Assessment of Trees Outside Forest

Study from Madhesh and Lumbini Provinces of Nepal

Government of Nepal
Ministry of Forests and Environment
Forest Research and Training Centre
Kathmandu, Nepal

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The Forest Research and Training Centre (FRTC) has undertaken several initiatives to identify practical solutions to forestry problems, generate evidence through forestry statistics, and strengthen the capacity of forest officials at both federal and provincial levels. It has also been instrumental in fostering collaboration between provincial and federal governments through scientific research and outreach. In continuation of these efforts, FRTC has undertaken this assessment in two provinces as part of its ongoing legacy of generating forestry statistics. I extend my sincere appreciation to all individuals and institutions whose valuable contributions made this assessment possible.

I extend my sincere appreciation and heartfelt gratitude to Mr. Ananda Khadka, whose dedication and expertise were pivotal in achieving this valuable outcome. I am also grateful for the important contributions of Mr. Raj Kumar Giri, Mr. Bimal Kumar Acharya, Ms. Muna Nyaupane, Mr. Amul Kumar Acharya, Mr. Madhav Neupane, and Mr. Alankar Dhungana whose efforts significantly enriched the process. Finally, I would like to express my deep thanks to Dr. Rajesh Malla, Deputy Director General, for his insightful review and research guidance, Mr. Rabindra Maharjan, and Mr. Rajendra Basukala, Deputy Director Generals and Mr. Nabaraj Pudasaini, Chief, REDD-IC, for overall coordination and collaboration.

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Finally, I would like to commend the entire FRTC technical team for their dedication in preparing this report and ensuring its contribution to evidence-based policy development and the sustainable management of TOF in Nepal. I am confident that the report will serve as a valuable reference for planners, researchers, and policymakers working towards achieving Nepal's climate, biodiversity, and sustainable development goals.

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Rajendra KC, PhD
Director General

कार्यकारी सारांश

निजी, नम्बरी तथा आवादी लगायतका वन क्षेत्र भन्दा बाहिर रहेका रूखहरू (Trees Outside Forests – TOF) नेपालका भू–दृश्यहरूको एक महत्वपूर्ण तर प्रायः कम मूल्याङ्कन गरिएको अङ्ग हुन्, जसले स्थानीय जनजीवन, जैविक विविधता संरक्षण, र जलवायु परिवर्तन न्यूनीकरणमा उल्लेखनीय योगदान पुर्‍याउँछन् । वन अनुसन्धान तथा प्रशिक्षण केन्द्रद्वारा गरिएको यस सर्वेक्षणले मधेश र लुम्बिनी प्रदेशका ५० वटा नगरपालिका क्षेत्रमा TOF स्रोतहरूको बर्तमान अवस्थाको अध्ययन गरेको छ । उपग्रहबाट लिइएका High resolution उपग्रह तस्वीरहरू, तहगत अनिर्धारित नमूना छनोट (stratified random sampling) र विस्तृत फिल्ड सर्वेक्षणको प्रयोग गरी, यस अध्ययनले पूर्व-निर्धारित तहहरू (कृषि क्षेत्र, बसोवास क्षेत्र, सार्वजनिक जग्गा, तथा सडक, नदी र नहर किनारा) मा रूखको घनत्व, आधार क्षेत्रफल, आयतन, जैविक पिण्ड लगायत कार्बन भण्डार सम्मको आधाररेखा अनुमान तयार गरेको छ ।

अध्ययनका नतिजाहरूले TOF स्रोतहरूमा स्थानगत भिन्नता (spatial variability) उच्च रहेको देखाएका छन् । बसोवास र कृषि क्षेत्रमा रूख घनत्व र जैविक पिण्ड विशेष रूपमा बढी पाइएका छन्, जसले वन बाहिरका क्षेत्रहरूमा रूख आवरण कायम राख्न र कार्बन सञ्चितीकरण (carbon sequestration) गर्न तिनीहरूको महत्वपूर्ण भूमिकालाई उजागर गर्छ ।

यस सर्वेक्षणले अध्ययन क्षेत्रमा परेका ५० वटा नगरपालिकाभित्र कूल ४२,५६२.५९ हेक्टर क्षेत्रफलमा वन क्षेत्र बाहिर रहेका रुखहरु पाइएको अनुमान गरेको छ, जसले नेपालका भुपरिधि स्तरीय कार्बन सञ्चितीकरणमा TOF को योगदान देखाउँछ र राष्ट्रियरूपमा निर्धारित योगदान (NDC) तथा द्विवार्षिक पारदर्शिता प्रतिवेदन (BTR) अन्तर्गत नेपालको जलवायु लक्ष्यहरू हासिल गर्न यस क्षेत्रको सम्भावनालाई प्रकाशमा ल्याउँछ ।

यस प्रतिवेदनले जलवायु सहनशीलता (climate resilience) प्रवर्द्धन, इन्धन काठ, घाँस र काठका सामग्रीका माध्यमबाट स्थानीय जीविकोपार्जन सशक्तीकरण, र खण्डित भुपरिधिमा जैविक विविधता कोरिडोर विस्तारका लागि TOF को प्रणालीगत अनुगमन र व्यवस्थापनको महत्व औंल्याएको छ । TOF लाई राष्ट्रिय वन नीतिहरू, जलवायु रणनीतिहरू र स्थानीय भूमि उपयोग योजनामा स्पष्ट रूपमा एकीकृत गर्नु नेपालका लागि पर्यावरणीय दिगोपन र सामाजिक-आर्थिक विकास दुवैका लागि बहुआयामिक फाइदा उठाउने माध्यम बन्न सक्छ ।

अध्ययनले TOF अनुगमनका लागि तथ्यांक प्रणाली सुदृढ गर्न, कृषि-वन प्रणाली र घर वरपर करेसाबारीमा वृक्षारोपण प्रवर्द्धन गर्न, तथा जलवायु वित्त (climate finance) का अवसरहरू उपयोग गरी नेपालमा TOF व्यवस्थापनलाई विस्तार गर्न सिफारिस गरेको छ । सरकारी निकायहरू, स्थानीय समुदायहरू र विकास साझेदारहरूबीचको सहकार्यले देशभर जलवायु-उत्थानसिल र न्यून-कार्बनयुक्त भुपरिधि निर्माणका लागि TOF को पूर्ण सम्भावना उपयोग गर्न मार्ग प्रशस्त गर्नेछ ।

Executive Summary

Trees Outside Forests (TOF) are a vital but often underrecognized component of Nepal's landscapes, contributing significantly to local livelihoods, biodiversity conservation, and climate change mitigation. This study, conducted by the Forest Research and Training Centre (FRTC), systematically assessed TOF resources across 50 municipalities in Madhesh and Lumbini provinces. Using high-resolution satellite imagery, stratified random sampling, and detailed field inventories, the study generated baseline estimates of tree density, basal area, volume, biomass, and carbon stocks across various predefined TOF strata: agricultural lands, settlements, public lands, and along roads, rivers, and canals.

Findings reveal substantial spatial variability in TOF resources, with settlements and agricultural areas showing notably higher tree densities and biomass, underscoring their key role in maintaining tree cover and sequestering carbon outside forest areas.

The assessment further estimated a TOF area of 42,562.59 hectares within the sampled 50 municipalities, highlighting the contribution of TOF to landscape-level carbon stocks and the potential to support Nepal's climate goals under its Nationally Determined Contributions (NDC) and Biennial Transparency Report (BTR) commitments.

The report emphasizes the significance of systematic monitoring and management of TOF for advancing climate resilience, supporting local livelihoods through the provision of fuelwood, fodder, and timber, and enhancing biodiversity corridors across fragmented landscapes. Integrating TOF explicitly into national forest policies, climate strategies, and local land use planning will enable Nepal to harness the multiple benefits of TOF, supporting both environmental sustainability and socio-economic development.

The study recommends strengthening data systems for TOF monitoring, promoting agroforestry and homestead tree planting, and leveraging climate finance opportunities to scale up TOF management in Nepal. Collaboration among government agencies, local communities, and development partners is crucial in realizing the full potential of TOF for building climate-resilient and low-carbon landscapes across the country.

Abbreviations and Acronyms

Acronym	Full Form
AFOLU	Agriculture, Forestry and Other Land Use
BTR	Biennial Transparency Report
CBD	Convention on Biological Diversity
CBS	Central Bureau of Statistics
CEO	Collect Earth Online
DFRS	Department of Forest Research and Survey
DoS	Department of Survey
FAO	Food and Agriculture Organization (of the United Nations)
FFP	Forest for Prosperity Program
FRA	Forest Resources Assessment
FRTC	Forest Research and Training Centre
GHG	Greenhouse Gas
GOFC-GOLD	Global Observation of Forest and Land Cover Dynamics
ICIMOD	International Centre for Integrated Mountain Development
IPCC	Intergovernmental Panel on Climate Change
IVI	Important Value Index
MoFE	Ministry of Forests and Environment
MoFSC	Ministry of Forests and Soil Conservation
MoUD	Ministry of Urban Development
MPFS	Master Plan for the Forestry Sector
MRV	Measurement, Reporting, and Verification
NDC	Nationally Determined Contribution
NFI	National Forest Inventory
RD	Relative Density
RDo	Relative Dominance
RF	Relative Frequency
TOF	Trees Outside Forests
UNFCCC	United Nations Framework Convention on Climate Change

Table of Contents

List of Figures

List of Tables

1. Introduction

1.1 Trees Outside Forests

As of 2022, forests (area ≥ 0.5 ha) in Nepal cover 6.4 million hectares, occupying 43.38% of the country's total area (FRTC, 2024). The total number of stems with a Diameter at Breast Height (DBH) ≥ 10 cm in Nepal's forests is estimated at 2,563.27 million, with an average density of 429.93 stems per hectare (DFRS, 2015).

Besides this number, many trees grow not only in forests, but are also found on agricultural lands, settlements and built-up areas, grasslands, roadsides, riversides and canal sides, public lands, and so on. These lands have not been assessed during the national forest inventories (DFRS, 2015).

The concept of "Trees Outside Forests" (TOF) was formally introduced by the Food and Agriculture Organization (FAO) of the United Nations in the mid-1990s, highlighting the critical ecological and socio-economic roles played by trees located on lands not classified as forests or other wooded lands. Notably, Bellefontaine et al. (2002) and Pain-Orcet and Bellefontaine (2004) contributed substantially to defining and conceptualizing TOF within the framework of the FAO's Forest Resources Assessment (FRA) program. This initiative sought to incorporate the significance of trees in agricultural landscapes, urban areas, and other non-forest settings, recognizing their essential contributions to rural livelihood improvement, biodiversity conservation, and carbon sequestration.

The significance of TOF is evident across diverse contexts, particularly in countries with low forest cover, where they often constitute the primary source of wood and non-wood forest products. This holds true even in regions where trees are so dispersed that maps produced by the FRA 2000 program indicate an absence of forest cover (FAO, 2001). TOF are found on agricultural lands, densely populated areas, fruit-tree plantations, and home gardens, frequently occupying a substantial proportion of the landscape. In urban areas, TOF provide essential aesthetic, environmental services, and microclimatic benefits, including shade and enhanced livability.

Communities, farmers, and herders who lack direct access to forests often diversify their production systems and protect their land by integrating various tree systems into their farms. Such trees include those in agroforestry systems, orchards, and small woodlots, as well as trees growing in meadows, pastoral areas, alongside rivers, canals, and roads, or in gardens, parks, and other urban green spaces. Land-use systems that incorporate TOF encompass alley cropping, shifting cultivation, permanent tree cover crops (such as tea and coffee), windbreaks, hedgerows, home gardens, and fruit-tree plantations.

By definition, TOF are all trees that fall outside the definitions of forest and other wooded lands (FAO, 2000a). They are primarily located on "other lands," including farmlands and built-up areas in both rural and urban settings. A significant proportion of TOF consists of planted or domesticated species, highlighting their managed and cultivated nature. TOF in Nepal usually include:

I. Trees in agricultural landscapes (e.g. scattered farm trees, agroforestry systems, homesteads), including the fruit orchards of mango, apple, citrus, etc.

II. Trees along roadsides, canals and rivers

III. Trees around settlements and built-up areas

IV. Trees in public land (e.g., park, abandoned land, pond, grazing land, temple, etc.)

The classification of TOF, however, presents methodological challenges. While established classifications exist for agroforestry systems, no universally accepted classification applies to all TOF (Kleinn, 2000). This is because TOF encompass a wide range of tree and shrub formations, from single trees to managed plantations, and their classification depends on both context and purpose. The FRA 2000's definition of "forest," which integrates land cover and land use considerations, further complicates the classification process for both forests and TOF (FAO, 2000).

1.2 Ecological and Socio-Economic Contributions of TOF

TOF contribute significantly to both ecological and socio-economic dimensions, particularly in countries like Nepal, where agriculture and rural livelihoods are closely linked to tree resources. TOF provide a wide array of ecological, economic, and social benefits. Ecologically, they act as natural barriers against soil erosion, enhance soil fertility and water retention, and promote biodiversity. Additionally, TOF contribute to climate change mitigation by capturing and storing atmospheric CO, , thus functioning as carbon sinks (Baral et al., 2009).The visible impact of farm trees on rural livelihoods, their contribution to carbon storage, and their role in maintaining biodiversity within farmland landscapes underscore the critical potential of TOF and agroforestry systems in Nepal's climate change mitigation and livelihood enhancement strategies, warranting further targeted studies for integration into national carbon frameworks (Baral et al., 2013).

