप-प्रध्यापक			
अनुसन्धान तह	व्यक्तिगत: अन्य	संस्थागत: राष्ट्रियय✓/ अन्तर्राष्ट्रिय		
अनुसन्धानको शीर्षक	**"Floristic Diversity, Vegetation Ecology and Ethnobotany of Chure Region of Madhesh Pradesh, Nepal"**			
अनुसन्धानको क्षेत्र	मधेश प्रदेश का ८ वटा जिल्ला।			
अनुसन्धानको विधि	Vegetation sampling, Plant specimen collection, Questionnaire survey, Interviews	नमूना संकलन	नमूनाको परीक्षण	
		वानस्पतिक मृत नमूना संकलन।	नेपालमा	-
अनुसन्धानको समयावधि	वि.स.२०८० देखि २०८२ सम्म।			
अनुसन्धानको शर्तहरु	(१)अनुसन्धानकर्ताले वन तथा भू-संरक्षण विभाग र राष्ट्रिय निकुञ्ज तथा वन्यजन्तु संरक्षण विभागबाट प्राप्त पत्रमा उल्लेखित शर्तहरुको पालना गर्नुपर्नेछ । (२)अनुसन्धानकर्ताले वन तथा वातावरण मन्त्रालय, मधेश प्रदेश,सम्बन्धितडिभिजन वन कार्यालय र सम्बन्धित निकुञ्जकार्यालयको समन्वयमा अध्ययन कार्य गर्नुपर्नेछ। (३)अनुसन्धानकर्ताले वनस्पति अनुसन्धान केन्द्र,धनुषाको समन्वय तथा प्रत्यक्ष निगरानीमा अध्ययन कार्य गर्नुपर्नेछ। (४)प्रत्येक वनस्पति प्रजातिका मृत नमूनाहरु (हर्बेरियम नमूनाहरु) बढीमा तीन प्रति संकलन गर्नुपर्नेछ । (५)वनस्पतिका नमूनाहरु संकलनको क्रममा नेपालको प्रतिबन्धित र साईटिसमा सूचीकृत वनस्पतिको नमूनाहरु संकलन गर्न पाईने छैन। (६)संकलित वनस्पतिका मृत नमूनाहरु (हर्बेरियम नमूनाहरु) प्रत्येकको एक थान श्री राष्ट्रिय हर्बेरियम तथा वनस्पति प्रयोगशाला (KATH) गोदावरी, ललितपुरमा बुझाउनु पर्नेछ र सोको जानकारी यस विभागलाई दिनुपर्नेछ। (७) अध्ययन अनुसन्धानको क्रममा नेपालबाट पहिलो पटक नयाँ बिरुवा पत्ता लागेमा अनुसन्धानकर्ताले नमूनाको Holotype तथा Isotype एकीन भएमा राष्ट्रिय हर्बेरियम तथा वनस्पति प्रयोगशाला गोदावरी, ललितपुरमा बुझाउनुपर्नेछ । (८) प्रस्तावमाउल्लेख भए बमोजिम अनुसन्धान प्रयोजनका लागि मात्र वनस्पतिका नमूना संरक्षण क्षेत्र बाहेकका क्षेत्रमा संकलन तथा अध्ययन अनुसन्धान गर्नुपर्नेछ। (९) अध्ययनकर्ताले अनुसन्धानबाट प्राप्त नतिजा प्रकाशन तथा प्रसारण गर्नुपूर्व एक प्रति प्रतिवेदन विभागमा बुझाउनुका साथै प्रकाशित लेख रचना ३५ दिनभित्र विभागमा पेश गर्नुपर्नेछ। (१०) अनुसन्धानकर्ताले नेपाल सरकारको प्रचलित ऐन, कानून तथा स्थानीय नियम, मूल्य र मान्यता विपरित कुनै पनि कार्य गर्न पाउने छैन।				

