Bamboo Resource Assessment (*Outside the Forest Area*) of Nepal

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

December 2025

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Citation:
FRTC, 2025. Bamboo resource assessment *(outside the forest area)* of Nepal. Forest Research and Training Centre (FRTC), Babarmahal, Kathmandu, Nepal.

ISBN: 978-9937-1-9508-9

Published by
Government of Nepal
Ministry of Forests and Environment
Forest Research and Training Centre
Babarmahal, Kathmandu, Nepal
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Email: info@frtc.gov.np
Web: http://frtc.gov.np

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Babarmahal, Kathmandu

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5315129

Acknowledgement

Nepal has been a proud founding member of the International Bamboo and Rattan Organization (INBAR) since 1997 and currently serves as the Chair of its 13th Council Session (2023–2025), following unanimous election during the 12th INBAR Council Meeting in Beijing. Bamboo resources hold immense cultural, economic, and ecological significance in Nepal, deeply interwoven with the livelihoods of rural communities. Despite this importance, a comprehensive assessment of bamboo outside forest areas had long been lacking. In response, the program **"Bamboo Resource Assessment Outside the Forest Area in Nepal"** was initiated and successfully implemented, and this report represents its key outcome.

I **would** like to extend my sincere appreciation to all individuals and institutions whose contributions made this work possible. My deepest gratitude goes to **Forest Research Officer Mr. Ananda Khadka**, whose dedication, technical expertise, and persistent effort were central to bringing this assessment and report to completion.

I am equally thankful to **DDG Dr. Rajesh Malla, Mr. Rabindra Maharjan, and Mr. Rajendra Kumar Basukala, in addition to former DG Mr. Yam Prasad Pokharel**, and **Under Secretaries Mr. Bimal Kumar Acharya and Mr. Raj Kumar Giri**, whose guidance and encouragement were invaluable throughout the program. I also acknowledge the significant support provided by officers **Mr. Amul Kumar Acharya, Mr. Kiran Kumar Pokharel, Mr. Prakash Lamichhane, Ms. Muna Nyupane, Mr. Madhav Neupane, and Mr. Rajaram Aryal**, who played essential roles in ensuring the successful execution of the assessment and finalization of this report.

Special recognition is extended to **Ms. Sangita Shakya** and **Ms. Apsara Paudel** for their contributions during the visual interpretation phase. I also express my appreciation to **Mr. Bishnu Prasad Dhakal, Mr. Keshav Ghimire, and Mr. Pratik Pandeya** for their diligent efforts in Quality Assessment and Quality Control, which significantly strengthened the overall reliability of the results. I am grateful to all officers of the Centre for their consistent cooperation and support.

My sincere thanks go to **Dr. A. N. Das**, **Mr. Hasta Bahadur Thapa**, and **Mr. Rajesh Tamang** for their insightful feedback and constructive comments, which enriched the quality and clarity of this report. I also acknowledge the valuable coordination and assistance received from forestry offices at district and local levels during fieldwork activities. Finally, I wish to express my deep appreciation to all who were directly or indirectly part of contributions and partnership in this important national endeavor.

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Rajendra K.C., PhD
Director General

कार्यकारी सारांश

नेपालमा बाँस एक महत्वपूर्ण प्राकृतिक स्रोत हो, जसले ग्रामीण जीविकोपार्जन, स्थानीय अर्थतन्त्र र वातावरणका विविध पक्षहरुको सन्तुलन कायम गरिरहेको हुन्छ । हालसम्म नेपालका वन बाहिर रहेका बाँसको बारेमा राष्ट्रिय स्तरमा भरपर्दो जानकारी तथा तथ्याङ्कको अभाव थियो, यद्यपि नेपालमा ५३ प्रजातिका बाँस पाइने तथ्य स्थापित भइसकेको छ । यस अभावलाई पूरा गर्न वन अनुसन्धान तथा प्रशिक्षण केन्द्रले **वन क्षेत्र बाहिर रहेका बाँसको स्रोत सर्वेक्षण गर्ने कार्यक्रम** पहिलो पटक कार्यान्वयन गरी, बाँसले ओगटेको क्षेत्रफल, यसको अवस्था, प्रजातिगत भौगोलिक उपलब्धता, र बाँसको बायोमास सम्बन्धी फिल्डमा आधारित विस्तृत तथ्याङ्क तथा जानकारी उत्पादन गरेको छ ।

यस अध्ययनका क्रियाकलापहरु मुख्य दुई चरणमा सम्पन्न भएका थिए । पहिलो चरणमा नेपालको नक्शामा वन क्षेत्र भन्दा बाहिर एवम् ३,५०० मिटरभन्दा कम उचाई भएका क्षेत्रहरूमा ५०० मि × ५०० मि को ग्रीड डिजाईन गर्दा प्राप्त नमुना बिन्दुहरुमा दुर संवेदन पद्धति मार्फत् बाँस भएका र नभएका क्षेत्र निर्धारण गरियो । त्यसपछि दोस्रो चरणमा १ हेक्टरको गोलाकार नमूना प्लटहरूमा गई विस्तृत फिल्ड इन्भेन्ट्री गरियो ।

बाँसले ओगटेको क्षेत्रफल अनुमानका लागि Olofsson *et al.* (2014) को accuracy-adjusted area estimation पद्धति अपनाइयो जसबाट प्राप्त नतिजा अनुसार नेपालको वन क्षेत्र बाहिर सम्भावित बाँस उपलब्ध क्षेत्रफल ३,०६,४७८ हेक्टर पाइयो तथा वास्तविक बाँसले ढाकेको क्षेत्र भने ३३,६३५ हेक्टर पाइयो । बाँसको औसत बायोमास ८.६७ टन प्रति हेक्टर (अधिकतम: ६४.८६ टन प्रति हेक्टर) पाइएको छ ।

यस अध्ययनले देखाए अनुसार वन क्षेत्र बाहिरका बाँस स्रोतहरू क्षेत्रफलका हिसाबले सीमित भए पनि आर्थिक, सामाजिक तथा पारिस्थितिक रूपमा अत्यन्त मूल्यवान छन् । नेपालको बाँस-आधारित निर्माण सामग्री प्रयोगसम्बन्धी नयाँ प्राविधिक मापदण्ड स्वीकृत भएसँगै, र विशेषतः बाँसको राजधानी खोटाङमा —दिगो मूल्य शृङ्खला विकासका थुप्रै पहलको सुरुवातसँग, बाँसलाई वातावरणमैत्री, स्थानीय रूपमा उपलब्ध, नवीकरणीय स्रोतका रूपमा प्रवर्द्धन गर्ने ठूलो अवसर छ ।

Executive Summary

Background

Bamboo is an integral natural resource in Nepal, supporting rural livelihoods, local economies, and ecological resilience across diverse landscapes. Although Nepal harbors 53 bamboo species—including 7 endemics—national-level, statistically robust information on bamboo resources outside forest areas has long been lacking. To fill this gap, the Forest Research and Training Centre implemented Nepal's first *Bamboo Resource Assessment Outside Forest Areas*, generating comprehensive field, spatial, and analytical estimates of bamboo distribution, species composition, and biomass.