Given these substantial contributions, TOF are increasingly prioritized in conservation and restoration efforts beyond forested landscapes, especially where they directly support community livelihoods and agricultural productivity (FAO, 2001). Their role in climate action is further reinforced through agroforestry systems (being recognized as a TOF), which enhances carbon sequestration by promoting the establishment of trees and shrubs (Pandey, 2007). Carbon sequestration by TOF involves capturing atmospheric carbon and storing it in biomass or soil organic matter, processes that are often facilitated by land-use changes (Baral et al., 2009).

1.3 Rationale

The assessment and monitoring of forest resources are fundamental components of both national and international environmental and developmental policy frameworks. These activities are also essential for fulfilling the obligations of various international agreements, including commitments related to climate change, biodiversity conservation, and sustainable development. In recent years, the demand for reliable, timely, and comprehensive national forestry data—together with enhanced national analytical capacities—has increased significantly. In response to this demand, the Forest Research and Training Centre (FRTC) has been proactively engaged in the periodic monitoring of forest resources at the national level.

Nepal has actively participated in the FRA process, but historically, data on TOF have been limited or partially reported. The FRA 2020 Country Report for Nepal acknowledges TOF but also realizes the lack of systematic national-level inventories specifically targeting TOF. Thus, a significant gap remains in the assessment and monitoring of trees located outside the forest areas. These trees, which account for a substantial proportion of national biomass and carbon stocks, are critical for several key ecosystem services and socio-economic functions.

Specifically, TOF play vital roles in:

a) **Carbon sequestration**, functioning as an important carbon sink in fragmented and non-forested landscapes;

b) **Livelihood support**, by supplying essential resources such as fuelwood, fodder, and timber for rural communities;

c) B**iodiversity conservation**, by providing habitats for a variety of species and contributing to landscape connectivity; and

d) **Soil conservation**, by enhancing soil fertility and mitigating erosion in agricultural fields.

Despite their recognized importance, detailed and systematic data on TOF—particularly regarding their spatial distribution, species composition, and carbon stocks—are largely unavailable in Nepal. To address this critical knowledge gap, FRTC has initiated TOF resource assessment including those situated on private lands and in other non-forest areas under the broader framework of the “Forest for Prosperity” program.

The assessment of TOF presents several methodological and logistical challenges due to their fragmented spatial distribution, complex ownership patterns, data deficiencies, and the absence of standardized assessment methodologies. Addressing these challenges requires the development of a robust, standardized, and replicable methodology for TOF assessment, thereby enabling consistent data collection and analysis over time to support policy, planning, and sustainable management.

1.4 Objective

The primary objective of TOF resource assessment is to systematically and scientifically assess tree resources outside forest areas, including those on private lands across Nepal (Figure 1).

Specific objectives of this assessment are to: -

- Identify areas with the presence of TOF.
- Collect comprehensive field data on plot-level variables, tree species composition, and associated biodiversity.
- Analyze collected data to estimate tree resource parameters, including tree density, basal area, growing stock, biomass, and carbon stock.
- Assess additional findings, related to biodiversity associated with TOF areas.

2. Methodology

2.1. Study Area

This study was confined on 50 municipalities (Annex 1) within the Madhesh and Lumbini provinces, specifically targeting areas outside the forested zones covered by the Forest for Prosperity program (Figure 1). The land use included in this study were agricultural lands, urban areas, built-up zones and settlements, grasslands, other wooded lands, riverbeds, roadsides, canal banks, public lands, and similar areas.

2.2. Sampling Design and Sample Plot Allocation

Identification of the TOF area (sampling frame) in the study area was essential to ensure comprehensive coverage of scattered tree resources before applying an appropriate sampling design. This process involved several steps such as identifying and categorizing TOF areas using high-resolution satellite imagery, preparing land-use maps, and conducting field validation. A **two-phase stratified random sampling** design was adopted, in which a 500 m * 500 m square grid was overlaid across the study area map to systematically allocate sample plots. At each grid intersection, a circular sample plot with an area of 0.25 hectare (radius = 28.21 m) was established. In the first phase, all sample plots (N=13,033) were visually interpreted in Collect Earth Online to assess the following land characteristics:

I. Forest or non-forest area

II. Presence or absence of tree cover

III. TOF strata (land use): agriculture, settlement, Road, canal, river, and public land park

After visual interpretations of all sample plots, 5119 plots were identified as plots having tree cover. Subsequently 254 sample plots for field inventory were selected by adopting the stratified random sampling design. The stratification was done based on the municipalities (50 municipalities of Madhesh and Lumbini provinces) and TOF strata. The TOF strata included **agriculture; public land park; road, canal, river; and settlement areas**, reflecting the diverse landscape contexts in

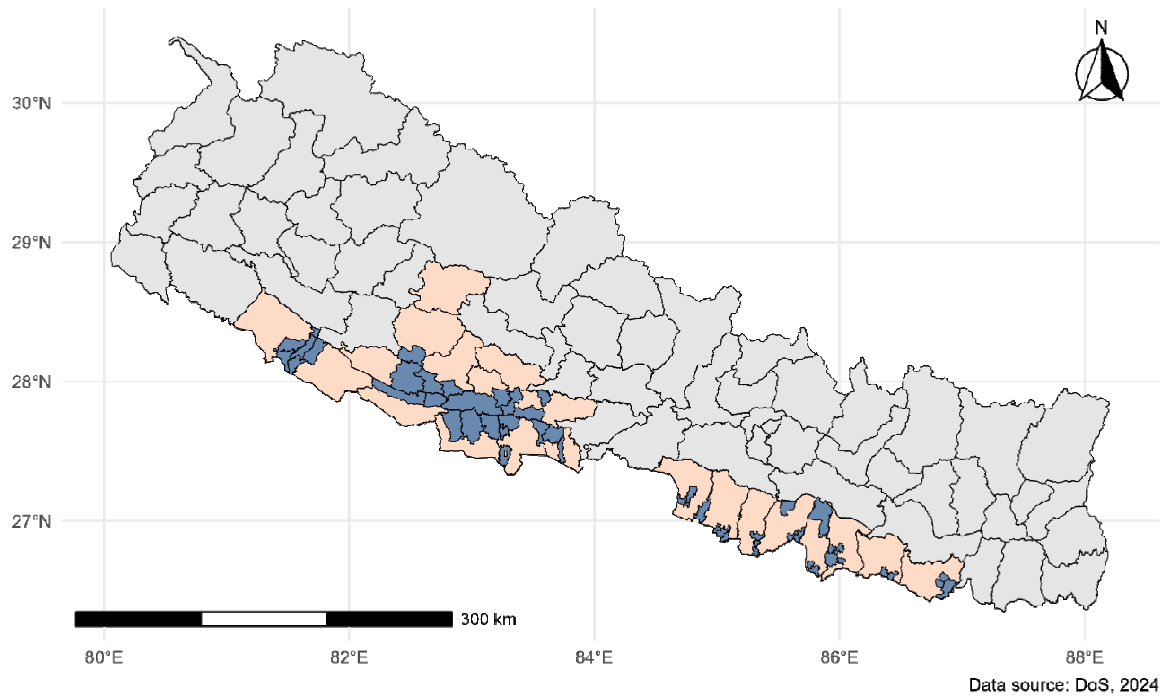

Figure 1: Study area map showing 50 municipalities sampled for TOF assessment in Nepal, covering selected 25 municipalities of each Madhesh and Lumbini provinces. Highlighted areas represent the municipalities where systematic TOF inventories were conducted.

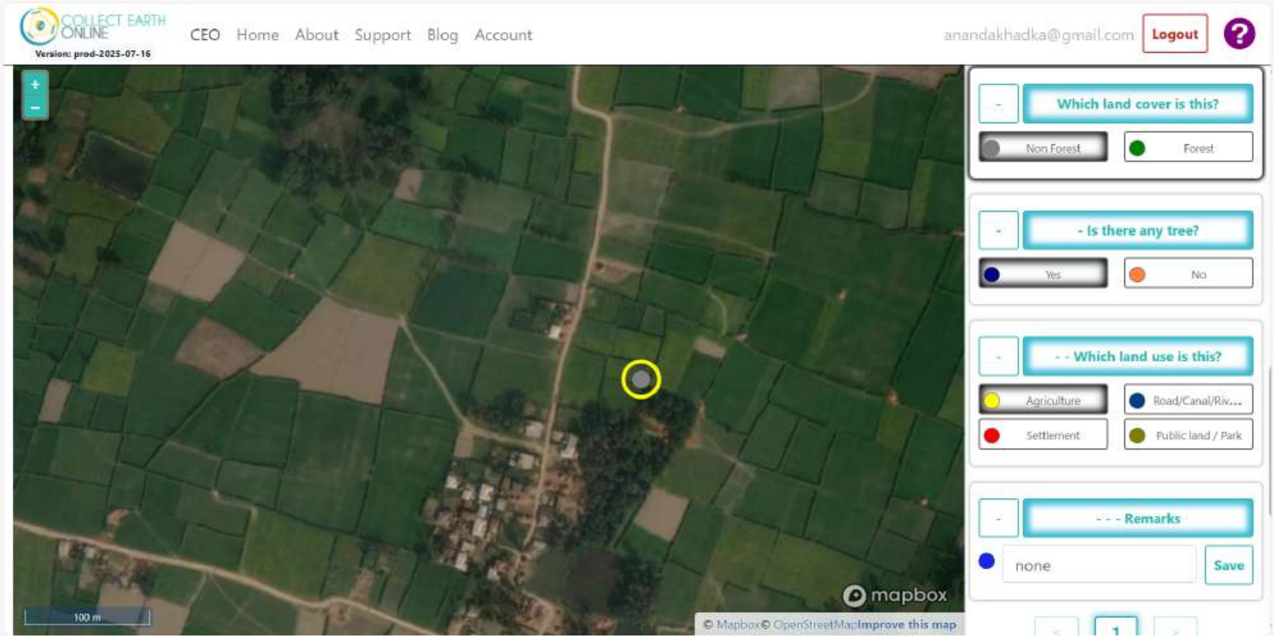

Photo 1: Visual interpretation in the Collect Earth Online

which TOF occur. During sample plots selection, a criterion was established to include at least one plot from each TOF stratum in each local level, where available within the sampling frame (N=5119). This ensured the representation of TOF from all the strata in the sampling frame, effectively capturing the diversity and distribution of TOF resources, enabling accurate assessment and monitoring. Field inventory was successfully carried out in 241 plots, of which 218 plots contained trees in non-forest land cover (Annex 2). The remaining plots either lacked tree presence or were inaccessible due to challenging terrain and topographical conditions.

2.3. Resource Assessment and Data Collection

A detailed field inventory (TOF resource assessment) was conducted in the second phase of the study. All trees with a diameter at breast height e”5 cm were enumerated within the sample plots. The following tree-level variables were measured and recorded: species, diameter at breast height, quality class, crown class, and

Photo 2: Sample tree measurement at Lumbini province

Photo 3: Sample tree measurement at Madhesh province

total height (including base height for leaning trees). All field measurements were taken in accordance with the guidelines provided in the **FRTC Trees Outside Forests Field Manual**.

In addition, dead woods were measured within the sub plot of radius 10 m from the center and information on other biodiversity (flora and fauna) observed within the plot area were also collected. The details on sample plot measurements (including tree measurements, dead wood measurements and biodiversity), etc. is available in the field manual.

2.4. Consultation with Concerned Stakeholders

Consultation and coordination with the farmers, local people, forest offices and other concerned authorities at field levels was important for accomplishing this study. The stakeholders' consultation provided important information regarding various aspects of trees outside forests.

2.5. Data Analysis

2.5.1. Estimating Area Covered by TOF

The sample-based area estimation approach was used to estimate the TOF area. A two-phase design using systematically distributed CEO sample plots was adopted. In the first phase, a total of 13,032 circular plots (0.25 hectare each) were generated across the study area. Visual interpretation of high-resolution satellite imagery identified tree presence in 5,119 of these plots, while the remaining plots were classified as tree-absent. For each plot, tree presence (1) or absence (0) was recorded and aggregated by local level. The proportion of plots with tree cover within each local level was computed and expanded to the respective

Photo 4. Focus group discussions conducted in Madhesh (left) and Lumbini (right)

non-forest land area (DFRS, 2018) to estimate TOF area.

To account for canopy density variation, average crown cover (%) was calculated from field-measured TOF sample plots and applied as a correction factor in the expansion process. Thus, the **true TOF area (hectare)** for each local level was derived as:

$$A_{(TOF)} = p \times A_{unit} \times CC$$

Where,

$A_{(TOF)}$ = sample-based unbiased estimator of TOF area in the local unit

A_{unit} = non-forest area represented by the local unit

p = estimated proportion of tree cover area (sample estimate of TOF occurrence)

$$= \frac{\text{n (number of interpreted points with tree presence)}}{\text{N (total number of interpreted sample points)}}$$

CC = average tree (crown) cover of respective local unit

2.5.2. Estimating Tree Stock, Biomass, and Carbon in TOF Areas

Following the estimation of TOF area, tree stock and carbon indicators were quantified using **sample-based area estimation methods**. These estimates—covering TOF area, tree stock, and biomass—were derived from systematically sampled CEO points and expanded to the total sampling frame, as well as to specific domains such as strata and municipalities. Field measurements from TOF plots were used to compute stem density, volume, aboveground biomass, and carbon stock per hectare.