वोधार्थः
श्री वन तथा वातावरण मन्त्रलाय, काठमाडौं
श्री वन तथा वातावरण मन्त्रलाय, मधेश प्रदेश
श्री वन तथा भू-संरक्षण विभाग, काठमाडौं
श्री डिभिजन वन कार्यालय धनुषा,महोत्तरी, सर्लाही, सप्तरी, सिराहा,रौतहट,बारा,पर्सा
श्री राष्ट्रिय निकुञ्ज तथा वन्यजन्तु संरक्षण विभाग, काठमाडौं
श्री वनस्पति अनुसन्धान केन्द्र,धनुषा।

०५/१५
संगिता स्वार
योजना अधिकृत

नेपाल सरकार
वन तथा वातावरण मन्त्रालय

वन तथा भू-संरक्षण विभाग

फोन नं. ४-२२७५७४, ४-२२०३०३
फ्याक्सः ४-२२७३७४

(कृपया पत्रोत्तरमा प्राप्त पत्र संख्या र मिति उल्लख गर्नुहोला ।
बबरमहल, काठमाडौं, नेपाल

प्राप्त पत्र संख्या र मितिः-
पत्र संख्याः- ४०८०/८१
च. नं.:- १८५

नेपाल सरकार वन तथा वातावरण मन्त्रालय वन तथा भू-संरक्षण विभाग बबरमहल

मिति : २०८०/०५/०४

विषयः अनुसन्धान अनुमति सम्बन्धमा ।

श्री नारायण प्रसाद घिमिरे,
पाल्पा, नेपाल ।

प्रस्तुत विषयमा Central Department of Botany, Tribhuwan University, Kirtipur, Kathmandu मा Assistant Professor को रुपमा कार्यरत तपाईले "Floristic Diversity, Vegetation Ecology and Ethnobotany of Chure Region of Madhesh Pradesh, Nepal" को विषयमा अध्ययन अनुसन्धानका लागि अध्ययन अनुमति उपलब्ध गराइदिनु हुन भनि मिति २०८०/०४/३० गते यस विभागमा दिनु भएको निवेदन साथ प्रपोजल प्राप्त भयो । सो सम्बन्धमा कारवाही हुँदा उक्त प्रपोजलमा उल्लेखित Methodology (Vegetation Sampling, Plant Collection, Questionnaire Survey, Interviews, Focus group discussion) अनुसार तपसिलको शर्तहरुको अधिनमा रही डिभिजन वन कार्यालयसँग समन्वय गरि सन् २०२३, अगष्ट देखि सन् २०२४, अगष्ट सम्मका लागि अनुसन्धान गर्नु हुन निर्देशानुसार अनुरोध छ ।

<u>शर्तहरु</u>

१. अनुसन्धानकर्ताले वन ऐन २०७६ तथा वन नियमावली २०७९, राष्टिय निकुञ्ज तथा वन्यजन्तु संरक्षण ऐन, २०२९ र नियमावली २०३० तथा यस मातहतका नियमावलीहरुको पूर्ण पालना गर्नुपर्नेछ ।
२. अनुसन्धान कार्य डिभिजन वन कार्यालयसँगको समन्वयमा गर्नुपर्नेछ ।
३. संकलित नमुनाहरुको अध्ययन र पहिचानपछि Central Department of Botany, किर्तिपुर, काठमाण्डौको हर्वेरियम प्रयोगशालामा र गोदावरी राष्टिय हर्वेरियम प्रयोगशाला, गोदावरी, ललितपुरमा गर्नुपर्नेछ ।
४. अनुसन्धानको क्रममा प्राप्त भएको जैविक विविधता संरक्षणसँग सम्बन्धित संवेदनशिल सूचनाहरु गोप्य राख्नु पर्नेछ अनाधिकृत रुपमा त्यस्ता सूचनाहरु कसैलाई पनि उपलब्ध गराउन पाइने छैन ।
५. अनुसन्धान कार्य समाप्त भए पश्चात एक प्रति रिपोर्ट/प्रतिवेदन (कागजी तथा विद्युतिय) यस विभागमा अनिवार्य रुपमा बुझाउनु पर्नेछ ।
६. तोकिएका शर्तहरुको पालना नगरिएमा विभागले कुनै पनि समयमा अनुसन्धान अनुमति रद्द गर्न सक्नेछ । =