Objectives

The assessment aimed to:

1. Map bamboo distribution outside forest areas using systematic sampling and visual interpretation.
2. Document bamboo species composition, clump structure, and size classes.
3. Develop species-specific allometric and taper equations for biomass estimation.
4. Generate statistically robust estimates of bamboo area and biomass at the national and provincial level.
5. Provide a baseline dataset to inform policy, planning, and bamboo sector development in Nepal.

Methods

A 500 m × 500 m grid was generated below 3,500 m elevation, producing 106,383 sample points across Nepal. Of these, 26,596 plots were visually interpreted to identify bamboo presence. A statistically valid sample of 800 field plots (650 bamboo-present, 150 bamboo-absent) was inventoried using 1-ha circular plots.

Field data included species identification, culm and clump counts, DBH and height measurements, crown and basal diameters, and biomass sampling. Mapping errors were quantified using a confusion matrix, yielding a User's Accuracy of 0.932 and Producer's Accuracy of 0.984. Area-adjusted bamboo estimates followed the *Olofsson et al. (2014)* accuracy framework, and uncertainty was quantified at 95 % confidence interval.

Key Findings

- Total bamboo-available area (outside forests): 306,478 ha
  (all non-forest grid points where bamboo could occur)
- Statistically estimated bamboo cover: 33,635 hectares (± 618 ha at 95% CI)
- Mean green biomass: 8.67 t/ha (maximum observed: 64.86 t/ha)
- Highest species biomass: *Dendrocalamus hookeri* (26.5 t/ha)
- Provincial biomass pattern:
  - Highest: Madhesh Province (~14.5 t/ha)
  - Lowest: Sudurpashchim Province (<5 t/ha)
- Species richness: 14 bamboo species recorded outside forest plots, consistent with expected distribution but confirming that non-forest bamboo resources are dominated by a few widely cultivated species.

Way Forward for Nepal

The findings demonstrate that bamboo resources outside forests, though limited in spatial extent,

hold high economic and ecological value. With Nepal's recent approval of bamboo-based construction norms, and growing provincial initiatives—particularly in Khotang, the national bamboo capital—there is substantial opportunity to promote bamboo as a climate-smart, locally available, and renewable resource.

Key recommended actions include:

- Scaling bamboo-based enterprises, especially in Madhesh, Koshi, and Bagmati where biomass potential is highest.
- Strengthening provincial and local value chains, including nurseries, handicrafts, engineered bamboo, and green construction.
- Integrating bamboo into carbon accounting and nature-based solutions, leveraging its high biomass productivity.
- Enhancing research, particularly species-specific growth, yield, and carbon models.
- Institutionalizing periodic national bamboo assessments to update baselines every 5–10 years.

This assessment provides a scientific benchmark for national planning, sectoral investments, and the sustainable development of Nepal's bamboo economy.

Abbreviations and Acronyms

CI	Confidence Interval
DBH	Diameter at Breast Height
DFID	Department for International Development
DFRS	Department of Forest Research and Survey
FAO	Food and Agriculture Organization
FRTC	Forest Research and Training Centre
INBAR	International Network for Bamboo and Rattan
MoFE	Ministry of Forests and Environment
MoFSC	Ministry of Forests and Soil Conservation
NARMSAP	Natural Resource Management Sector Assistance Programme
NLCMS	National Land Cover Monitoring System
P	Producer’s Accuracy
SD	Standard Deviation
SE	Standard Error
TLS	Terrestrial Laser Scanning
U	User’s Accuracy

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1. INTRODUCTION

1.1 Background

Bamboo is a fast-growing, woody, perennial evergreen plant belonging to the family *Poaceae*. In Nepal, bamboo species are traditionally categorized into two groups — *bans* and *nigalo* (Das, 1988; Stapleton, 1994). Bamboos with a base diameter greater than 4 cm are referred to as *bans*, whereas those with a diameter of 4 cm or less are classified as *nigalo*.

Globally, approximately 136 genera and 1,698 species of bamboo have been recorded (Lobovikov *et al*., 2005; Soreng *et al*., 2022). Of these, Nepal hosts 12 genera and 53 species (Das, 2002), including seven endemic species (Stapleton, 1994; Das, 2002; Rajbhandari *et al*., 2021).

Bamboo's global distribution extends from tropical to temperate regions — a pattern also reflected in Nepal, where species occur across diverse climatic zones from the tropical lowlands to temperate highlands. In Nepal, bamboo is distributed from the Terai plains to elevations of approximately 4,000 meters, occurring both in natural forests and on farmlands (Karki & Karki, 1995; Ghimire, 2008).

As a perennial woody grass, bamboo represents one of Nepal's most important non-timber forest products. Large bamboo species, predominantly from the genera *Bambusa* and *Dendrocalamus* (locally called *bans*), are widely cultivated on private farmlands in the Terai and mid-hills (Das, 1988). The eastern regions of Nepal, from Dhaulagiri to the Sikkim border, have the highest bamboo density due to favorable climatic conditions (Stapleton, 1994). Most bamboo species in Nepal exhibit *pachymorph* rhizomes and form distinct clumps (Stapleton, 1994). The Forest Research and Training Centre (FRTC) has also introduced the monopodial *Phyllostachys pubescens* (Mosso bamboo) for diversification. However, many bamboo stands have been lost due to overexploitation, gregarious flowering, and forest fires, particularly in the Churia, Terai, and mid-hill regions.

1.2 Economic and Ecological Significance of Bamboo

Bamboo holds a prominent place in Nepalese society, deeply integrated into the cultural, social, and economic fabric of rural communities. It is an essential component of traditional farming systems and contributes substantially to rural livelihoods by providing raw materials, income opportunities, and employment, particularly among socially and economically marginalized groups (Das, 2001).

Globally, nearly 2.5 billion people rely on bamboo for daily needs, using it for construction, handicrafts, papermaking, energy production, and a wide array of household purposes (Scurlock *et al*., 2000). Bamboo's versatility and renewability have earned it various descriptors, such as "poor man's timber," "friend of human beings," "green gasoline," "cradle-to-coffin timber," and "green gold," reflecting its economic and ecological importance.

In Nepal, bamboo contributes to employment generation, provides fodder, food, shelter, and household materials, and supports sustainable livelihoods. For centuries, it has been utilized for construction, papermaking, fishing, agricultural tools, handicrafts, and woven products. Compared to conventional timber, bamboo grows rapidly, matures within short rotation periods, and has desirable physical qualities, including straight stems, smooth texture, and fine luster. Ecologically, bamboo aids in soil conservation, slope stabilization, and carbon sequestration, contributing to climate resilience and sustainable land management.

Given these socioeconomic and environmental benefits, an accurate assessment of bamboo resources is essential for informed policy formulation, sustainable management, and integration into national forest and land-use planning. The following sections present the methodology and results of a comprehensive assessment of bamboo resources outside forest areas in Nepal.

1.3 Rationale of the Study

Taxonomic research on bamboo in Nepal began in the early 1980s under the Department of Forest Research and Survey (DFRS), with support from DFID (UK), but was never fully completed. While large bamboo species are extensively cultivated by farmers on their land outside forest areas, comprehensive data on species composition, spatial distribution, and density remain limited. Specifically, information on culm and clump density, basal area, and variation across provinces is lacking.