Stem density (trees per hectare) was calculated by summing the number of live trees within each sample plot and multiplying by the expansion factor (i.e. one hectare over sample plot area in hectare). The basal area (BA) of individual trees within TOF plots was calculated to estimate the cross-sectional area of tree stems at breast height (1.3 meters above the ground). For each tree with a DBH e"5 cm, the BA was calculated using the following equation:

$$BA = \frac{\pi \times dbh^2}{40{,}000}$$

where:

- BA = basal area in square meters (m^2),
- dbh = diameter at breast height in centimeters (cm),
- π = 3.1416

Tree volume and aboveground biomass were estimated using species-specific allometric equations (Equations 1 and 2) developed by Sharma and Pukkala (1990), incorporating measured diameter at breast height (DBH), total tree height, and species-specific wood density values recorded in each plot. Carbon stock was subsequently derived by applying a conversion factor of 0.47 to the estimated biomass, following IPCC guidelines for biomass-to-carbon conversion (IPCC, 2006).

Equations for Estimating Tree Volume and Biomass

The following species-specific allometric equations developed by Sharma and Pukkala (1990) were used to estimate tree volume and aboveground biomass:

(a) Tree Volume Estimation

Tree volume (V, in dm^3) was estimated using the following equation:

$$V = a + b \ln D + c \ln H$$

where:

D = Diameter at breast height (cm)

H = total tree height (m)

a,b,c = species-specific parameters

(b) Aboveground Biomass Estimation

Aboveground stem biomass (B, in kg) was estimated using the following equation:

$$B = V \times \rho$$

where:

V = Stem volume

= wood density (kg $m^{"3}$) specific to each species

Species-specific densities in addition to branch to stem and foliage to stem biomass ratios for several species derived from MPFS (MoFSC, 1988)

For each indicator, mean values per hectare were computed across all TOF plots. To enable local-level policy support, the results were further summarized by municipalities and TOF strata.

2.5.3. TOF Biodiversity

(a) Tree Species Richness

Tree species richness within TOF plots was assessed by identifying and recording all tree species with a diameter at breast height (DBH) of ≥5 cm in each sampled plot across 50 municipalities in Madhesh and Lumbini provinces. Species were identified in the field with the support of local knowledge and verified using standard field guides where necessary. The total number of unique tree species present in each plot was counted to determine plot-level species richness. The data were then aggregated to compute the total TOF tree species richness across all TOF strata.

(b) Important Value Index (IVI)

The Important Value Index is a composite measure used to quantify the ecological dominance and relative importance of tree species in a given area, combining three key parameters (Curtis & McIntosh, 1951):

I. **Relative Density (RD):** Proportion of individuals of a species relative to the total number of individuals of all species.
II. **Relative Frequency (RF)**: Proportion of the occurrence of a species relative to the sum of frequencies of all species.
III. **Relative Dominance (RDo)**: Proportion of basal area occupied by a species relative to the total basal area of all species.

The IVI for each species was calculated as:

$$IVI = RD + RF + RD_o$$

The IVI was used to assess the ecological dominance of tree species across TOF plots, combining relative density, frequency, and dominance to identify key species for TOF management and conservation.

For this assessment, all tree species with a DBH ≥5 cm recorded during the field inventory were included. Basal area for each tree was calculated using DBH measurements, and plot-level data were aggregated to compute total density, frequency, and basal area per species across all TOF strata, including agricultural lands, settlements, public lands, and linear infrastructures. This enabled the identification of ecologically dominant species within the TOF landscape, providing a basis for prioritizing species in TOF management, conservation, and landscape restoration planning.

2.5.4. Outlier management in ToF

During the analysis, two individual trees of *Ficus religiosa* with exceptionally large DBH of 271.0 cm and 241.7 cm were identified as extreme outliers. These trees, often referred to as "wolf trees," exhibited unusually large, open-grown forms that are ecologically interesting but structurally atypical for TOF across Nepal.

Given their extraordinary size and isolated occurrence, these trees could not reasonably be generalized to represent the broader TOF population at national or provincial scales. Retaining them in the dataset would have disproportionately influenced estimates of stem density, basal area, volume, biomass, and carbon stock. Therefore, they were excluded from the main calculations following careful inspection of size-frequency distributions and consideration of species-specific growth norms. This exclusion ensured that the final TOF estimates reflect the typical size structure and stocking conditions prevalent across the country, rather than being skewed by rare, atypical individuals.

3. Results

3.1. TOF Area

Using a sample-based area estimation method applied to 13,032 systematically distributed CEO plots—each representing an equal portion of the non-forest area within the sampling frame—a total of 5,119 plots were visually interpreted as having tree presence and covering 42,562.59 hectares of TOF area within the study area.

The figure (2) illustrates the variation in TOF area (ha) among surveyed municipalities, highlighting significant differences in TOF extent across municipalities and rural municipalities. Baijanath rural municipality and Bardibas municipality lead with the highest TOF area, demonstrating their critical role in landscape-level tree presence, while several municipalities exhibit comparatively low TOF coverage, emphasizing spatial disparities important for targeted interventions and policy prioritization.

3.2. Tree Density

Tree densities exhibited considerable variation across the landscape. Plots within settlement and agricultural strata frequently recorded higher stem densities, in some cases exceeding 400 and 600 stems per hectare, despite having comparatively lower median values. In contrast, strata such as roads/canals/rivers and public land parks generally showed much lower densities (Figure 3). These patterns underscore the important role of farmlands and settlements in sustaining tree cover outside forest areas within the study region.

The highest observed stem density was greater than 600 trees/ha (156 trees in a plot) located within a small teak (*Tectona grandis*) plantation established on a patch of cropland. This outlier, along with other extreme values seen in different strata, illustrates how localized land-use practices and plantation initiatives can significantly influence stocking levels within the TOF landscape.

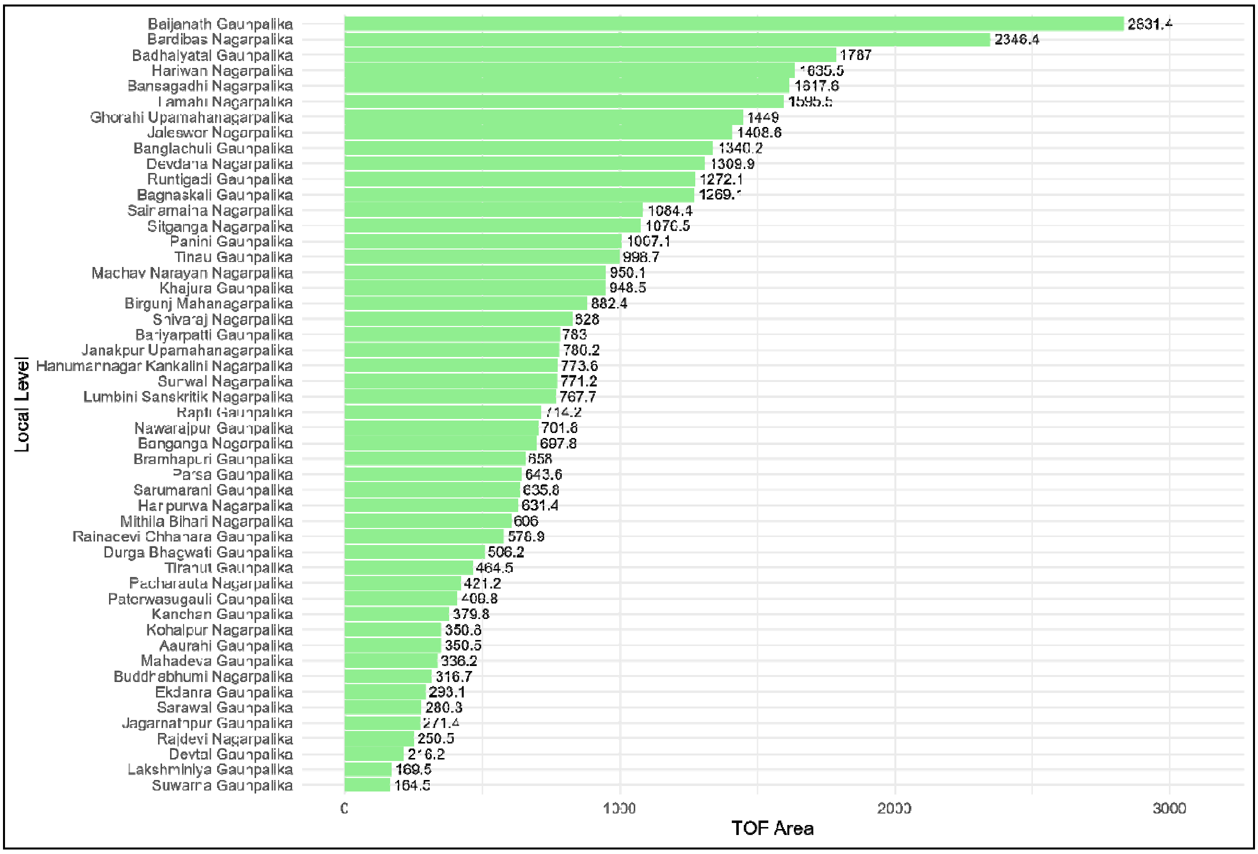

Figure 2: Distribution of TOF Area Across 50 Municipalities in Nepal's Lumbini and Madhesh Provinces.

Note: The TOF area reported here has been estimated by upscaling TOF area measured within the sample plots laid at the intersections of 500 m x 500 m grids systematically across selected municipalities.

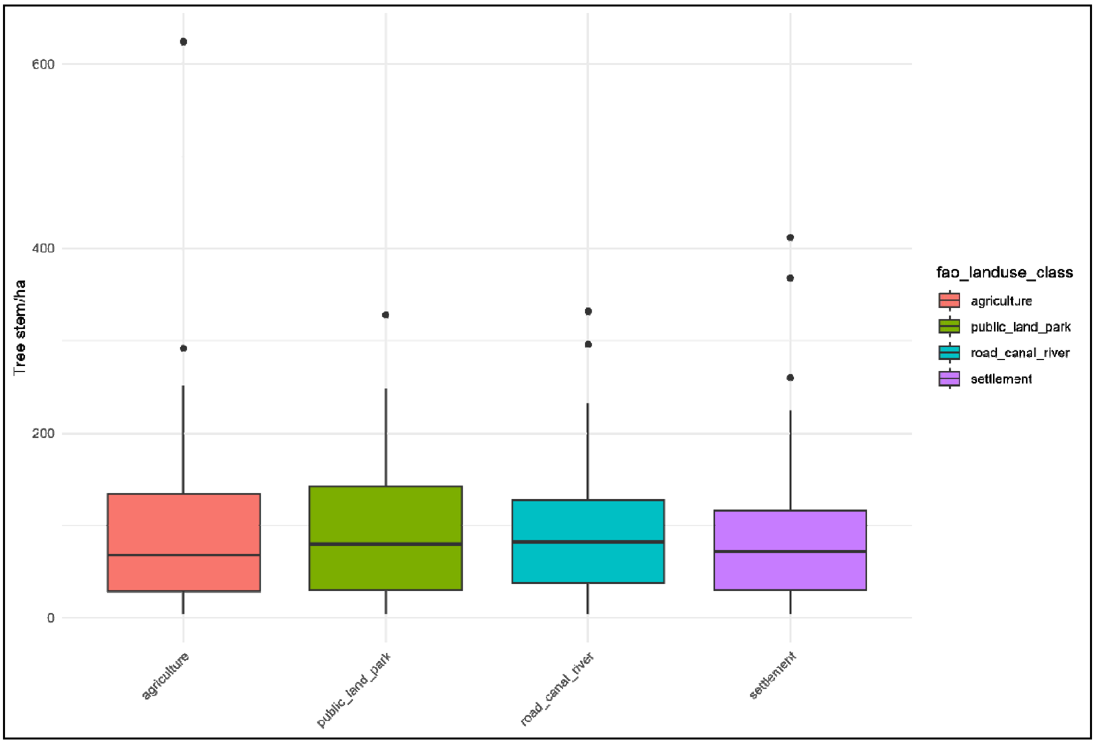

Figure 3 : Tree density (stems per hectare) across TOF strata in the study area. The boxplots display the distribution of tree stems per hectare within *agriculture*, *public land park*, *Road, canal, river*, and *settlement* land use strata across sampled plots.

3.3. Basal Area

Basal area per hectare varied conspicuously across TOF strata (Figure 4). *Public land and park* areas recorded the highest median basal area (~3.0 m²/ha), with values ranging up to over 17 m²/ha in certain plots. This high variability suggests the presence of well-established trees and small-scale plantations in some public land locations. *Road, canal, and river* corridors and *agricultural* areas showed moderate median basal areas (~1.8 m²/ha and ~1.5 m²/ha, respectively), while *settlement* areas exhibited the lowest median (~1.2 m²/ha).