(सबनम पाठक)
सहायक वन अधिकृत

<u>बोधार्थ</u>

श्री डिभिजन वन कार्यालय, सप्तरी, सिराहा, धनुषा, महोत्तरी, सर्लाही, बारा, पर्सा, रौतहट। : जानकारी तथा आवश्यक सहयोगका लागि अनुरोध छ ।

नेपाल सरकार
वन तथा वातावरण मन्त्रालय
राष्ट्रिय निकुञ्ज तथा वन्यजन्तु संरक्षण विभाग

फोन नं. : ४२२०८५०
: ४२२०९१२
: ४२२७९२६
फ्याक्स नं. : ४२२७६७५

पत्र संख्या २०८०/८१, ६३५ .... शाखा)
चलानी नं. : - ४३१

पो.ब. नं. - ८६०
बबरमहल, काठमाडौं
Email : info@dnpwc.gov.np
http//:www.dnpwc.gov.np

इकोलोजी

मिति: २०८०/०५/१५

विषय: अध्ययन-अनुसन्धान अनुमति सम्बन्धमा ।

श्री चितवन राष्ट्रिय निकुञ्ज कार्यालय,
कसरा, चितवन ।

प्रस्तुत विषयमा तहाँ निकुञ्ज क्षेत्रमा निम्नानुसारको अध्ययन अनुसन्धानको अनुमति प्रदान गरिएको व्यहोरा आदेशानुसार अनुरोध छ ।

अनुसन्धानकर्ताको नाम	Narayan Prasad Ghimire सहितको ५ जनाको नेपाली टोली		
ठेगाना	Palpa	इमेल : np.ghimire@cdbtu.edu.np	फोन नं: ९८४१६५२९९८
सम्बद्ध संस्था	Central Department of Botany, Tribhuvan University.		
अनुसन्धानको प्रकृति	Personal		
पद	Assistant Professor		
अनुसन्धानको तह	Others		
अनुसन्धानको शीर्षक	Floristic diversity vegetation ecology and Ethnobotany of Chure region of Madhesh Pradesh, Nepal.		
अनुसन्धान विधि	Vegetation sampling, plant specimen collection, questionnaire, interviews.	नमूना संकलन	नमूना परिक्षण कहाँ गर्ने
		गर्ने	नेपाल
अनुसन्धानको अवधि	१ सेप्टेम्बर,२०२३ देखि २९ अगस्ट, २०२४ सम्म		

शर्तहरु :