A review of past studies highlights the absence of consistent, spatially explicit, and statistically robust bamboo inventory data at the national scale. There are no standardized maps of bamboo distribution, biomass allometric equations, taper models, or conversion ratios between green and oven-dry biomass for Nepal. Therefore, updated, field-based, and spatially validated data are urgently needed.

This study addresses these gaps by generating detailed information on bamboo species, distribution, culm and clump density, basal area, size attributes (diameter and height), and biomass. The results provide baseline information for the historical assessment and sustainable management of bamboo resources in Nepal.

1.4 Objectives

Overall Objective:

To assess bamboo resources available outside forest areas in Nepal.

Specific Objectives:

1. To conduct field inventory and prepare maps of bamboo resources available in Nepal.
2. To assess the diversity and distribution of bamboo species.
3. To develop biomass and taper models for bamboo species.
4. To generate comprehensive bamboo-related information to support sustainable management and policy development.

2. Methodology

2.1 Study Area

This research was conducted outside of the forest area of Nepal. The non-forest area had been derived from the annual land cover map of year 2019 produced by the National Land Cover Monitoring System (NLCMS) of Nepal (FRTC, 2022). NLCMS was developed to provide annual land cover maps of the country from 2000 to 2019. By using consistent remote sensing datasets, this operational and flexible system is able to produce annual land cover maps of the whole country (FRTC, 2022).

Prior to this assessment, FRTC conducted a study on "Visual interpretation prior to Bamboo Resource Assessment in Nepal", the output of which revealed that bamboo species in Nepal are confined to the area with elevation lower than 3500 m above sea level. This distribution area was also supported by the various literatures, e.g., Das, 1988; Stapleton, 1994; Shrestha, 1998, etc.

Thus, for this research, the non-forest area (besides area occupied by the forests and other wooded land) that are located below an altitude of 3500 m (above mean sea level) across the entire country was taken (Figure 1).

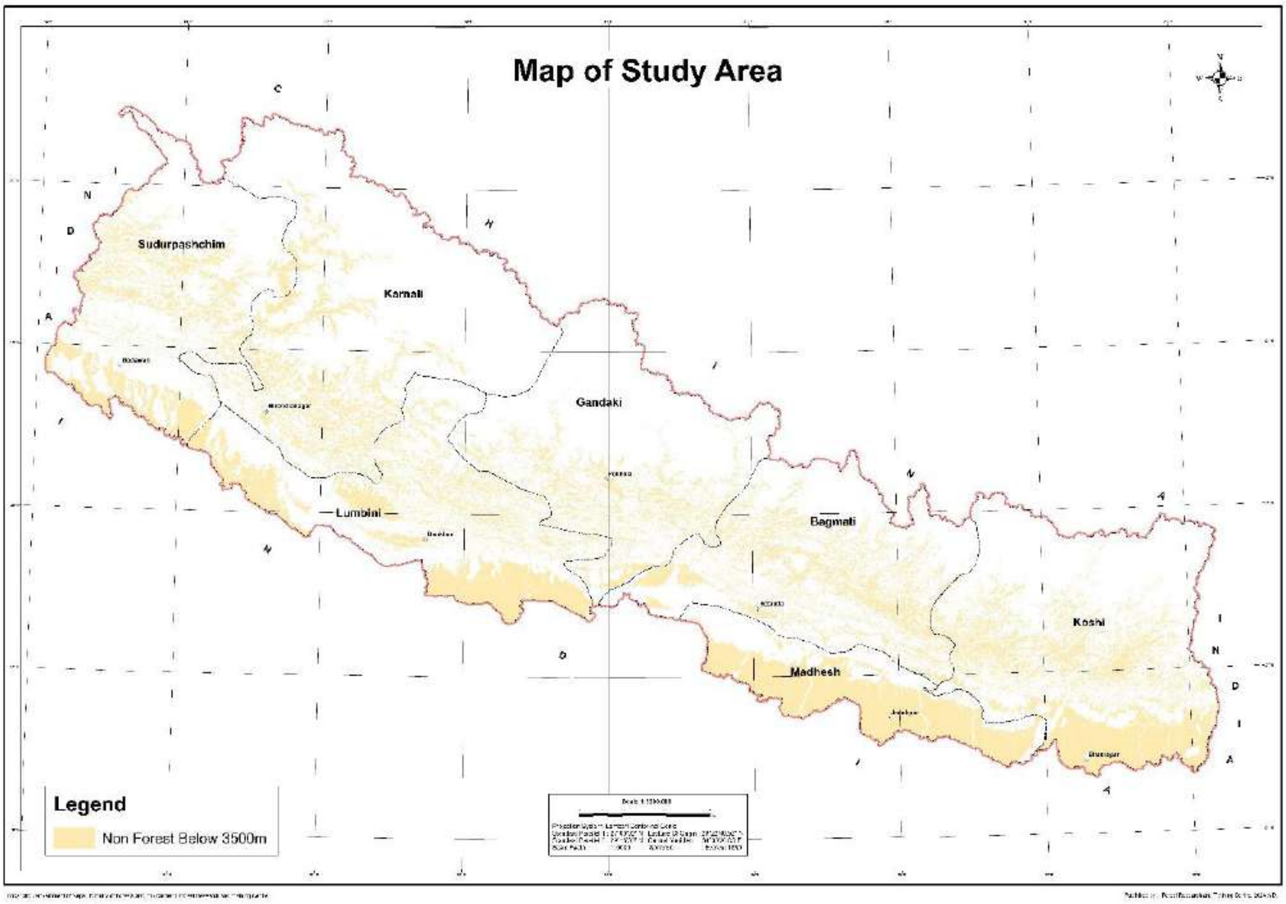


Figure 1: Study area of bamboo resources assessment in Nepal

2.2 Sample Plot Allocation and Design

The sample plots for the bamboo resources assessment outside the forest area were designed and selected adopting a two-phase stratification approach. In the first phase the sample grids were systematically generated in the "non-forest" area of the entire country and stratified based on Normalized Difference Vegetation Index (NDVI) generated from time series Sentinel-2 and Landsat images. In total 197,108 numbers of plots were generated out of which 106,383 plots were found inside the study area i.e., non-forest area located below of 3500 m altitude. Out of all plots, every 4th plots (26,596 points) were sampled for which visual interpretation was done using Collect Earth Online (CEO). A summary of the process—from generating sample plots to selecting the final plots for field verification—is presented below (Table 1).

Table 1: Two phase sampling and allocation of sample plots

SN	Particulars	No. of sample plots
1	Generation of grids throughout Nepal @ 500m spacing interval	588,485
2	First phase sampling: selection of plots in the non-forest area	197,108
3	Sample plots below 3500m elevation	106,383
4	Every 4th sample plot taken for visual interpretation (Bamboo present or absent)	26,596
5	Bamboo presence plots	1468
6	Bamboo absence plots	25128
7	Second phase sampling: Selection of plots for field inventory	800

During the visual interpretation for bamboo availability in the first phase, bamboo clumps were present in 1468 sample plots and for the rest 25077 sample plots, bamboo clumps were not found (absent). In the second phase, the following stratification was performed to allocate sample plots for field inventory/assessment (Table 2).