The occurrence of several high outliers, especially in public lands and parks, reflects the presence of mature remnant trees as well as unmanaged growth. In the agricultural strata, such outliers indicate localized conditions, such as dense tree planting. However, the presence of outliers in each stratum indicates variability, with certain plots along roads or within settlements maintaining notable tree cover and contributing

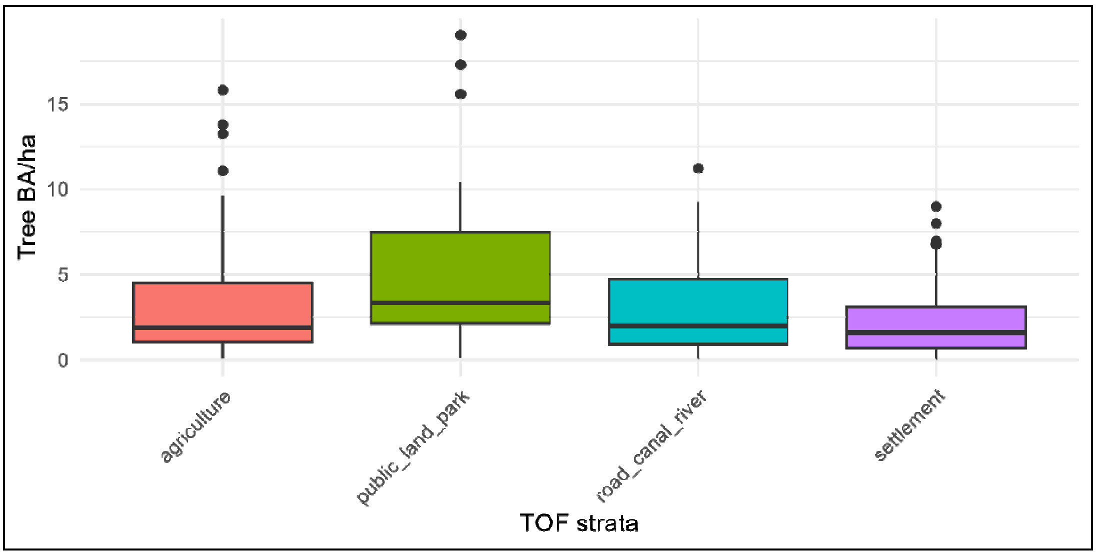

Figure 4: Tree basal area (m^2 per ha) across TOF strata

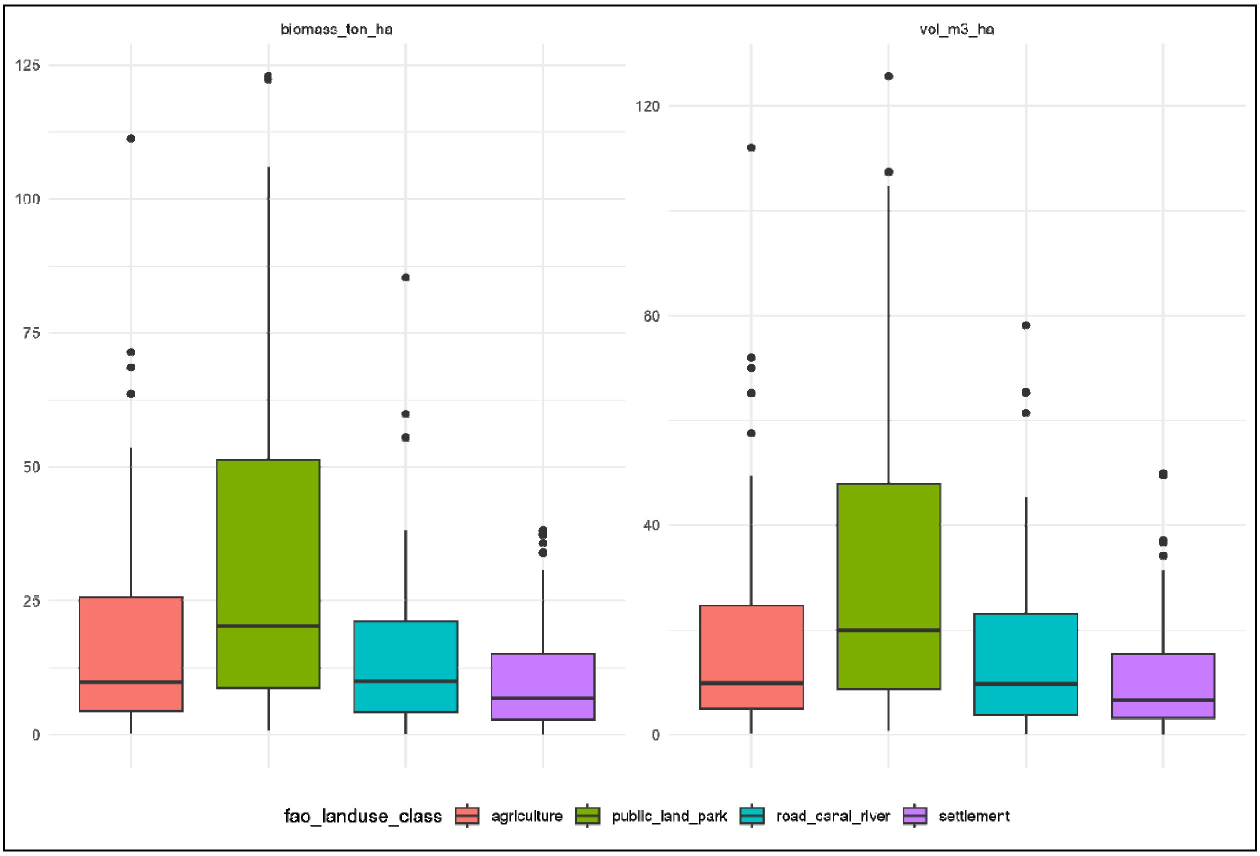

Figure 5: Distribution of tree volume and biomass per hectare across TOF strata

to local biomass. These variations suggest that, while most TOF areas have relatively modest basal area, certain sites contribute disproportionately to carbon storage and canopy cover within the landscape.

These patterns highlight the heterogeneous nature of TOF across land use classes, underlining their potential contribution to biomass and carbon storage even outside traditional forests. The variability observed also points to opportunities for targeted interventions, such as enriching linear plantations along roads and canals or promoting homestead tree planting in settlements, to enhance tree cover and carbon sequestration within TOF landscapes.

3.4. Tree Volume, Biomass, and Carbon Stock

The final analysis of TOF across sampled plots (Annex 3), when disaggregated by municipalities (Annex 2), reveals marked variation in tree stem volume, biomass, and carbon stocks. Volume and aboveground biomass also displayed notable spatial variation (Figure 5). For example, plots in **public lands and parks** recorded median volumes of about 20 m^3/ha and biomass above 20 tons/ha. Such plots also contain high outliers, suggesting some have very large trees contributing disproportionately to total volume. Conversely, plots in **settlement** strata have lower median volume, but occasional outliers indicate notable tree cover along roads or within settlements.

These patterns indicate that, while most TOF plots have moderate biomass and volume, certain plots—particularly in agricultural areas, public lands, and parks—play a disproportionately important role in local carbon storage and canopy cover. The presence of outliers in each stratum highlights the heterogeneity of TOF, reflecting both managed and unmanaged tree growth across the landscape.

Carbon stocks followed a similar pattern (Figure 6). The boxplot illustrates the distribution of carbon stock per hectare across different TOF strata. Public land and park areas have the highest median carbon stock (8.7 tC/ha), indicating a concentration of larger or more mature trees in these locations. Agriculture and Road, canal, river strata have similar median values (4.2 tC/ha), but agriculture shows a slightly wider spread,

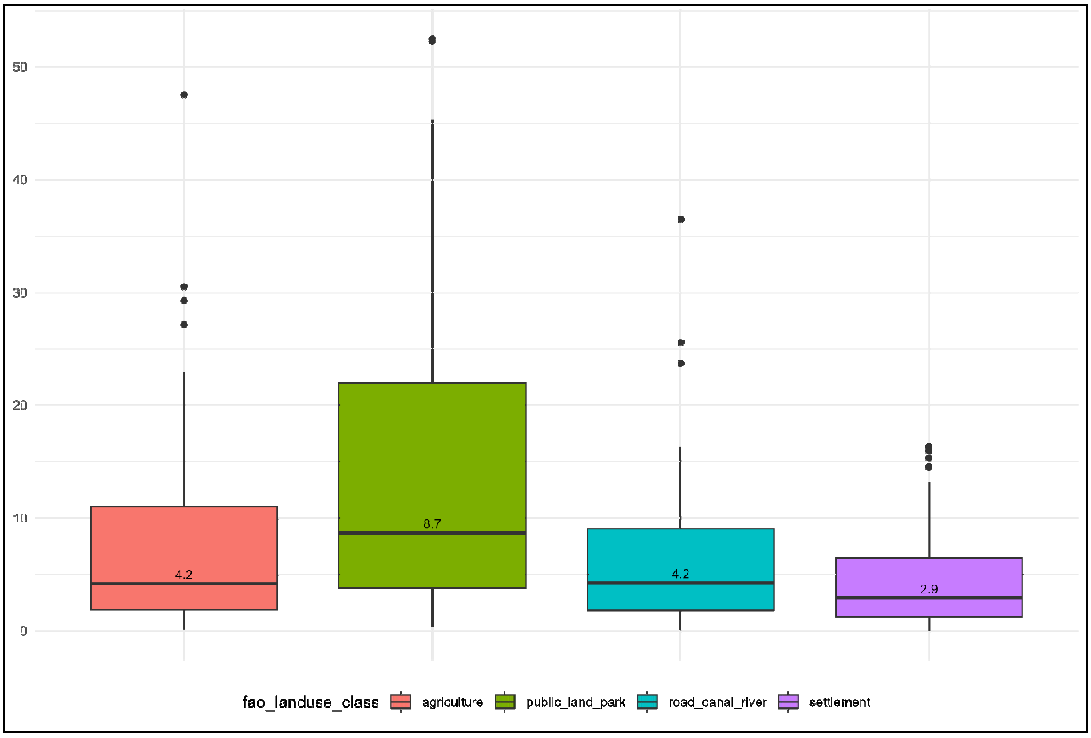

Figure 6: Distribution of carbon per hectare by strata across TOF strata

suggesting greater variability in tree density and size. Settlement areas exhibit the lowest median carbon stock (2.9 tC/ha), reflecting lower tree density or smaller tree sizes in urbanized zones. The data also show a few extremey high values, particularly in public land park and agriculture strata, highlighting specific plots with unusually high biomass and carbon storage potential.

The biomass distribution across the top 10 TOF species shows a strong dominance of *Mangifera indica*, which alone accounts for over 1,000 tons/ha — far exceeding other species (Figure 7). *Dalbergia sissoo* and *Eucalyptus camaldulensis* follow, with biomass values slightly above 300 tons/ha, reflecting their prevalence in plantation and roadside planting schemes. Other notable contributors include *Shorea robusta* and *Syzygium cumini*, each of which occurs in both agroforestry and public land contexts. The relatively lower biomass of species like *Tectona grandis* and *Trewia nudiflora* likely reflects their restricted distribution and younger age classes in the surveyed TOF areas. This distribution aligns with trends reported in similar studies in Nepal and neighboring regions, where a few large, long-lived species contribute disproportionately to total biomass and carbon storage.

Overall, the analysis demonstrates that TOF contributes significantly to landscape-level tree resources, with settlements and agricultural areas playing a central role in maintaining tree presence outside forests. The observed variability across land use types and districts reflects differences in land management, local ecological conditions, and human interventions across the sampled municipalities.

3.5. Biodiversity in TOF

3.5.1. Tree Species Diversity

The assessment of TOF across 50 municipalities in Madhesh and Lumbini provinces revealed notable **tree species diversity** (Annex 4) within agricultural lands, settlements, and public spaces. A wide range of native and introduced species was recorded, including *Antidesma acidum*, *Albizia chinensis*, *Ficus religiosa*, and *Mangifera indica*, reflecting the integration of TOF within diverse land use systems. The presence of multipurpose species such as *Azadirachta indica* (Neem), *Artocarpus heterophyllus* (Jackfruit), and *Syzygium cumini* (Jamun), as identified during the assessment of trees outside forest of Nawalparasi, Morang, and Dhanusa districts, highlights the role of TOF in

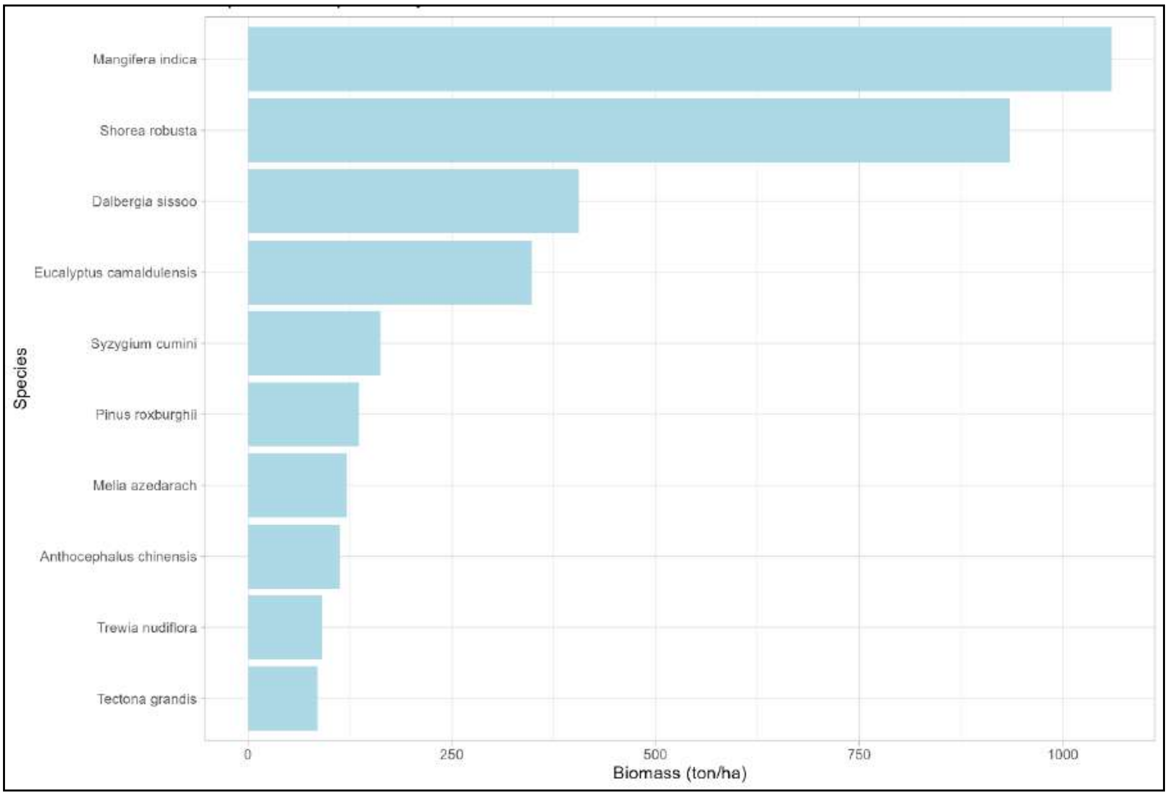

Figure 7: Distribution of biomass among the top 10 species

providing food, fodder, and ecosystem services to rural and peri-urban communities (DFRS, 2007; Kharal et al., 2008).