१. अनुसन्धानकर्ताले राष्ट्रिय निकुञ्ज तथा वन्यजन्तु संरक्षण ऐन, २०२९ र नियमावली, २०३० तथा मातहतका सबै नियमावलीहरुको पूर्ण पालना गर्नु पर्नेछ ।
२. अनुसन्धानकर्ताले आफ्नो अनुसन्धानको प्रस्ताव सम्बन्धित निकुञ्ज कार्यालय समेत पेश गर्नु पर्नेछ ।
३. अध्ययन अनुसन्धान गर्दा सम्बन्धित निकुञ्ज कार्यालयसँग समन्वय गरी गर्नु पर्नेछ ।
४. अनुसन्धानकर्ताले अनुसन्धान समाप्त भएपछि प्राप्त तथ्यांक, एक प्रति कागजी र एक प्रति इलोक्ट्रोनिक प्रतिवेदन यस विभाग र निकुञ्ज कार्यालयमा बुझाउनु पर्नेछ ।
५. अनुसन्धानकर्ताले नतिजाहरु प्रकाशित गर्दा अनुसन्धानमा संलग्न यस विभाग र अन्तर्गतका कर्मचारीको योगदानको आधारमा सहलेखकको रुपमा समावेश गराउनु पर्नेछ ।
६. अध्ययनको क्रममा नचिनिएका प्रजातीको मात्र नमूना संकलन गर्नुपर्ने र सो नमूना संकलन गर्दा सम्बन्धित निकुञ्जको प्राबिधिक कर्मचारीको रोहबरमा मात्र गर्नु पर्नेछ ।
७. नमूना संकलन गर्दा हर्वेरियम प्रयोगशालामा अभिलेखिकरण तथा ल्याव परिक्षण प्रयोजनका लागि जम्मा २ वटा मात्र नमूना संकलन गर्नु पर्नेछ ।
८. संकलित नमूना विदेश लैजान पाईने छैन ।
९. तोकिएका शर्तहरुको पालना नगरेमा विभागले कुनै पनि समयमा अनुमतिपत्र रद्द गर्न सक्नेछ ।
१०. बाँकीको हकमा प्रचलित ऐन कानून बमोजिम हुनेछ ।

(अशिम थापा)
इकोलोजिष्ट

बोधार्थ:
श्री **Narayan Prasad Ghimire सहितको ५ जनाको नेपाली टोली :** सम्बन्धित निकुञ्ज कार्यालयसंग समन्वय गरी अध्ययन अनुसन्धान गर्नु हुन ।

नेपाल सरकार
वन तथा वातावरण मन्त्रालय
राष्ट्रिय निकुञ्ज तथा वन्यजन्तु संरक्षण विभाग
पर्सा राष्ट्रिय निकुञ्ज कार्यालय
आधाभार, बारा

PARSA NATIONAL PARK
पर्सा राष्ट्रिय निकुञ्ज
२०४१

पत्र संख्या: २०८०/०८१ मिति : २०८०/०५/२९
चलानी नं.: २६८

विषय : अध्ययन अनुसन्धान अनुमति सम्बन्धमा।

श्री नारायण प्रसाद घिमिरे,

Central Department of Botany, Tribhuvan University, Kirtipur।

प्रस्तुत विषयमा राष्ट्रिय निकुञ्ज तथा वन्यजन्तु संरक्षण विभागको पत्र संख्या २०८०/०८१/ईको २४ चलानी नं. ४०१ मिति २०८०/०४/३० गतेको पत्रानुसार यस पर्सा राष्ट्रिय निकुञ्जमा निम्नानुसारको अध्ययन अनुसन्धान अनुमति दिईएको व्यहोरा अनुरोध गर्दछु।

अनुसन्धानकर्ताको नाम	Narayan Prasad Ghimire		
ठेगाना	पाल्पा, गण्डकी प्रदेश	ईमेल : np.ghimire@cdbtu.edu.np	फोन नं. ९८४१६५२९९८
सम्बद्ध संस्था	Central Department of Botany, Tribhuvan University, Kirtipur		
अनुसन्धानको प्रकृति	Institutional		
पद	Assistant Professor		
अनुसन्धानको तह	अन्य		
अनुसन्धानको शिर्षक	Floristic diversity, vegetation, ecology and ethnobotany of chure region of Madhesh Pradesh, Nepal		
अनुसन्धान विधि	Vegetation Sampling, plant sample collection, Questionnaire survey, interviews, focus group discussion.	**नमुना संकलन**	**नमुना परिक्षण गर्ने स्थान**
		गर्ने	नेपाल
अनुसन्धानको अवधि	२०८०/०५/२९ गते देखि २०८१/०४/१४ गते सम्म		

शर्तहरु :

१.अनुसन्धानकर्ताले राष्ट्रिय निकुञ्ज तथा वन्यजन्तु संरक्षण ऐन २०२९ र नियमावली २०३० तथा मातहतका सबै नियमावलीहरुको पूर्ण पालना गर्नु पर्नेछ।