Table 2: Stratification and field plots allocation

SN	Strata	No. of sample plots
1	Bamboo presence plots	650
2	Bamboo absence plots	100
3	Plots with NDVI≥0.1 and NDVI <0.4 (Probable bamboo area) *	50
	Total	**800**

**Wang et. al. (2009) revealed most bamboo presence area with NDVI > 0.48. Thus, in this research, plots with NDVI more than 0.4 were considered as bamboo presence plots, and plots with NDVI from 0.1 to 0.4 as probable bamboo plots.*

A total of 1468 bamboo presence plots were identified from the image visual interpretations. Out of all, 734 plots were selected using systematic sampling approach with a random start (choosing every second plots where generated random number was 2). Out of selected 734 bamboo presence plots, field inventory was carried out in 650 plots. In addition, 100 plots from bamboo absence list and 50 bamboo probable plots (NDVIe”0.1 and NDVI <0.4) were also selected following the simple random sampling technique.

Finally, 800 sample plots were selected for the detailed field inventory under this program (Figure 2).

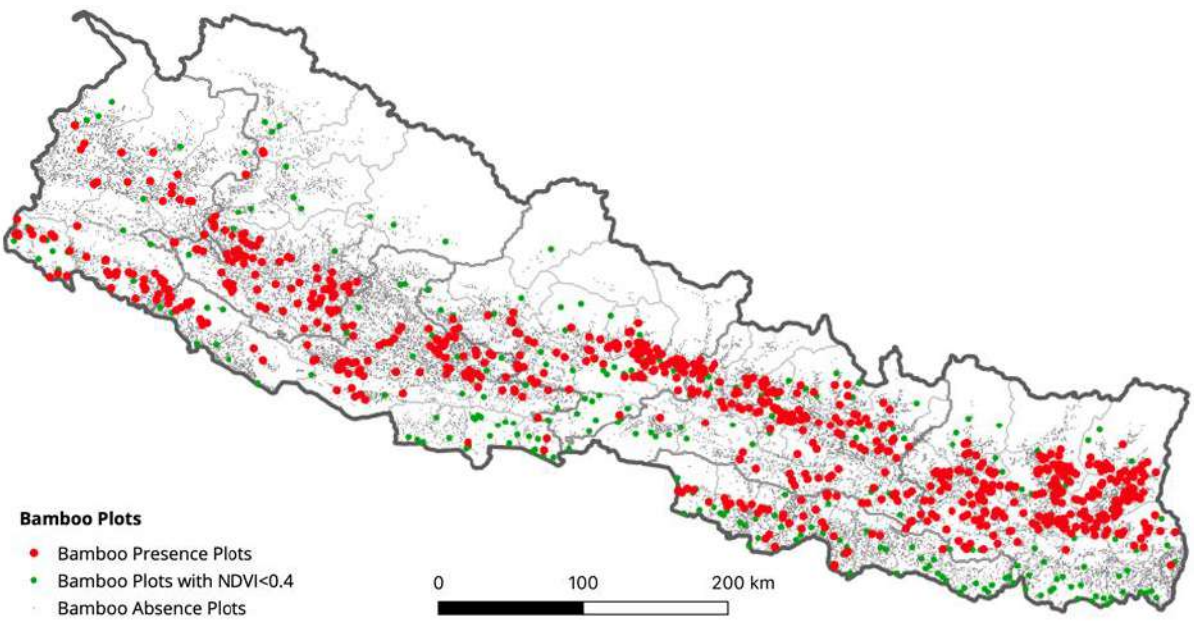


Figure 2: Sample plots for field inventory

For the bamboo resource inventory in Nepal, circular sample plots of radius 56.42 m (1 ha area), were designed (Figure 3). Bamboo clumps within the sample plots were assessed, geo-referenced and inventoried to further data collection. The details on location, topography, and other bio-physical attributes like species, sub species, number and size of each individual clump, average diameters and total height of culms, etc. inside the sample plot were recorded.

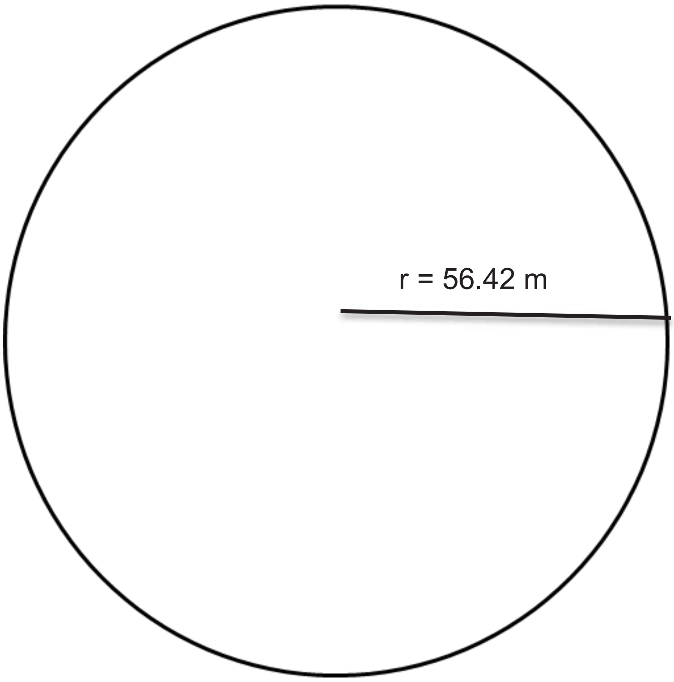


Figure 3: Circular sample plot of 1 ha area

All data, information, samples, measurements, etc. were also collected and recorded in field tally sheets as guided in the field manual (FRTC, 2023).

2.3 Bamboo Area Estimation

Previous bamboo resource studies in Nepal and neighboring regions have used a combination of remote sensing, field sampling, and spatial modeling to estimate bamboo area and biomass.

- Lobovikov *et al*. (2007) under the INBAR–FAO bamboo resource assessment framework recommended the use of crown cover as a proxy for bamboo area when integrating field data with satellite imagery.
- Recent studies in India and China have also demonstrated that crown-based bamboo cover estimation better aligns with remote sensing classification accuracy and canopy-level biomass prediction (Du *et al*., 2018).

Accordingly, the current assessment adopts the crown area–based approach for bamboo area estimation, ensuring consistency with international bamboo resource assessment standards.

Bamboo resources outside forest areas were assessed using a systematic 500 m × 500 m grid sampling design. Within each grid cell, a 1-hectare circular sample plot was established in locations identified through visual interpretation of high-resolution satellite imagery (below 3,500 m elevation) to determine bamboo presence or absence. Field inventories were conducted in all bamboo-present plots to record clump number, and clump base diameters and crown diameters at two perpendicular sides for each bamboo clump.

For each plot containing bamboo, the bamboo-covered area was estimated by summing the individual clump canopy (crown) areas within the 1-ha plot. The crown area of each clump was calculated as the area of a circle, using the mean of two perpendicular crown diameter measurements taken in the field:

$$A_{crown} = \pi \times (\frac{\bar{D}_{crown}}{2})^2$$

where

$$\bar{D}_{crown} = \frac{D_1 + D_2}{2}$$

Here, D_1 and D_2 represent the two perpendicular crown diameter measurements. The average bamboo-covered area per plot was obtained by summing all individual clump crown areas.