This diversity underlines the **ecological and socio-economic significance of TOF**, supporting biodiversity corridors, offering resilience to climate variability, and enhancing local livelihoods through the provisioning of fruits, fuelwood, and medicinal resources. The recorded species composition also demonstrates the potential of TOF in **landscape-level restoration initiatives**, aligning with Nepal's commitments under the Kunming-Montreal Global Biodiversity Framework and national climate goals (CBD, 2022).

3.5.2. Important Value Index (IVI)

The IVI analysis (Annex 5) revealed notable patterns in the ecological dominance of tree species across TOF strata in Madhesh and Lumbini provinces. Species with higher IVI values, such as *Mangifera indica* (Mango), *Dalbergia sissoo* (Sissoo) and *Eucalyptus camaldulensis* (Eucalyptus), indicate their widespread presence, frequent occurrence across plots, and substantial contributions to total basal area within TOF areas. This dominance reflects the multipurpose value of these species for local communities, including their use for shade, medicinal purposes, and as sources of fodder and fuelwood.

Conversely, species with lower IVI values, while less dominant, contribute to species richness and ecological diversity within the TOF landscape. Their presence underscores the heterogeneity of TOF systems across different land use strata, including agricultural lands, settlements, and public spaces. The distribution of IVI values across species also highlights the influence of local management practices, cultural preferences, and site-specific ecological conditions on species composition.

Overall, the IVI results emphasize the ecological and socio-economic significance of dominant TOF species in maintaining landscape resilience and providing ecosystem services. These findings can guide prioritization for TOF management, conservation, and restoration initiatives by focusing on maintaining populations of ecologically important species while promoting underrepresented native species to enhance biodiversity within TOF areas.

4. Discussions

4.1. Variability Across TOF Strata

Calculating variability across various TOF strata was a critical step in TOF analysis because it reveals the distribution and spread of tree volume, biomass, and density across the landscape. While mean or median values provide central estimates, they do not capture the heterogeneity in tree resources that is often present due to differences in management practices, ecological conditions, and land tenure systems across the strata.

Assessing variability using metrics like standard deviation and coefficient of variation helps identify areas with highly clustered tree resources versus areas with uniformly low or moderate tree presence. This information is crucial for:

- Targeting interventions: Identifying districts or land uses with low tree presence for restoration or agroforestry promotion.
- Understanding carbon potential: Recognizing areas where high-density TOF can contribute significantly to carbon storage.
- Designing policies: Supporting decisions that consider not just averages but also the diversity of TOF conditions across landscapes.

By quantifying variability systematically, the analysis ensured a robust understanding of TOF contributions to the landscape, enabling better-informed planning for climate mitigation, livelihoods, and sustainable land management. The overall variability of tree density, volume, and biomass is presented in Tables 1, 2, and 3, respectively.

4.2. Policy and Research Implications

In countries such as Nepal, where forestry, agriculture, and livestock are closely intertwined, integrating TOF into land-use planning is essential for sustainable development (Regmi, 1998; Garforth et al., 1999). TOF exhibit high adaptability, occurring as naturally regenerated, planted, or coppice forms. They are found in both urban and rural settings, with ownership structures that range from private holdings to communal and government-managed lands.

Despite their ubiquity, the potential of TOF in Nepal remains underexplored. Fundamental parameters, including species richness and diversity, carbon stocks, and the economic valuation of carbon storage, have not yet been systematically assessed. Addressing these knowledge gaps through targeted research

Table 1: Variability on tree density (per hectare) among different strata

SN	TOF strata	N	mean	median	sd	cv	max	min
1	Agriculture	66	92.6	68	95.0	102.6	624	4
2	Public land park	31	98.7	80	81.9	83.0	328	4
3	Road, canal, river side	54	93.0	82	74.1	79.7	332	4
4	Settlement	67	86.1	72	77.9	90.5	412	4

Table 2: Variability on volume (per hectare) among different strata

SN	TOF strata	N	mean	median	sd	cv	max	min
1	Agriculture	66	18.4	9.8	21.1	115.0	112.0	0.2
2	Public land park	31	32.3	19.9	33.0	102.1	125.6	0.7
3	Road, canal, river side	54	16.1	9.6	17.2	107.1	78.1	0.1
4	Settlement	67	11.2	6.6	11.7	104.5	50.0	0.0

Table 3: Variability on biomass (per hectare) among different strata

SN	TOF strata	N	mean	median	sd	cv	max	min
1	Agriculture	66	18.2	9.8	21.0	114.9	111.2	0.2
2	Public land park	31	34.5	20.3	35.3	102.2	122.9	0.7
3	Road, canal, river side	54	15.2	9.9	16.4	108.0	85.3	0.1
4	Settlement	67	10.7	6.8	10.3	96.9	38.1	0.04

is essential to provide critical insights for policymakers, thereby enabling the development of effective strategies to enhance the role of TOF in promoting sustainable development.

TOF hold substantial potential for enhancing landscape resilience, climate change mitigation, and sustainable livelihoods in Nepal. The current assessment demonstrates that TOF contributes significantly to tree cover, biomass, and carbon storage across diverse land use classes, including agriculture, settlements, public lands, and roadside areas. Recognizing and quantifying these contributions is essential for advancing national climate commitments, including NDC targets and REDD+ implementation.

From a policy perspective, TOF resources highlight opportunities for integrating tree-based systems within agricultural landscapes and urban planning. Promoting agroforestry, homestead tree planting, and linear plantations along roads and canals can enhance both tangible and intangible benefits (carbon sequestration, fuelwood, fodder, and microclimate regulation). Strengthening policy frameworks to include TOF explicitly within forest and land use planning can incentivize community and private sector participation, ensuring sustainable management of these dispersed resources.

Research implications include the need for further methodological refinement to monitor TOF systematically across the country. Combining systematic plot-based inventories with high-resolution remote sensing can enhance the accuracy and scalability of TOF assessments, allowing wall-to-wall mapping and trend analysis over time. Additionally, understanding species composition, growth rates, and management practices within TOF can refine biomass estimation models and carbon accounting, contributing to more robust national greenhouse gas inventories.

Overall, TOF plays a critical yet underrecognized role in Nepal's landscape management, and its systematic integration into policy and research agendas will support climate adaptation, mitigation, and biodiversity conservation while providing tangible benefits to local communities.

4.3. Significance of TOF in the Context of Emerging Issues in Nepal

TOF are increasingly significant in addressing a range of emerging environmental, social, and economic challenges in Nepal. As the country experiences rapid urbanization, land fragmentation, and climate variability (CBS, 2021; MoFE, 2021; ICIMOD, 2020), TOF systems embedded within agricultural lands, settlements, public spaces, and along infrastructure corridors are becoming critical for sustaining ecosystem services and community resilience (FAO, 2016; Kleinn, 2000; Pandey, 2007).

A. Urbanization and Settlement Expansion:

With increasing population pressures and expanding settlements, TOF provide essential green spaces within urban and peri-urban areas, contributing to microclimate regulation, air quality improvement, and urban biodiversity conservation (Saito et al., 2020; MoUD, 2017). They also enhance the aesthetic and recreational value of urban landscapes, aligning with the need for climate-resilient cities in Nepal.

B. Agricultural Landscape Resilience:

TOF play a pivotal role in diversifying farming systems through agroforestry and boundary plantations, providing shade, windbreaks, and soil fertility enhancement. As climate change impacts agricultural productivity, TOF can buffer households by offering alternative sources of fodder, fuelwood, and income, thereby strengthening livelihoods in rural areas.

C. Climate Change Mitigation and Adaptation:

In the context of Nepal's NDC commitments and climate adaptation needs, TOF represent an untapped carbon sink outside traditional forest boundaries (MoFE, 2021). Their potential for carbon sequestration and contribution to landscape-scale restoration make them a valuable component of climate strategies, especially in low-tree cover areas where forest expansion may not be feasible.

D. Disaster Risk Reduction:

TOF can contribute to reducing the risks associated with floods, landslides, and soil erosion, particularly in the lowlands and mid-hills, where land degradation and water management are pressing issues. Linear plantations along roads and rivers can stabilize soil and provide buffer zones against environmental hazards (FAO, 2001; Sharma et al., 2019; MoFE, 2021).

E. Biodiversity Conservation:

TOF act as critical ecological corridors, supporting pollinators, seed dispersers, and native flora and fauna across landscapes. Their conservation aligns with Nepal's commitments under the Kunming-Montreal Global Biodiversity Framework and national biodiversity strategies (FAO, 2016; CBD, 2022; MoFE, 2014).

F. Energy Security and Livelihoods:

TOF provide a significant share of household energy needs in the form of fuelwood while reducing pressure on natural forests. By integrating trees into farmland and settlements, TOF also contribute to timber, fruit, and non-timber forest product supplies, enhancing household incomes and resilience (FAO, 2001; Neupane et al., 2002; FAO, 2016).

In summary, TOF are strategically positioned to address emerging issues related to **climate change, urbanization, disaster risks, biodiversity loss, and rural livelihoods in Nepal.** Recognizing, quantifying, and mainstreaming TOF within national policies and planning frameworks will enable Nepal to leverage these resources effectively, ensuring environmental sustainability while supporting socio-economic development in a changing landscape.

4.4. Outlier Detection and Landscape Carbon Potential

Outlier detection in the TOF dataset revealed plots with exceptionally high tree volume, biomass, and stem densities across specific land use strata and districts. These outliers, identified through boxplot analysis and statistical thresholds, often correspond to locations with over-matured remnant trees in public land, dense homestead plantations, community-managed agroforestry, or roadside tree belts, particularly within settlement and agricultural land use classes.

Recognizing and analyzing these outliers is critical for landscape-level carbon assessments, as they can significantly influence biomass and carbon stock estimates and inform targeted climate interventions (IPCC, 2006; GOFC-GOLD, 2016). High biomass outlier plots, while few in number, can contribute disproportionately to the overall carbon stock within TOF landscapes. Their presence indicates the significant carbon sequestration potential embedded within localized, small-scale tree management systems outside forest areas. Including these values, while using robust statistical approaches to prevent skewing overall means, ensures a realistic representation of TOF's carbon storage variability across diverse land use types and management practices.

Moreover, identifying where and why these high-biomass TOF pockets occur can inform targeted policy interventions, such as incentivizing homestead and farmland tree planting or protecting high-density TOF patches within peri-urban and rural areas, thereby enhancing landscape-scale carbon sequestration efforts in Nepal (FAO, 2016; Pandey, 2007; MoFE, 2021).

5. Conclusions

This assessment of TOF across 50 municipalities in Nepal's Madhesh and Lumbini provinces highlights the significant yet underrecognized role of TOF in enhancing landscape resilience, supporting livelihoods, and contributing to climate change mitigation and adaptation. TOF are widely distributed across homesteads, agricultural lands, settlements, public lands, and linear infrastructures, collectively contributing to tree cover, biomass, and carbon stocks outside the conventional forest domain.

The findings reveal substantial spatial variability in tree volume, biomass, and stem density across different land use classes and districts, reflecting diverse management practices and ecological conditions in the landscape. While some areas exhibit high-density TOF pockets, others demonstrate opportunities for expanding TOF interventions to enhance ecosystem services and carbon sequestration potential.

The study underscores the need for systematic monitoring of TOF resources using a combination of field-based inventories and high-resolution remote sensing to strengthen data availability for national greenhouse gas inventories under Nepal's BTR and NDC tracking. Integrating TOF explicitly into forest, climate, and land use policies will be essential for harnessing their full potential while addressing emerging challenges such as climate variability, land fragmentation, and urbanization.

Promoting agroforestry, homestead tree planting, and urban greening, alongside maintaining and expanding linear plantations, can support sustainable livelihoods and biodiversity conservation while enhancing Nepal's contribution to global climate goals. Collaboration among the Ministry of Forests and Environment, local governments, research institutions, and communities will be critical in mainstreaming TOF within the federal, provincial and local level development planning.

In conclusion, recognizing, managing, and investing in TOF offers a practical pathway toward building climate-resilient, low-carbon landscapes while delivering tangible co-benefits to people and ecosystems across Nepal.

6. Way Forward

The current assessment highlights the critical yet underrepresented role of TOF in contributing to Nepal's climate change mitigation, adaptation, and landscape restoration objectives. TOF areas—embedded within agricultural lands, settlements, public spaces, and along infrastructure—offer significant opportunities for carbon sequestration, biodiversity conservation, and livelihood enhancement across diverse landscapes.

In the context of Nepal's recently submitted Biennial Transparency Report (BTR) to the UNFCCC, improving TOF data and integration into the national greenhouse gas inventory is essential. While the BTR has advanced the inclusion of AFOLU sectors, TOF remains a gap in comprehensive landscape-level carbon accounting. Strengthening TOF monitoring through systematic ground-based inventories, coupled with high-resolution remote sensing and improved allometric models, will enable robust and transparent reporting under future BTRs and NDC tracking.