२.अध्ययन अनुसन्धान गर्दा यस कार्यालयको कर्मचारीको प्रत्यक्ष रोहवरमा गर्नु पर्नेछ।

३.अनुसन्धानकर्ताले आफ्नो अनुसन्धानको प्रस्ताव यस कार्यालयमा पेश गर्नु पर्नेछ।

४.अनुसन्धानकर्ताले अनुसन्धान समाप्त भएपछि एक प्रति प्रतिवेदन र एक प्रति ईलोक्ट्रोनिक प्रतिवेदन यस कार्यालयमा अनिवार्य रुपमा उपलब्ध गराउन पर्नेछ।

५.यस कार्यालयले तोकेको ठाउँमा मात्र नमुना संकलन गर्नु पर्नेछ र संकलित नमुना विदेश लैजान पाईने छैन्।

६.नमूना संकलन गर्दा हर्वेरियम प्रयोगशाला अभिलेखिकरण तथा ल्याब परिक्षण प्रयोजनका लागि जम्मा २ वटा मात्र नमुना संकलन गर्नु पर्नेछ।

७.तोकिएको शर्तहरुको पालना नगरेमा विभागले कुनै पनि समयमा यो अनुमति रद्द हुनेछ।

८.बाँकीको हकमा प्रचलित कानुन बमोजिम हुनेछ।

डा. अशोक कुमार राम
प्रमुख संरक्षण अधिकृत

बोधार्थ :

श्री सबुज गण गण, आधाभार ब्यारेक : जानकारीका लागि अनुरोध छ।

प्रमुख संरक्षण अधिकृत

Photo plates


a. Establishing a CCSP


b. Data collection in plot


c. Measuring DBH of a tree


d. A Sal forest in Chure


e. A mixed forest in Chure


f. A riverine forest in Chure


g. Plastic pollution in Chure


h. Grazing activity in Chure

i. Firewood collection in Chure

j. Tree cutting for timber in Government forest of Chure

k. Logging activity in Chure

l. Pathways through streams in between the forest of Chure

m. Looping activity to harvest fodder

n. Timber and fodder harvest from a Community forest

o. Plant collection **p. Herbarium drying**

q. Prepared herbarium

Group Photo during field visit at the Chure region of Madhesh Province

Prabesh Shrestha

133.0_Prabesh Shrestha_Tree Diversity, Regeneration, Disturbance in Chure, Madhesh Province, Nepal.p

Tribhuvan University

Document Details

Submission ID

trn:oid:::3117:459433026

Submission Date

May 15, 2025, 3:33 PM GMT+5:45

Download Date

May 16, 2025, 8:34 AM GMT+5:45

File Name

133.0_Prabesh Shrestha_Tree Diversity, Regeneration, Disturbance in Chure, Madhesh Province, ...pdf

File Size

5.4 MB

118 Pages

34,310 Words

160,171 Characters

10% Overall Similarity

The combined total of all matches, including overlapping sources, for each database.

Filtered from the Report

- Bibliography
- Quoted Text
- Cited Text
- Small Matches (less than 8 words)

Match Groups

245 Not Cited or Quoted 10%
Matches with neither in-text citation nor quotation marks

0 Missing Quotations 0%
Matches that are still very similar to source material

0 Missing Citation 0%
Matches that have quotation marks, but no in-text citation

0 Cited and Quoted 0%
Matches with in-text citation present, but no quotation marks

Top Sources

9% Internet sources
7% Publications
0% Submitted works (Student Papers)

Integrity Flags

0 Integrity Flags for Review

No suspicious text manipulations found.

Our system's algorithms look deeply at a document for any inconsistencies that would set it apart from a normal submission. If we notice something strange, we flag it for you to review.

A Flag is not necessarily an indicator of a problem. However, we'd recommend you focus your attention there for further review.