The average bamboo cover area per plot was then obtained as:

$$A_{bamboo,plot} = \frac{\sum A_{crown}}{N}$$

Although both clump base area and clump crown area were estimated, the crown area was used for estimating bamboo-covered area, as it more accurately represents the visible canopy extent and corresponds with satellite-detected bamboo features.

The bamboo-covered proportion derived from sample plots was aggregated and extrapolated to the respective grid cells, and overall study area (**2659575 hectares**), accounting for the total non-forest area below 3,500 m altitude. Spatial interpolation and area estimation followed standard statistical expansion techniques.

The mapped bamboo area was first obtained by pixel counting, i.e., multiplying the number of pixels classified as bamboo by the pixel area. However, since classification errors affect mapped area estimates, the final bamboo cover was adjusted using field-verified accuracy data following the method of Olofsson *et al*. (2013, 2014). The adjusted proportion of true bamboo cover (p_{true}) was computed as:

$$p_{\text{true}} = W_b \times U + (1 - W_b) \times r$$

where,

W_b is the mapped bamboo proportion, U is the user's accuracy (probability that a mapped bamboo pixel is truly bamboo), and is the false-negative rate (probability that an unmapped pixel is actually bamboo).

Finally, the actual bamboo area was estimated by multiplying the adjusted proportion of true bamboo with the area of interest (AOI):

Area bamboo = $P\ true \times\ AOI$

Accuracy Assessment

All types of errors namely, sampling error, non-sampling error, and classification error, had been addressed with a two-phase stratified sampling design and confusion matrix analysis. The probability of bamboo plot in map be actually in the field was measured by user's accuracy (U), defined as:

$$U\ = \frac{True\ positives}{Total\ mapped\ as\ bamboo}$$

Also, the probability of bamboo plot in the field was correctly mapped as bamboo was measured by producer's accuracy (P), defined as:

$$P\ = \frac{True\ positives}{Total\ field\ bamboo}$$

User's accuracy and producer's accuracy quantified commission and omission errors, respectively, which had been corrected using accuracy-adjusted area estimation following Olofsson *et al*. (2014). On the other hand, producing the confidence intervals for bamboo area estimation addressed the sampling error while use of standard field manuals, trainings to field crews and visual interpreters, and QAQC reviews minimized the non-sampling errors. In this way, this integrated approach ensured robust and unbiased estimate of bamboo cover outside forests in Nepal.

2.4 Biomass Assessment

Bamboo forests are very important for absorbing significant amount of carbon dioxide from the atmosphere and reducing the effects of climate change (Yiping *et al*, 2010). The significance of studying bamboo biomass is thus well recognized due to their increasing role in the balance of oxygen and carbon dioxide.

For this study, a total of 367 bamboo culms, from seven species/varieties, of varying sizes were destructively sampled. The species/varieties were selected based on people's preferences, usages, abundance and availability. Those species, along with their distribution for biomass measurement, are listed in Table 3.

Bamboo samples were collected from different districts. A destructive sampling approach was adopted to acquire data on total green mass of bamboo culm, branches and foliage. Besides, green samples of culm, branches and foliage were also collected. The samples were labeled, measured fresh weight and brought to the FRTC laboratory for drying, where further data on air-dry, and oven-dry weights were subsequently recorded. All procedures from sample selection to the laboratory analysis were performed as guided by the field manual (FRTC, 2023).

Allometric equations were developed in the form of linear and non-linear regressions. Exponential and power models among non-linear regressions were used for estimating total aboveground biomass. Biomass (total green mass on bamboo) was modeled against DBH and height individually and in combination.

Table 3: Species (major seven bamboo species) for biomass assessment

SN	Local name	Botanical name	Altitudinal range	Distribution	Number of samples
1	Dhanu/ Bholka/ Ban/ Harauti/ Harod/ Ghar bans	*Bambusa balcooa*	Terai-1400 m	Cultivated all over the Terai region (flat plains) of Nepal and in the lower mid-hills including Kathmandu, Pokhara and Surkhet Valleys, more common in eastern half of Nepal (from Dhaulagiri region)	51
2	Mal/ Malka/ Lisinga bans	*Bambusa teres* Buch.-Ham.	Terai-1500 m	Commonly cultivated to the east of Ramechhap in the mid-hills and Rautahat in the Terai, but now available in eastern half of the country; also in Chitwan, Makwanpur and other western hills; most commonly cultivated bamboo species on the farmlands east of Bagmati River in the Terai.	52

3	Taru/Tharu/ Sate/Chille bans	*Bambusa nutans*	Terai-1500 m	Commonly cultivated species to the west of Hetauda in central, western and mid-western regions but more common in the hills of central and western Nepal.	58
4	Jhapta/Chav/Kada/Koraincho bans	*Bambusa tulda*	Terai-1200 m	Most commonly cultivated species all over the Terai regions of Nepal including Chitwan district and Kathmandu valley	50
5	Kalo/Bhalu bans	*Dendrocalamus hookeri*	600-2000 m	Cultivated mainly in hills of eastern Nepal but rare in central Nepal	52
6	Choya/Tama/Guliyo/Dhungre/Ban bans	*Dendrocalamus hamiltonii*	Terai-2000 m	Cultivated all over hills of Nepal; one of the most commonly cultivated bamboo species in the mid-hills; found from Terai to the hills	50
7	Choya/Khasre/Phusre/Tama/Tame bans	*Bambusa nepalensis*	1000-2200 m	Most commonly/widely cultivated species in eastern, central and western hills of Nepal, common from east Nepal to Tansen in the west; found in Kathmandu valley and western mid-hills	54

Source: Stapleton (1994) and Das (2004)

2.5 Development of Taper Equations

For development of taper equations, firstly diameter at the breast height (DBH) and total height were measured. Then, the bamboo culm was harvested for measurements to be used for biomass assessment and development of taper equations. After felling of culms, diameters at several sections were measured, for instance, at 0.3 m, 1.3 m, 2.0 m and at intervals of 2 m were measured from its base up to the tip of the culm. The length of the culm was also measured.

For derivation of biomass and taper equations, detail calculations were performed in MS Excel and Rstudio. Final selection of models (equations) was based on the statistical outputs e.g. R^2, SE and RMSE of individual models. Several Rpackages e.g. tidyverse, caret, ggpmisc, splines, ggplot2, dplyr, etc. were used to develop the taper equations in Bspline regression and 5th degree polynomial model (R core team 2022).

2.6 Focus Group Discussion

Seventeen focus group discussions were held in 17 districts representing each province and geographic regions (Table 4). Due information on various socio-economic and bio physical aspects of bamboo were collected. Concerned Forest Offices were also consulted in the whole process from identifying participants to the group discussion. Farmers, craft makers, local businessmen, traders and other concerned stakeholders were included.