Policy linkages are crucial. Explicitly incorporating TOF within national forest policies, climate action plans, and sub-national land use planning will create enabling conditions for communities and local governments to scale TOF management. Incentivizing agroforestry, homestead tree planting, and linear plantations through climate finance mechanisms can support NDC implementation while enhancing rural livelihoods and climate resilience.

Collaboration among the government bodies and other concerned stakeholders will be key to mainstreaming TOF within climate strategies. By recognizing and investing in TOF, Nepal can strengthen its contribution to global climate goals while securing multiple co-benefits at the landscape level.

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Appendices

Annex 1: TOF field plots by district and local level

SN	Local level	District	Road canal river	Settlement	Public land park	Agriculture
1	Panini	Arghakhanchi	1	2	0	0
2	Sitganga	Arghakhanchi	0	1	1	0
3	Baijanath	Banke	1	1	0	2
4	Khajura	Banke	1	1	1	2
5	Kohalpur	Banke	0	2	1	0
6	Devtal	Bara	0	2	0	2
7	Pacharauta	Bara	1	2	0	3
8	Suwarna	Bara	1	2	0	2
9	Badhaiyatal	Bardiya	2	1	0	2
10	Bansagadhi	Bardiya	1	1	2	1
11	Banglachuli	Dang	2	1	1	1
12	Ghorahi	Dang	1	2	1	0
13	Lamahi	Dang	1	2	0	0
14	Rapti	Dang	2	1	1	0
15	Aaurahi	Dhanusha	2	1	1	1
16	Janakpur	Dhanusha	2	1	0	1
17	Lakshminiya	Dhanusha	2	2	0	1
18	Mithila Bihari	Dhanusha	1	2	0	2
19	Banganga	Kapilbastu	2	1	1	1
20	Buddhabhumi	Kapilbastu	1	0	2	1
21	Shivaraj	Kapilbastu	0	1	1	2
22	Bardibas	Mahottari	2	1	1	0
23	Ekdanra	Mahottari	0	2	1	2
24	Jaleswor	Mahottari	2	1	1	1
25	Sarawal	Nawalparasi (Bardaghat Susta west)	1	2	0	2
26	Sunwal	Nawalparasi (Bardaghat Susta west)	2	1	1	1
27	Bagnaskali	Palpa	2	1	0	2
28	Rainadevi Chhahara	Palpa	1	0	0	1
29	Tinau	Palpa	1	0	1	2
30	Birgunj	Parsa	1	2	1	1
31	Jagarnathpur	Parsa	0	2	0	2
32	Paterwasugauli	Parsa	1	2	0	1
33	Sarumarani	Pyuthan	0	0	1	2
34	Durga Bhagwati	Rautahat	0	2	0	2

SN	Local level	District	Road canal river	Settlement	Public land park	Agriculture
35	Madhav Narayan	Rautahat	2	1	0	2
36	Rajdevi	Rautahat	1	2	0	2
37	Runtigadi	Rolpa	1	2	1	1
38	Devdaha	Rupandehi	1	1	0	1
39	Kanchan	Rupandehi	1	1	1	1
40	Lumbini Sanskritik	Rupandehi	2	1	2	1
41	Sainamaina	Rupandehi	2	0	1	1
42	Hanumannagar Kankalini	Saptari	1	2	1	1
43	Mahadeva	Saptari	1	2	0	1
44	Tirahut	Saptari	0	2	1	3
45	Bramhapuri	Sarlahi	0	2	0	2
46	Haripurwa	Sarlahi	1	1	1	2
47	Hariwan	Sarlahi	2	1	0	1
48	Parsa	Sarlahi	0	2	0	2
49	Bariyarpatti	Siraha	2	1	1	1
50	Nawarajpur	Siraha	0	1	2	1
	Total		**54**	**67**	**31**	**66**

Annex 2: Local level-wise TOF tree inventory results (Values per ha)

SN	Local level	District	Tree density	BA (m2)	Vol (m3)	Biomass (ton)	Carbon (ton)
1	Panini	Arghakhanchi	156	4.56	17.50	17.79	7.60
2	Sitganga	Arghakhanchi	82	2.46	11.27	12.07	5.16
3	Baijanath	Banke	252	3.75	16.40	14.60	6.24
4	Khajura	Banke	66	1.03	3.28	3.27	1.40
5	Kohalpur	Banke	105	3.76	22.42	27.60	11.79
6	Devtal	Bara	49	1.96	11.13	9.34	3.99
7	Pacharauta	Bara	53	1.65	8.79	8.66	3.70
8	Suwarna	Bara	37	0.94	4.06	4.15	1.77
9	Badhaiyatal	Bardiya	231	3.78	24.14	22.94	9.80
10	Bansagadhi	Bardiya	164	4.77	24.54	25.57	10.92
11	Banglachuli	Dang	146	4.25	23.51	22.64	9.67
12	Ghorahi	Dang	76	0.86	3.30	3.39	1.45
13	Lamahi	Dang	52	3.43	28.09	30.44	13.01
14	Rapti	Dang	88	1.58	9.25	9.98	4.26
15	Aaurahi	Dhanusha	89	4.63	25.76	24.86	10.62
16	Janakpur	Dhanusha	18	1.69	9.19	9.17	3.92
17	Lakshminiya	Dhanusha	70	1.08	5.51	5.60	2.39
18	Mithila Bihari	Dhanusha	93	2.68	13.61	13.50	5.77
19	Banganga	Kapilbastu	35	0.91	5.13	5.85	2.50
20	Buddhabhumi	Kapilbastu	35	2.44	18.69	21.65	9.25
21	Shivaraj	Kapilbastu	89	2.75	15.42	14.77	6.31
22	Bardibas	Mahottari	79	0.99	5.33	6.25	2.67
23	Ekdanra	Mahottari	98	5.53	30.90	27.85	11.90
24	Jaleswor	Mahottari	89	4.98	31.91	31.70	13.54
25	Sarawal	Nawalparasi (Bardaghat Susta west)	86	2.64	12.84	12.36	5.28
26	Sunwal	Nawalparasi (Bardaghat Susta west)	78	2.03	10.09	9.36	4.00
27	Bagnaskali	Palpa	190	4.77	17.77	17.36	7.42
28	Rainadevi Chhahara	Palpa	62	0.90	3.10	3.06	1.31
29	Tinau	Palpa	129	7.23	45.19	50.36	21.52
30	Birgunj	Parsa	52	3.26	23.18	25.35	10.83
31	Jagarnathpur	Parsa	49	1.52	7.69	7.53	3.22
32	Paterwasugauli	Parsa	52	1.43	6.33	5.10	2.18
33	Sarumarani	Pyuthan	137	5.53	27.30	27.51	11.76

SN	Local level	District	Tree density	BA (m2)	Vol (m3)	Biomass (ton)	Carbon (ton)
34	Durga Bhagwati	Rautahat	107	4.82	24.11	23.65	10.10
35	Madhav Narayan	Rautahat	87	4.91	27.73	26.57	11.35
36	Rajdevi	Rautahat	63	2.10	11.24	9.08	3.88
37	Runtigadi	Rolpa	139	4.07	23.97	22.14	9.46
38	Devdaha	Rupandehi	113	4.69	25.22	22.51	9.62
39	Kanchan	Rupandehi	58	1.31	6.59	7.41	3.16
40	Lumbini Sanskritik	Rupandehi	77	3.46	17.95	16.04	6.85
41	Sainamaina	Rupandehi	84	2.85	13.37	14.86	6.35
42	Hanumannagar Kankalini	Saptari	36	1.90	10.68	10.39	4.44
43	Mahadeva	Saptari	72	2.45	14.07	14.25	6.09
44	Tirahut	Saptari	88	3.89	18.92	18.58	7.94
45	Bramhapuri	Sarlahi	76	1.93	14.01	14.64	6.25
46	Haripurwa	Sarlahi	84	3.53	26.79	26.69	11.40
47	Hariwan	Sarlahi	128	3.27	16.44	15.53	6.63
48	Parsa	Sarlahi	118	2.54	19.35	19.02	8.13
49	Bariyarpatti	Siraha	63	3.73	18.73	18.43	7.88
50	Nawarajpur	Siraha	114	11.06	67.86	67.02	28.64

Annex 3: Plotwise TOF tree inventory results (Values per ha)

SN	Plot no	Trees density	Ba (m^2)	Vol (m^3)	Biomass (ton)	Carbon (ton)	Mean DBH (cm)	Mean height (m)
1	44	72	1.16	5.06	4.25	1.82	13.02	6.7
2	243	12	1.05	5.71	5.6	2.39	33.23	10.93
3	268	76	1.96	7.97	7.85	3.36	16.38	6.49
4	282	4	0.22	0.8	1.12	0.48	26.6	8.2
5	329	100	8.98	49.52	37.3	15.94	28.81	11.01
6	381	88	2.75	11.15	11.1	4.74	16.99	6.61
7	420	64	0.77	3.58	4.6	1.97	11.51	7.33
8	442	48	1.96	10.92	13.03	5.57	21.45	10.76
9	488	224	7.41	35.68	34.92	14.92	15.15	6.76
10	529	76	1.94	11.01	10.82	4.62	15.09	10.15
11	617	128	5.79	30.48	27.41	11.71	21.09	8.08
12	720	100	4.52	18.33	18.11	7.74	21.03	7.89
13	775	56	1.33	5.26	5.19	2.22	15.73	6.22
14	813	176	6.78	32.78	16.97	7.25	21.18	9.23
15	836	84	4.66	24.84	19.91	8.51	21.56	8.74
16	849	20	0.32	1.46	1.93	0.83	13.08	6.8
17	850	260	5.55	27.96	26.06	11.13	14.51	8.65
18	1062	64	2.2	11.52	10.79	4.61	17.76	8.07
19	1098	52	2.1	11.41	11.79	5.04	20.28	9.08
20	1113	76	0.44	1.99	2.22	0.95	8.07	7.09
21	1169	16	0.2	0.89	1.18	0.5	11.17	6
22	1205	164	3.32	15.77	16.01	6.84	13.36	6.82
23	1607	64	0.94	5.98	7.9	3.38	12.93	10.17
24	1671	8	1.01	5.21	6.37	2.72	39.85	10.3
25	1775	12	0.38	2.61	3.44	1.47	19.87	13.58
26	1902	76	0.89	2.64	2.61	1.12	11.27	4.33
27	2006	44	0.75	3.64	4.44	1.9	12.83	6.61
28	2168	72	1.44	5.34	5.48	2.34	14.75	6.11
29	2211	12	4.63	48.04	59.92	25.6	51.27	17.76
30	2260	64	2.77	24.56	32.43	13.86	22.51	17.48
31	2457	16	2.46	16.41	15.96	6.82	38.75	10.72
32	2500	4	0.21	1.73	2.29	0.98	25.9	18.27
33	2657	20	1.06	7.96	10.32	4.41	19.16	7.03
34	2779	12	2.94	20.72	20.29	8.67	52.4	15.5
35	2814	76	1.13	4.13	4.08	1.74	13.27	5.54
36	2887	172	5.49	31.58	35.56	15.19	18.47	10.18
37	2930	12	0.18	0.71	0.94	0.4	12.7	6.27
38	3025	60	1.43	9.14	9	3.84	16.03	8.73
39	3153	120	5.2	24.45	25.69	10.97	19.94	6.03
40	3165	328	15.57	104.69	122.89	52.51	20.66	10.31
41	3172	84	4.59	16.04	17.52	7.48	22.7	5.27
42	3192	32	1.03	5.36	5.6	2.39	18.05	7.88
43	3221	96	2.48	9.41	9.55	4.08	16.26	5.57
44	3276	36	7.1	46.26	47.25	20.19	30.39	7.51
45	3394	48	2.17	11.06	13.73	5.87	22.13	8.53

SN	Plot no	Trees density	Ba (m^2)	Vol (m^3)	Biomass (ton)	Carbon (ton)	Mean DBH (cm)	Mean height (m)
46	3436	116	2.75	11.48	10.4	4.45	14.52	5.79
47	3466	36	0.56	3.05	4.09	1.75	12.64	8.41
48	3495	132	1.3	7.71	7.71	3.3	10.33	7.98
49	3550	104	3.1	19.91	21.84	9.33	17.4	10.14
50	3630	80	1.34	6.35	6.26	2.68	12.7	6.6
51	3675	8	0.7	4.41	4.3	1.84	29.8	9.05
52	3819	132	9.25	78.15	85.35	36.47	28.34	16.94
53	3843	16	0.35	1.7	1.68	0.72	15	7.03
54	4052	52	1.02	3.79	3.74	1.6	14.57	6.12
55	4058	224	4.5	12.72	11.97	5.11	14.47	3.33
56	4189	72	0.78	2.41	2.38	1.02	10.41	4.51
57	4192	296	7.43	21.69	21.51	9.19	16.35	4.38
58	4346	168	2.3	7.75	9.18	3.92	12.01	4.87
59	4397	144	4.49	23.31	22.67	9.68	18.13	8.75
60	4453	212	5.57	24.23	23.88	10.2	14.59	5.99
61	4454	72	1.85	6.88	6.8	2.9	16.08	5.71
62	4470	80	2.48	10.11	10.39	4.44	19.07	7.49
63	4567	116	6.28	24.66	24.65	10.53	14.17	4.08
64	4578	156	6.62	30.95	30.21	12.91	18.06	5.25
65	4702	184	5.08	20.09	19.54	8.35	14.98	6.55
66	4755	176	7.49	40.84	41.93	17.92	19.96	8.22
67	5100	52	0.37	2.11	2.09	0.89	8.29	6.45
68	5341	232	2.1	5.18	5.63	2.4	10.03	3.76
69	5381	160	4.81	17.94	19.26	8.23	16.72	5.1
70	5493	100	0.73	1.53	1.52	0.65	9.38	3.3
71	5494	28	0.55	2.93	2.89	1.24	14.4	7.65
72	5578	124	1.8	6.62	7.08	3.02	11.63	4.85
73	5587	104	5.99	45.18	38.19	16.32	24.88	12.87
74	5634	4	0.04	0.11	0.13	0.06	10.8	5.5
75	5756	64	0.48	1.19	2.12	0.91	9.46	3.32
76	5798	172	7.89	48.06	48.01	20.51	21.82	9.96
77	5874	624	6.51	44.88	45.07	19.26	10.81	9.89
78	6099	144	1.59	5.46	5.41	2.31	11.15	5.22
79	6143	56	1.55	4.31	4.33	1.85	14.05	6.58
80	6347	124	1.88	5.74	5.73	2.45	12.32	4.44
81	6652	100	0.89	4.04	4.1	1.75	9.7	6.34
82	6693	144	3.73	21.48	26.18	11.19	15.86	8.35
83	6705	4	0.11	0.76	0.75	0.32	18.7	12.64
84	6854	88	1.55	5.41	5.71	2.44	13.78	4.93
85	6991	160	3.99	15.28	15.03	6.42	16.13	5.99
86	7003	108	1.9	5.91	6.55	2.8	13.9	5.09
87	7116	52	0.62	2.05	2.02	0.86	10.88	4.09
88	7167	120	5.73	42.29	30.32	12.95	22.15	12.38
89	7206	192	2.14	6.2	7.2	3.07	10.99	4.07
90	7233	332	3.62	15.46	8.05	3.44	10.74	6.4
91	7234	212	2.26	9.85	10.95	4.68	10.83	6.81