Table 4: Locations of Focus Group Discussion

Province	District
Koshi	Taplejung
	Sankhuwasabha
	Jhapa
Madhesh	Bara
Bagmati	Dhading
	Nuwakot
	Lalitpur
Gandaki	Baglung
	Lamjung
	Gorkha
Lumbini	Palpa
	Rolpa
	Dang
Karnali	Surkhet
	Jajarkot
Sudurpaschim	Kanchanpur
	Dadeldhura

2.7 Bamboo Mapping

The density of bamboo species (categorised culms per ha and clumps per ha), distribution of bamboo in sample plots were mapped based on the number of culms of each assessed clump and number of clumps in the plot. To determine clump density, the total number of clumps for each species was calculated per hectare, and for mapping, it was categorised into classes 1-5, 6-10,11-15,16-20 and >20. Similarly, culm density was assessed by calculating the total number of green culms per hectare for each species. The resulting densities were then classified into classes of 0-50, 50-100, 100-200, 200-400 and >400 for the mapping process.

2.8 Quality Assurance/Quality Control

Quality Assessment and Quality Control (QAQC) mechanism was used to check the accuracies of field inventory, data collection, data entry, and analysis. A systematic Quality Assurance and Quality Control (QA/QC) procedure was applied to ensure the reliability and consistency of the bamboo resource assessment. A total of 10% of all field plots were selected for independent verification. The QA/QC process was implemented in two stages. The first stage involved a field-level re-assessment of 80 plots (10% of the 800 validation plots) to evaluate measurement accuracy, adherence to field protocols, and consistency in data collection procedures. The second stage consisted of a 15% re-validation of data entry, during which attribute records were cross-checked for transcription errors, completeness, and logical consistency.

In addition to field and data-entry verification, QA/QC was also performed during the data analysis phase. All analytical steps, intermediate outputs, and final results were reviewed in detail through technical consultations with senior forest technicians and higher-level officials. This multi-level validation process ensured methodological transparency, minimized potential errors, and strengthened the overall credibility of the assessment outcomes.

2.9 Methodological Limitations

Despite strong methodological rigor, some limitations should be acknowledged:

I. **Visual interpretation biases**: small or young clumps may be missed in high-resolution imagery.

II. **Clump-area extrapolation**: crown area was used as the proxy for bamboo cover; basal area or culm density might yield different estimates.

III. **Temporal mismatch** between imagery acquisition and field inventory could affect accuracy in areas with fast-growing species.

IV. **Exclusion of forest bamboo** means total national bamboo resources are larger than reported here.

Addressing these limitations in future assessments—such as using LiDAR, high-resolution drone imagery, or species-specific object-based classification—could enhance precision.

3. Results

3.1 Bamboo Cover Area

3.1.1 Estimated Bamboo Area Outside Forests

This assessment identified a total of **306,478 hectares** of bamboo-available area within the non-forest landscapes of Nepal, derived from a systematically generated 500 m grid network below 3,500 m elevation. Based on the visual interpretation of 26,596 sample plots and subsequent field verification of 800 plots, the analysis estimated the actual bamboo cover outside forest areas to be **33,635 hectares** (± 618 ha at 95% CI)**.**

The classification accuracy assessment indicated a **user's accuracy of 0.93** and a **producer's accuracy of 0.98**, reflecting a high level of reliability in the bamboo detection and mapping process. Incorporating these accuracy adjustments and sampling uncertainties, the estimated bamboo area outside forests represents a statistically robust measure of bamboo distribution across non-forest zones.

3.1.2 Accuracy Assessment

The accuracy of the bamboo visual interpretation was assessed using 800 independent field validation plots**,** comprising 650 plots mapped as bamboo and 150 plots mapped as non-bamboo**.** The resulting confusion matrix (Table 5) summarizes the agreement between the mapped and field-observed classes. Among these, 606 plots were true positives (correctly identified as bamboo) and 140 were true negatives (correctly identified as non-bamboo)**,** while 44 plots were commission errors (mapped as bamboo but field-verified as non-bamboo) and 10 plots were omission errors (mapped as non-bamboo but bamboo was present in the field).

The user's accuracy for the bamboo class—representing the correctness of mapped bamboo plots—was 0.932 whereas, the producer's accuracy **—**indicating the proportion of actual field bamboo correctly identified on the map—was 0.984. These accuracy metrics demonstrate a high level of mapping reliability for bamboo detection, with low commission errors (7%) and minimal omission errors (2%)**,** confirming the robustness of the visual interpretation and classification procedures applied in this assessment.

Table 5 : Confusion matrix and mapping accuracy

Field class (true)	Map class (predicted)		
	Bamboo	Non-Bamboo	Total
Bamboo (present in field)	606	10	616
Non-Bamboo (absent in field)	44	140	184
Total (field plots)	650	150	800
A. User's accuracy (correctness of mapped bamboo):	0.932		
B. Producer's accuracy (how much actual bamboo was captured):	0.984		

3.2 Information on Bamboo Distribution

3.2.1 Altitudinal Distribution of Bamboo

Bamboo distribution was observed at altitudes ranging from the highest point of 2007 m (Dhadegaun, Phidim-3, Panchthar) in Koshi province to the lowest of 57 m (Khutta, Loharpatti-4, Mahottari) in Madhesh province, outside of forests (Table 6). However, it can be found up to 3500 m above sea level in Nepal, primarily in forested areas.

Table 6: Altitudinal distribution of bamboo

SN	Province	Altitude (m)	
		Maximum	Minimum
1	Koshi	2007	70
2	Madhesh	349	57
3	Bagmati	1941	190
4	Gandaki	1510	117
5	Lumbini	1814	90
6	Karnali	1725	84
7	Sudurpaschim	1943	135

3.2.2 Bamboo Clumps Density by Land Use

Distribution of bamboo clumps per plot in different types of land use revealed that bamboo distribution in different land use classes did not vary significantly, however the number of clumps was lesser in built-up area (Table 7).

Table 7: Clumps per plot by type of land use

SN	Land use	Clumps per plot
1	Agriculture	4
2	Built up	2
3	Forest	3
4	Marginal Land	4

3.2.3 Province wise distribution of bamboo species

Altogether 53 species of bamboo had been reported from Nepal. Among them, 7 species are endemic and 28 species are native to Nepal (annex 2). However, in this study, we found out a total of 14 bamboo species in sample plots in various districts and physiographic regions outside forests of Nepal.

Major species were *Bambusa teres* (Mal bans), *Bambusa nutans* (Taru bans), *Bambusa balcooa* (Dhanu bans), *Bambusa nepalensis* (Khasre/Fusre bans), *Bambusa tulda* (Chab/Jhapta bans) and *Dendrocalamus hamiltonii* (Tama bans) as shown in table 8**.**

Table 8: Bamboo species found in sample plots by provinces

SN	Local name	Scientific name	Province						
			Koshi	Madhesh	Bagmati	Gandaki	Lumbini	Karnali	Sudurpaschim
1	Mal bans	*Bambusa teres*	*	*	*	*	*	-	*
2	Taru bans	*Bambusa nutans*	-	*	*	*	*	*	*
3	Bhalu bans	*Dendrocalamus hookerii*	*	-	*	-	-	-	-
4	Dhanu bans	*Bambusa balcooa*	-	*	*	*	*	*	-
5	Chab/Jhapta bans	*Bambusa tulda*	-	*	-	-	-	-	-
6	Khasre/Fusre bans	*Bambusa nepalensis*	*	-	*	*	*	*	*
7	Tama bans	*Dendrocalamus hamiltonii*	*	-	*	*	*	*	-
8	Katha bans	*Dendrocalamus strictus*	-	*	*	-	*	*	*
9	Kande bans	*Bambosa bamboos*	-	*	*	-	*	-	*
10	Dhungre bans	*Dendrocalamus giganteus*	*	-	*	-	-	-	-
11	Nigale bans	*Bambusa jaintiana*	-	-	*	*	*	-	*
12	Pahelo bans	*Bambusa vulgaris*	-	-	*	-	-	-	-
13	Murali bans	*Cephalostachyum latifolium*	-	-	*	-	-	-	-
14	Paryang/Padang	*Himalayacalamus hookerianus*	-	-	*	-	-	-	-

3.2.4 Clump size (clump base and crown area)

The average clump base area for all bamboo species was 24.4 m^2. The highest recorded base area was 924 m^2 for *Bambusa teres* whereas the lowest base area was less than 1 m^2 for *Bambusa nepalensis* and *Dendrocalamus giganteus.* (Table 9).

Table 9: Clump base area (m^2)

SN	Local name	Scientific name	Average	Minimum	Maximum	sd
1	Kande bans	*Bambusa bambos*	19.9	0.5	118.8	22.0
2	Mal bans	*Bambusa teres*	54.0	5.0	924.0	74.9
3	Murali bans	*Bambusa jaintiana*	6.9	0.5	103.6	15.5
4	Bhalu bans	*Dendrocalamus hookeri*	24.0	0.6	168.0	30.3
5	Tama/choya bans	*Bambusa nepalensis*	23.0	0.3	192.0	28.0
6	Dhungre bans	*Dendrocalamus giganteus*	24.7	0.3	270.0	44.8
7	Tama bans	*Dendrocalamus hamiltonii*	14.7	1.0	127.1	16.5
8	Taru bans	*Bambusa nutans*	21.6	1.0	672.0	39.1
9	Dhanu bans	*Bambusa balcooa*	31.2	1.0	683.3	55.2
		Grand Total	**24.4**	**0.3**	**924.0**	**59.0**

Similarly, the average clump crown area for all bamboo species was 86.1 m^2. The highest recorded crown area was 6830 m^2 for *Bambusa teres* whereas the lowest base area was around 1 m^2 for several species (Table 10).

Table 10: Clump crown area (m^2)

SN	Local Name	Scientific Name	Clump crown area	Minimum	Maximum	sd
1	Kande bans	*Bambusa bambos*	71.8	1.0	240.5	59.3
2	Mal bans	*Bambusa teres*	116.0	1.0	6830.0	247.0
3	Murali bans	*Bambusa alamii*	19.4	1.0	119.2	24.7
4	Bhalu bans	*Dendrocalamus hookeri*	77.1	2.0	840.0	101.7
5	Tama/choya bans	*Bambusa nepalensis*	75.8	6.0	1440.0	133.2
6	Dhungre bans	*Dendrocalamus giganteus*	47.3	1.2	304.0	52.2
7	Tama bans	*Dendrocalamus hamiltonii*	40.4	1.0	325.8	38.5
8	Taru bans	*Bambusa nutans*	54.1	1.0	416.6	51.7
9	Dhanu bans	*Bambusa balcooa*	89.4	1.0	1147.6	115.3
	Grand Total		**86.1**	**1.0**	**6830.0**	**173.4**

The bamboo clumps found in Koshi and Madhesh provinces had larger crown diameters compared to those in other provinces. Clump and crown sizes are interrelated to each other, with a larger clump base indicating a larger crown. These are related to the number of culms as well. The bamboo clumps with smaller crown diameters contained lesser number of culms in the clumps. The mean crown diameters of bamboo in Sudurpaschim and Gandaki were smaller than other provinces (Table 11). Higher culms regeneration was noticed in the clumps with larger crown diameters.

Table 11: Province wise clump crown diameter of bamboo species

SN	Province	Crown diameter (m)		
		Diameter 1	Diameter 2	Average
1	Koshi	8.4	5.5	7.0
2	Madhesh	7.4	5.5	6.5
3	Bagmati	6.2	3.5	4.9
4	Lumbini	4.9	3.6	4.3
5	Karnali	4.4	3.5	3.9
6	Gandaki	4.2	2.9	3.6
7	Sudurpaschim	3.6	3.1	3.3
	Overall mean	6.4	4.3	5.3

3.2.5 Diameter at breast height (DBH) of different bamboo species

Out of all species of bamboo found in this assessment, the maximum recorded DBH was 18.5 cm of *Dendrocalamus giganteus* (Dhungre bans) and the minimum recorded DBH was 0.4 cm of *Bambusa nutans* (Taru bans). The average DBH of bamboo was found highest i.e. 10.7 cm and lowest 3.6 cm for *Dendrocalamus giganteus* (Dhungre bans) and *Bambusa jaintiana* (Murali bans) respectively, with the grand average of 6.4 cm of all species (Table 12).

Table 12: (DBH) of different bamboo species (cm)

Local Name	Species/ size category	Average	Minimum	Maximum	sd
Dhanu bans	*Bambusa balcooa*	7.1	0.7	12.9	1.9
	L	8.8	5.0	12.9	1.3
	M	7.1	3.0	10.0	1.1
	S	5.2	0.7	8.0	1.1
Tama/Choya bans	*Bambusa nepalensis*	6.6	0.7	12.9	1.9
	L	8.4	5.0	12.9	1.2
	M	6.8	3.0	10.0	1.1
	S	4.8	0.7	7.9	1.2
Mal bans	*Bambusa teres*	6.2	1.0	17.7	1.5
	L	7.7	5.0	17.7	1.0
	M	6.2	3.3	10.0	0.9
	S	4.7	1.0	7.9	0.9
Taru bans	*Bambusa nutans*	5.8	**0.4**	12.8	1.6
	L	7.2	5.0	12.8	1.1
	M	5.9	3.0	9.7	1.1
	S	4.4	0.4	8.0	1.0
Jhapta bans	*Bambusa tulda*	5.9	2.4	8.9	1.3
	L	7.2	6.1	8.9	0.6
	M	6.0	5.1	7.2	0.6
	S	4.5	2.4	6.1	0.8
Tama bans	*Dendrocalamus hamiltonii*	7.8	1.4	16.0	2.4
	L	10.0	5.1	16.0	1.8
	M	7.7	3.5	10.0	1.3
	S	5.4	1.4	8.0	1.4
Bhalu bans	*Dendrocalamus hookeri*	10.4	2.9	18.2	2.8
	L	12.3	8.0	18.2	2.0
	M	8.9	4.5	10.0	1.0
	S	6.6	2.9	8.0	1.4
Kath bans	*Dendrocalamus strictus*	3.7	1.0	9.2	1.3
	L	6.2	5.0	9.2	1.3
	M	3.9	3.0	8.3	1.1
	S	3.2	1.0	6.7	0.9
Dhungre bans	*Dendrocalamus giganteus.*	**10.7**	5.3	18.5	2.7
	L	12.5	10.2	**18.5**	2.4
	M	9.2	8.4	10.0	0.6
	S	7.1	5.3	8.0	0.8
Kande bans	*Bambusa bambos*	5.7	1.8	10.1	1.6
	L	7.3	5.0	10.1	1.2
	M	5.8	3.3	8.4	1.0
	S	4.2	1.8	6.5	0.9
Murali bans	*Bambusa jaintiana*	**3.6**	0.5	9.0	1.3
	L	6.2	5.0	9.0	1.2
	M	4.0	3.0	6.8	0.9
	S	3.2	0.5	5.8	1.0
	Grand Total	**6.4**	**0.4**	**18.5**	**2.0**

L: large size, M: medium size and S: small size

3.2.6 Base diameters (D30), internode length and culmination height

The large size bamboos, *Dendrocalamus hookeri* and *Dendrocalamus hamiltonii* had attained the greater D30 (diameter at 0.3 m height from ground) and DBH (Table 13). The mean internode length of seven major bamboo species varied from 28.92 cm for *Dendrocalamus hamiltonii* to 40.22 cm for *Bambusa teres.* As anticipated, the internode length at 1.3 m was the greatest for *Bambusa teres*. The average culmination height was the highest (16.27 m) *for Dendrocalamus hookeri* and the lowest (9.19 m) for *Bambusa tulda*.