SN	Plot no	Trees density	Ba (m^2)	Vol (m^3)	Biomass (ton)	Carbon (ton)	Mean DBH (cm)	Mean height (m)
92	7331	132	5.68	37.03	35.77	15.28	21.55	9.63
93	7343	176	9.06	65.3	55.48	23.71	21.03	8.81
94	7355	56	0.64	2.19	2.17	0.93	10.93	4.64
95	7581	212	4	20.32	20.55	8.78	13.6	7.18
96	7584	56	6.4	47.94	63.68	27.21	36.11	18.05
97	7762	64	1.7	7.91	7.79	3.33	16.81	7.58
98	7825	128	6.05	30.01	29.67	12.68	22.24	9.2
99	7845	412	6.76	27.75	27.8	11.88	12.93	5.76
100	8057	368	6.98	34.14	34.06	14.55	13.57	6.6
101	8065	220	8.88	49.7	55.15	23.56	19.66	8.84
102	8116	40	0.24	0.96	1.16	0.5	8.31	5.35
103	8170	8	0.07	0.23	0.23	0.1	10.3	4.56
104	8315	112	7.68	47.95	47.72	20.39	25.06	10.27
105	8401	28	0.7	3.3	3.26	1.39	16.2	8.05
106	8447	36	1.27	2.34	1.2	0.51	20.1	3.34
107	8455	48	3.28	17.7	17.79	7.6	25.45	9.42
108	8468	16	0.26	1.49	1.47	0.63	13.5	8.65
109	8532	8	0.23	1.36	1.34	0.57	18.95	11.45
110	8591	72	1.34	7.87	7.86	3.36	14.19	8.87
111	8622	140	4.48	27.43	28.1	12.01	17.01	8.9
112	8713	80	6.02	26.48	25.58	10.93	21.36	8.04
113	8772	4	0.71	4.56	4.45	1.9	47.5	14.5
114	8781	104	1.15	6.42	6.34	2.71	11.04	8.67
115	8836	156	10.4	68.64	69.1	29.53	27.14	12.13
116	8839	116	19.04	125.64	122.35	52.27	40.45	12.4
117	8881	160	6.49	31.41	30.81	13.16	19.64	8.08
118	8901	84	1.55	5.25	5.18	2.21	13.71	5.14
119	8916	100	6.34	29.6	28.99	12.39	21.11	8.8
120	8930	56	6.92	36.55	35.54	15.19	30.86	7.99
121	8955	248	17.28	107.4	106.05	45.31	25.92	11.4
122	8990	80	2.61	15.06	15.28	6.53	14.81	6.7
123	9055	100	13.25	71.91	71.45	30.53	37.64	11.32
124	9082	28	0.73	2.23	2.2	0.94	17.6	5.03
125	9086	52	1.58	8.16	8.34	3.56	17.98	9.67
126	9125	52	1.47	11.61	11.52	4.92	16.06	8.96
127	9190	124	1.65	7.43	8.12	3.47	10.71	6.67
128	9257	24	1.14	4.67	4.59	1.96	24.2	7.85
129	9261	72	1.65	10.6	10.38	4.44	13.52	7.79
130	9264	56	7.78	39.3	37.97	16.22	39.25	10.75
131	9273	136	4.3	25.65	26.05	11.13	17.46	8.93
132	9343	48	3.36	25.3	25.94	11.08	26.08	14.87
133	9397	20	7.51	35.3	34.33	14.67	58.68	11.24
134	9481	52	0.6	2.01	1.99	0.85	10.65	5.06
135	9515	56	1.19	5.48	5.43	2.32	15.39	7.29
136	9524	80	6.78	36.63	33.91	14.49	26.56	9.34
137	9570	32	1.08	6.96	6.82	2.91	16.51	7.47

SN	Plot no	Trees density	Ba (m^2)	Vol (m^3)	Biomass (ton)	Carbon (ton)	Mean DBH (cm)	Mean height (m)
138	9574	224	7.99	49.95	38.13	16.29	18.93	9.48
139	9605	88	11.21	61.39	59.87	25.58	36.6	10.1
140	9631	176	5.03	28.84	26.05	11.13	17.91	10.2
141	9719	8	0.92	5.84	6.53	2.79	38.2	14.9
142	9725	72	5.1	31.1	30.97	13.23	24.24	9.84
143	9734	4	0.85	5.2	5.07	2.17	52.1	14
144	9741	24	0.23	0.99	0.98	0.42	10.53	7.08
145	9874	36	4.74	24.74	24.11	10.3	35.03	10.54
146	9916	92	3.58	16.84	11.94	5.1	21.06	8.65
147	9982	24	1.61	7.45	4.29	1.83	28.62	9.47
148	9995	88	1.23	4.97	4.91	2.1	11.99	5.95
149	10021	36	1.05	6.07	6.39	2.73	16.78	7.58
150	10061	144	2.48	14.21	14.01	5.99	13.53	8.11
151	10069	88	3.13	19.32	17.59	7.52	19.85	10.08
152	10120	32	0.23	1.33	1.32	0.56	9.3	9.26
153	10131	72	1.34	8.79	8.87	3.79	14.17	10.09
154	10137	16	0.26	0.9	0.89	0.38	13.57	6
155	10167	20	0.54	2.1	2.08	0.89	17.64	7.32
156	10241	168	4.73	25.13	25.46	10.88	15.84	7.9
157	10251	188	2.33	13.5	13.72	5.86	11.47	8.25
158	10257	92	4.77	22.53	21.84	9.33	18.9	6.85
159	10264	40	0.85	3.83	2.69	1.15	13.97	6.03
160	10295	32	1.61	17.21	16.88	7.21	22.1	16.14
161	10305	28	1.19	4.86	4.84	2.07	17.07	5.9
162	10333	140	1.8	8.89	8.77	3.75	11.56	7.47
163	10339	4	0.08	0.41	0.41	0.17	16.4	8.5
164	10377	4	0.14	0.97	0.96	0.41	21	13.2
165	10383	4	0.01	0.04	0.04	0.02	5.3	5.6
166	10394	252	15.8	69.92	68.53	29.28	24.19	9.38
167	10412	40	0.34	1.34	1.32	0.56	8.93	5.45
168	10414	56	1.32	5.59	5.5	2.35	15.81	6.31
169	10436	148	1.71	6.43	6.36	2.72	11.53	6.14
170	10467	28	1.99	13.77	14.88	6.36	27.99	13.79
171	10506	28	2.63	21.55	21.08	9.01	33.19	16.27
172	10529	12	0.13	0.59	0.78	0.33	11.87	7.43
173	10600	136	2.42	16.34	15.89	6.79	11.93	7.7
174	10614	216	13.78	112.01	111.24	47.53	26.12	14.85
175	10625	8	1.59	11.11	10.83	4.63	50.25	16
176	10630	44	1.39	6.33	6.41	2.74	16.7	7.55
177	10685	64	0.92	5.03	4.97	2.12	12.61	8.71
178	10694	88	11.06	65.14	63.56	27.16	36.9	12.27
179	10699	44	0.38	1.58	1.89	0.81	10.08	5.98
180	10727	292	5.79	49.39	48.6	20.76	14.1	12.59
181	10797	60	0.98	3.53	3.48	1.49	12.67	5.18
182	10930	112	1.9	11.67	12.08	5.16	13.36	9.43
183	10969	164	9.64	57.51	53.65	22.92	25.19	10.51

SN	Plot no	Trees density	Ba (m^2)	Vol (m^3)	Biomass (ton)	Carbon (ton)	Mean DBH (cm)	Mean height (m)
184	10972	128	3.33	13.83	12.98	5.55	16.45	6.88
185	11019	24	0.88	4	4.03	1.72	21.45	8.65
186	11031	104	4.32	23.34	22.92	9.79	21.15	8.38
187	11043	136	3.17	24.97	26.82	11.46	15.01	13.11
188	11053	20	0.39	3.2	3.16	1.35	14.88	12.5
189	11082	44	0.69	2.4	2.31	0.99	12.79	5.74
190	11137	12	0.16	0.64	0.63	0.27	12.3	6.13
191	11157	12	0.58	3.56	3.49	1.49	23.27	10.17
192	11238	16	0.44	1.58	1.55	0.66	16.82	7.15
193	11250	8	0.98	3.9	5.15	2.2	39.4	10.2
194	11301	96	2	9.34	8.64	3.69	15.12	7.78
195	11520	32	1.04	5.85	3.7	1.58	15.78	9.76
196	11576	136	3.6	23.5	18.63	7.96	15.89	9.67
197	11579	12	2.77	13.6	13.49	5.76	50.33	11.4
198	11622	128	2.26	13.47	15.45	6.6	13.07	8.22
199	11661	16	0.66	2.43	2.39	1.02	20.68	7.62
200	11683	92	0.46	2.5	3.31	1.41	7.66	7.2
201	11836	80	0.58	2.91	3.85	1.65	9.29	7.28
202	12081	68	2.54	12.09	11.85	5.06	18.58	6.82
203	12248	104	5.48	19.32	18.04	7.71	21.23	5.81
204	12295	40	2.28	14.64	11.2	4.78	24.41	9.29
205	12433	208	3.04	19.88	17.04	7.28	12.31	9.26
206	12523	196	4.48	18.32	18.07	7.72	16.03	6.87
207	12551	40	3.03	15.49	15.15	6.47	27.98	9.14
208	12635	12	1.86	9.43	9.18	3.92	42.77	10.33
209	12644	68	1.17	4.66	4.24	1.81	14.14	6.88
210	12645	28	0.21	1	1.32	0.56	9.29	7.35
211	12710	32	1.89	9.45	4.83	2.06	24.09	7.94
212	12719	20	0.09	0.26	0.3	0.13	7.48	4.12
213	12776	84	3.5	18.63	18.32	7.83	21.64	9.57
214	12808	88	2.85	15.65	15.38	6.57	18.65	8.58
215	12881	12	4.94	63.03	78.89	33.71	71.57	31.53
216	12909	56	0.98	3.87	3	1.28	14.31	6.44
217	12952	12	0.16	1	0.99	0.42	12.8	10.77
218	12978	108	2.69	10.99	11.59	4.95	15.46	6.38

Note: These results are derived from systematically sampled plots using a 500 m × 500 m grid design, and while they provide representative estimates within the sampled areas, they do not replace comprehensive wall-to-wall assessments across the entire districts.

Annex 4: TOF Biodiversity - Tree Species Diversity

SN	Code	Species name	Family	Common name
1	4842	*Antidesma acidum* Retz.	Phyllanthaceae	Archale, Himalcheri, Amari
2	4951	*Pouzolzia rugulosa* (Wedd.) Acharya & Kravtsova	Urticaceae	Daar, Getha, Jenthi, Jenti
3	5306	*Phyllanthus velutinus* (Wight) Mull.Arg	Phyllanthaceae	Anbin, Chamari, Kath Mauwa
4	5326	*Grewia optiva* J.R.Drumm. ex Burret	Malvaceae	Bhimal, Bhebul, Syal Phusre
5	5447	*Leucaena leucocephala* (Lam.) de Wit	Fabaceae	Ipil Ipil
6	5493	*Macropanax dispermus* (Blume) Kuntz	Araliaceae	Charipila
7	5558	*Morus alba* L.	Moraceae	Kimbu, Kimmu, Kalo Kimbu
8	5569	*Bergera koenigii* L.	Rutaceae	Asare, Mitho Nim, Khole Jamun,
9	5598	*Oroxylum indicum* (L.) Kurz	Bignoniaceae	Tatelo, Karam Kanda, Sauna, Laamendho
10	5665	*Picrasma javanica* Blume	Simaroubaceae	Teju, Taju
11	5688	*Premna interrupta* Wall. ex Schauer	Lamiaceae	Ginneri, Giniyar, Gideri
12	5698	*Prunus domestica L.*	Rosaceae	Alu Bakhara, Aalucha
13	6029	*Wendlandia heynei* (Schult.) Santapau & Merchant	Rubiaceae	Rato Kaiyo, Ban Kaiyo, Tilko
14	6047	*Zanthoxylum armatum* DC.	Rutaceae	Timur, Yerma, Primu
15	6063	*Senegalia chundra* (Roxb. ex Rottler) Maslin	Fabaceae	Khair, Khaira
16	6089	*Adina cordifolia* (Roxb.) Hook.f. & Benth	Rubiaceae	Karam,
17	6090	*Aegle marmelos* (L.) Correa	Rutaceae	Bel, Bel Patra
18	6091	*Diploknema butyracea* (Roxb.) H.J.Lam	Sapotaceae	Chiuri,
19	6098	*Albizia julibrissin* (Osbeck) Merr.	Fabaceae	Rato Siris
20	6103	*Albizia odoratissima* (L.f.) Benth.	Fabaceae	Karkur Sirish, Siran, Karkure Siris
21	6104	*Albizia procera* (Roxb.) Benth.	Fabaceae	Seto Sirish
22	6105	*Albizia lebbeck* (L.) Benth.	Fabaceae	Kalo Sirish
23	6112	*Annona squamosa* L.	Annonaceae	Sitaphal,
24	6113	*Terminalia anogeissiana* Gere & Boatwr.	Combretaceae	Banjhi, Dhau, Bajhi, Bakli, Bhalayo
25	6114	*Breonia chinensis* (Lam.) Capuron	Rubiaceae	Kadam,
26	6120	*Artocarpus heterophyllus* Lam.	Moraceae	Katahar
27	6121	*Artocarpus integer* (Thunb.) Merr.	Moraceae	Panas, Rukh Katahar
28	6122	*Artocarpus lacucha* Buch.-Ham.	Moraceae	Badahar
29	6123	*Azadirachta indica* A.Juss.	Meliaceae	Nim
30	6126	*Piliostigma malabaricum* (Roxb.) Benth.	Fabaceae	Tanki, Amil Tanki, Asoti
31	6127	*Bauhinia purpurea* L.	Fabaceae	Tanki, Rato Koiralo, Koiralo,
32	6131	*Bauhinia variegata* L.	Fabaceae	Koiralo
33	6134	*Betula alnoides* Buch.-Ham. ex D.Don	Betulaceae	Saur,
34	6139	*Bombax ceiba* L.	Malvaceae	Simal, Simar

SN	Code	Species name	Family	Common name
35	6144	*Bridelia retusa* (L.) A.Juss.	Phyllanthaceae	Gayo, Kaja
36	6147	*Buchanania lanzan* Spreng.	Anacardiaceae	Piyari, Kaja, Gayo Char
37	6172	*Cassia fistula* L.	Fabaceae	Rajbrichya
38	6175	*Castanopsis indica* (Roxb. ex Lindl) A.DC.	Fagaceae	Dhale Katus
39	6181	*Celtis australis* L.	Cannabaceae	Khari, Khadko
40	6188	*Camphora officinarum* Boerh. ex Fabr.	Lauraceae	Kapoor
41	6193	*Cinnamomum tamala* (Buch.-Ham.) T.Nees & C.H.Eberm.	Lauraceae	Tejpat, Shisi
42	6195	*Citrus aurantiifolia* (Christm.) Swingle	Rutaceae	Kagati
43	6196	*Citrus aurantium* L.	Rutaceae	Kip, Suntola
44	6201	*Citrus limon* (L.) Osbeck	Rutaceae	Nibuwa,
45	6202	*Citrus maxima* (Burm.) Merr.	Rutaceae	Bhogate
46	6207	*Syzygium nervosum* DC.	Myrtaceae	Kyamuna,
47	6224	*Crateva unilocularis* Buch.-Ham.	Capparaceae	Siplikan, Khaichola
48	6235	*Dalbergia latifolia* Roxb.	Fabaceae	Satisal
49	6239	*Dalbergia sissoo* Roxb. ex DC.	Fabaceae	Sisam, Sissoo, Sisawa
50	6246	*Ougeinia oojeinensis* (Roxb.) Hochr.	Fabaceae	Sadan, Pandan, Tinkire, Sandan Pipli
51	6256	*Diospyros malabarica* (Desr.) Kostel.	Ebenaceae	Allo, Kalo Tendu, Khallu, Teju, Halabed
52	6274	*Elaeocarpus sphaericus* (Gaertn.) Heer	Elaeocarpaceae	Rudrakchya, Dana, Ada
53	6282	*Eriobotrya elliptica* Lindl.	Rosaceae	Maya
54	6287	*Erythrina stricta* Roxb.	Fabaceae	Phaledo,
55	6288	*Eucalyptus alba* Reinw. ex Blume	Myrtaceae	Masala,
56	6290	*Eucalyptus camaldulensis Dehnh.*	Myrtaceae	Masala
57	6306	*Ficus auriculata* Lour.	Moraceae	Nibharo,
58	6307	*Ficus benghalensis* L.	Moraceae	Bar
59	6310	*Ficus benjamina* L.	Moraceae	Sami,
60	6315	*Ficus hispida* L.f.	Moraceae	Kharseto, Kharawa, Kharseto, Thotne
61	6316	*Ficus lacor* Buch.-Ham.	Moraceae	Kabhro, Pakadi, Palaksa,
62	6320	*Ficus neriifolia* Sm.	Moraceae	Dudhilo,
63	6322	*Ficus racemosa* L.	Moraceae	Pakar, Dumri, Gullar, Dumari
64	6323	*Ficus religiosa* L.	Moraceae	Pipal, Pipar
65	6325	*Ficus semicordata* Buch.-Ham. ex Sm.	Moraceae	Khanyu, Khanayo, Khaniyo,
66	6330	*Fraxinus bungeana* A.DC.	Oleaceae	Lankuri
67	6335	*Garuga pinnata* Roxb.	Burceraceae	Dabdabe,
68	6341	*Grewia asiatica* L.	Malvaceae	Falsa, Fussi, Syal Phusro, Phosro
69	6345	*Holoptelea integrifolia* (Roxb.) Planch.	Ulmaceae	Khamari, Kanju, Papari, Methe Phal

SN	Code	Species name	Family	Common name
70	6364	*Juniperus indica* Bertol.	Cupressaceae	Sukpa, Sukri, Dhupi, Pamo
71	6369	*Lagerstroemia parviflora* Roxb.	Lythraceae	Bot Dhaiyaro, Asare, Sidda
72	6385	*Litchi chinensis Sonn.*	Sapindaceae	Litchi
73	6401	*Litsea monopetala* (Roxb.) Pers.	Lauraceae	Kutmero,
74	6403	*Ilex excelsa* (Wall.) Voigt	Aquifoliaceae	Puwale, Pwale
75	6411	*Madhuca longifolia var. latifolia* (Roxb.) A.Chev.	Sapotaceae	Latimauwa, Mahuwa
76	6415	*Magnolia globosa* Hook.f. & Thomson	Magnoliaceae	Rukh kamal
77	6419	*Mallotus philippensis* (Lam.) Müll.Arg.	Euphorbiaceae	Rohini,
78	6425	*Mangifera indica* L.	Anacardiaceae	Aanp,
79	6428	*Melia azedarach* L.	Meliaceae	Bakenu, Bakaino, Khaibasi,
80	6435	*Mesua ferrea* L.	Calophyllaceae	Nageswar, Phalame, Ruk Kesar, Potal
81	6446	*Miliusa velutina* (DC.) Hook.f. & Thomson	Annonaceae	Karyauta,
82	6455	*Moringa oleifera* Lam.	Moringaceae	Shovanjan
83	6456	*Myrica esculenta* Buch.-Ham. ex D.Don	Myricaceae	Kaphal,
84	6504	*Phoenix sylvestris* (L.) Roxb.	Arecaceae	Khajur, Kandel, Tadi
85	6507	*Phyllanthus emblica* L.	Phyllanthaceae	Amala,
86	6513	*Pinus roxburghii* Sarg.	Pinaceae	Rani Salla, Khote Salla, Salla,
87	6517	*Pithecellobium dulce* (Roxb.) Benth.	Fabaceae	Jangal Jalebi
88	6523	*Monoon longifolium* (Sonn.) B.Xue & R.M.K.Saunders	Annonaceae	Nakkali
89	6526	*Populus ciliata* Wall. ex Royle	Salicaceae	Pipal Lahara
90	6534	*Prunus campanulata* Maxim.	Rosaceae	Paiyun
91	6541	*Prunus persica* (L.) Batsch	Rosaceae	Aaru, Aadu, Khale
92	6548	*Psidium guajava* L.	Myrtaceae	Amba, Belauti, Ambak, Runi, Latam
93	6553	*Pyrus communis* L.	Rosaceae	Naspati
94	6556	*Pyrus pashia* Buch.-Ham. ex D.Don	Rosaceae	Mayal, Pana
95	6592	*Roystonea regia* (Kunth) O.F.Cook	Arecaceae	Kupital
96	6593	*Salix babylonica* L.	Salicaceae	Bains, Tissi
97	6602	*Falconeria insignis* Royle	Euphorbiaceae	Khirro
98	6603	*Saraca asoca* (Roxb.) W.J.de Wilde	Fabaceae	Ashok, Asau
99	6609	*Schima wallichii* (DC.) Korth.	Theaceae	Chilaune, Goichasi
100	6610	*Schleichera oleosa* (Lour.) Oken	Sapindaceae	Kusum, Gosum, Gausam
101	6615	*Shorea robusta* C.F.Gaertn.	Dipterocarpaceae	Sal,Sakhuwa, Chimar, Sakhu
102	6632	*Spondias pinnata* (L.f.) Kurz	Anacardiaceae	Amaro, Yamar
103	6637	*Sterculia villosa* Roxb. ex Sm.	Malvaceae	Odal, Odane, Andal
104	6639	*Stereospermum colais* (Buch.-Ham. ex Dillwyn) Mabb.	Bignoniaceae	Padari

SN	Code	Species name	Family	Common name
105	6641	*Streblus asper* Lour.	Moraceae	Khaksi, Berulo, Bedulo
106	6651	*Syzygium cumini* (L.) Skeels	Myrtaceae	Jamun, Jambu Phadir, Kalo
107	6652	*Syzygium jambos* (L.) Alston	Myrtaceae	Jamun, Gulaf Jamun
108	6655	*Tamarindus indica* L.	Fabaceae	Imili, Titri, Tetor, Tale Amilo
109	6659	*Tectona grandis* L.f.	Lamiaceae	Teak, Sagawan, Saguan
110	6660	*Terminalia paniculata* B.Heyne ex Roth	Combretaceae	Asna, Saj, Yasal, Sajha, Asan
111	6661	*Terminalia arjuna* (Roxb. ex DC.)	Combretaceae	Arjun
112	6662	*Terminalia bellirica* (Gaertn.) Roxb.	Combretaceae	Barro, Barai, Bahera
113	6664	*Terminalia chebula* Retz.	Combretaceae	Harro, Harai, Thulo Harro
114	6669	*Toona ciliata* M.Roem.	Meliaceae	Tooni, Tuna Tuni
115	6676	*Mallotus nudiflorus* (L.) Kulju & Welzen	Euphorbiaceae	Gutel, Vellor, Ramrittha, Gamari,
116	6701	*Ziziphus mauritiana* Lam.	Rhamnaceae	Bayar, Bayari, Pewandi

Annex 5: TOF Biodiversity - Important Value Index (IVI) of top 20 species

SN	Species	Density	Frequency	Dominance	Rd	Rf	Rdo	Ivi
1	*Mangifera indica* L.	755	106	49.47	15.13	9.43	28.68	53.24
2	*Dalbergia sissoo* Roxb. ex DC.	477	80	11.42	9.56	7.12	6.62	23.3
3	*Eucalyptus camaldulensis* Dehnh.	412	55	11.1	8.25	4.89	6.44	19.58
4	*Mallotus nudiflorus* (L.) Kulju & Welzen	286	32	8.7	5.73	2.85	5.04	13.62
5	*Melia azedarach* L.	283	42	6.24	5.67	3.74	3.62	13.03
6	*Syzygium cumini* (L.) Skeels	145	45	6.16	2.91	4	3.57	10.48
7	*Psidium guajava* L.	161	60	2.02	3.23	5.34	1.17	9.74
8	*Tectona grandis* L.f.	188	26	3.85	3.77	2.31	2.23	8.31
9	*Breonia chinensis* (Lam.) Capuron	96	40	4.47	1.92	3.56	2.59	8.07
10	*Leucaena leucocephala* (Lam.) de Wit	162	31	2.38	3.25	2.76	1.38	7.39
11	*Shorea robusta* C.F.Gaertn.	94	12	7.33	1.88	1.07	4.25	7.2
12	*Bombax ceiba* L.	67	28	4.69	1.34	2.49	2.72	6.55
13	*Antidesma bunius* (L.) Spreng.	98	32	2.21	1.96	2.85	1.28	6.09
14	*Pinus roxburghii* Sarg.	99	6	5.36	1.98	0.53	3.11	5.62
15	*Garuga floribunda* var. floribunda	92	19	2.64	1.84	1.69	1.53	5.06
16	*Moringa oleifera* Lam.	99	20	1.53	1.98	1.78	0.89	4.65
17	*Azadirachta indica* A.Juss.	47	27	1.63	0.94	2.4	0.94	4.28
18	*Ficus hispida* L.f.	70	20	0.8	1.4	1.78	0.46	3.64
19	*Wendlandia heynei* (Schult.) Santapau & Merchant	74	17	1.12	1.48	1.51	0.65	3.64
20	*Morus alba* L.	78	16	0.89	1.56	1.42	0.52	3.5

Note:
Rd: Relative Density
Rf: Relative Frequency
Rdo: Relative dominance

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