Table 13: Diameters, internode length and culmination height of 7 major bamboo species

Local name	Scientific name	Mean D30 (cm)	Mean DBH (cm)	Mean internode length (cm)	Mean culmination height (m)	Number of samples
Dhanu bans	*Bambusa balcooa*	7.55	7.05	29.66	13.30	3885
Choya bans	*Bambusa nepalensis*	7.13	6.62	31.40	11.38	2198
Mal bans	*Bambusa teres*	6.39	6.24	40.22	13.43	8025
Taru bans	*Bambusa nutans*	6.36	5.83	31.10	12.29	2572
Chab/Jhapta bans	*Bambusa tulda*	6.04	5.90	30.29	9.19	82
Tama bans	*Dendrocalamus hamiltonii*	8.92	8.33	28.92	12.12	1135
Bhalu bans	*Dendrocalamus hookeri*	10.82	10.28	34.02	16.27	261

L*3.2.7 Green, dead/dry and broken culms*

Green culms per clump were found the highest for bamboos assessed in Madhesh province, followed by Koshi province (Table 14). The number of dead or dry culms per clump did not show significant variation across all provinces, ranging from 3 culms per clump in Koshi and Sudurpaschim provinces to 7 culms per clump in Gandaki province.

Table 14: Province wise mean green, dead/dry and broken culms

SN	Province	Mean (culms per clump)		
		Green culms	Dead/dry culms	Broken culms
1	Koshi	84	3	3
2	Madhesh	105	4	5
3	Bagmati	65	5	5
4	Gandaki	61	7	8
5	Lumbini	64	5	17*
6	Karnali	50	5	7
7	Sudurpaschim	61	3	2
	Overall mean	72	4	7

*cut culms included

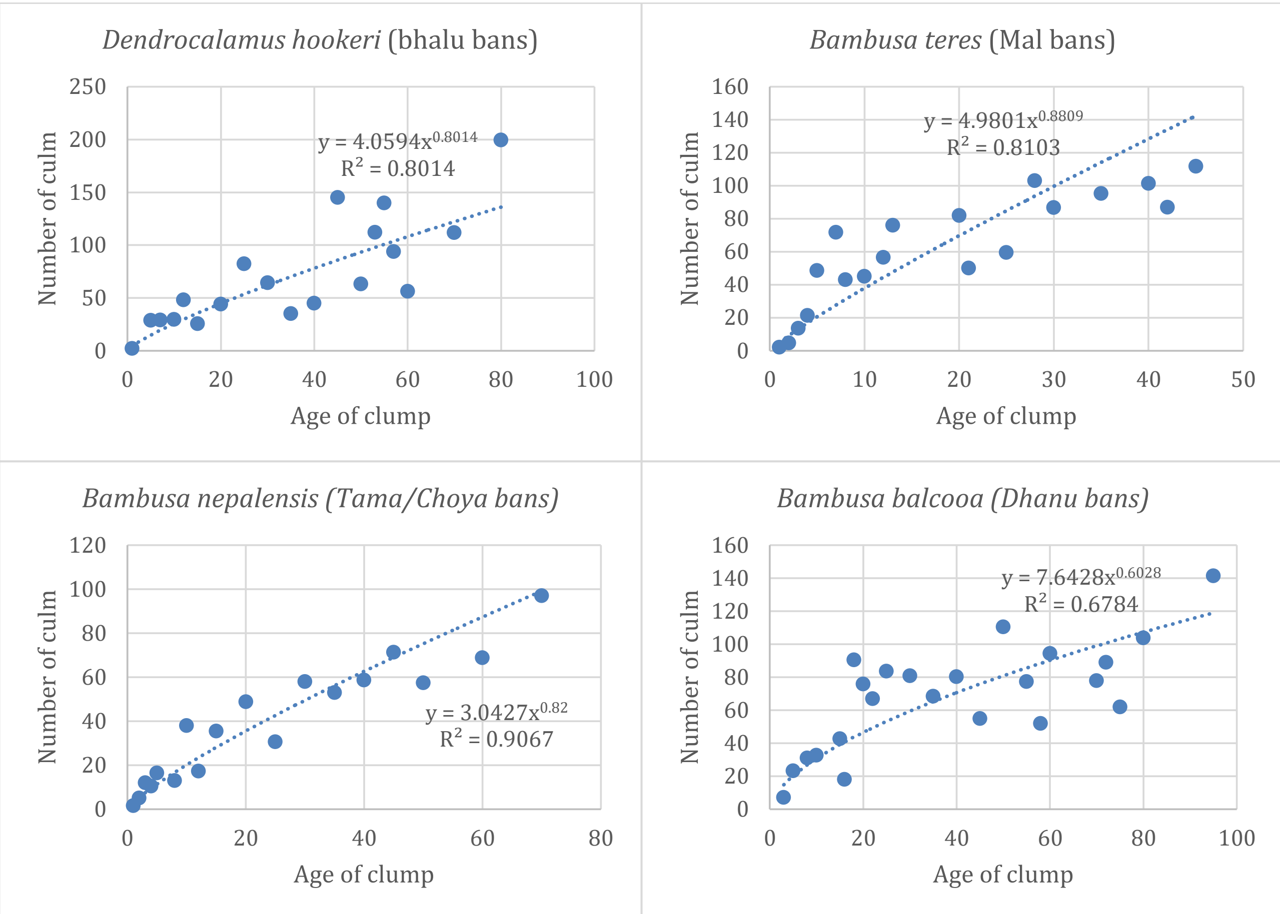
However, broken culms per clump was found significantly higher in Lumbini, it was mainly due to inclusion of cut culms in Gulmi and Arghakhanchi districts. In these districts, many culms were found top cut for the use of fodder for their cattle. Lumbini province had the highest number of clumps per plot. In general, the number of clumps per plot was found to be similar for all provinces (Table 15).

Table 15: Province - wise average number of clumps

SN	Province	Number of clumps per plot
1	Koshi	4
2	Madhesh	4
3	Bagmati	4
4	Gandaki	4
5	Lumbini	5
6	Karnali	3
7	Sudurpaschim	3
	Average	4

3.2.8 Culms number in Clump by Age and Species

Models were developed to predict the total number of bamboo culms by age and species of clump. The following figure (4) illustrates various models and equations for different bamboo species.



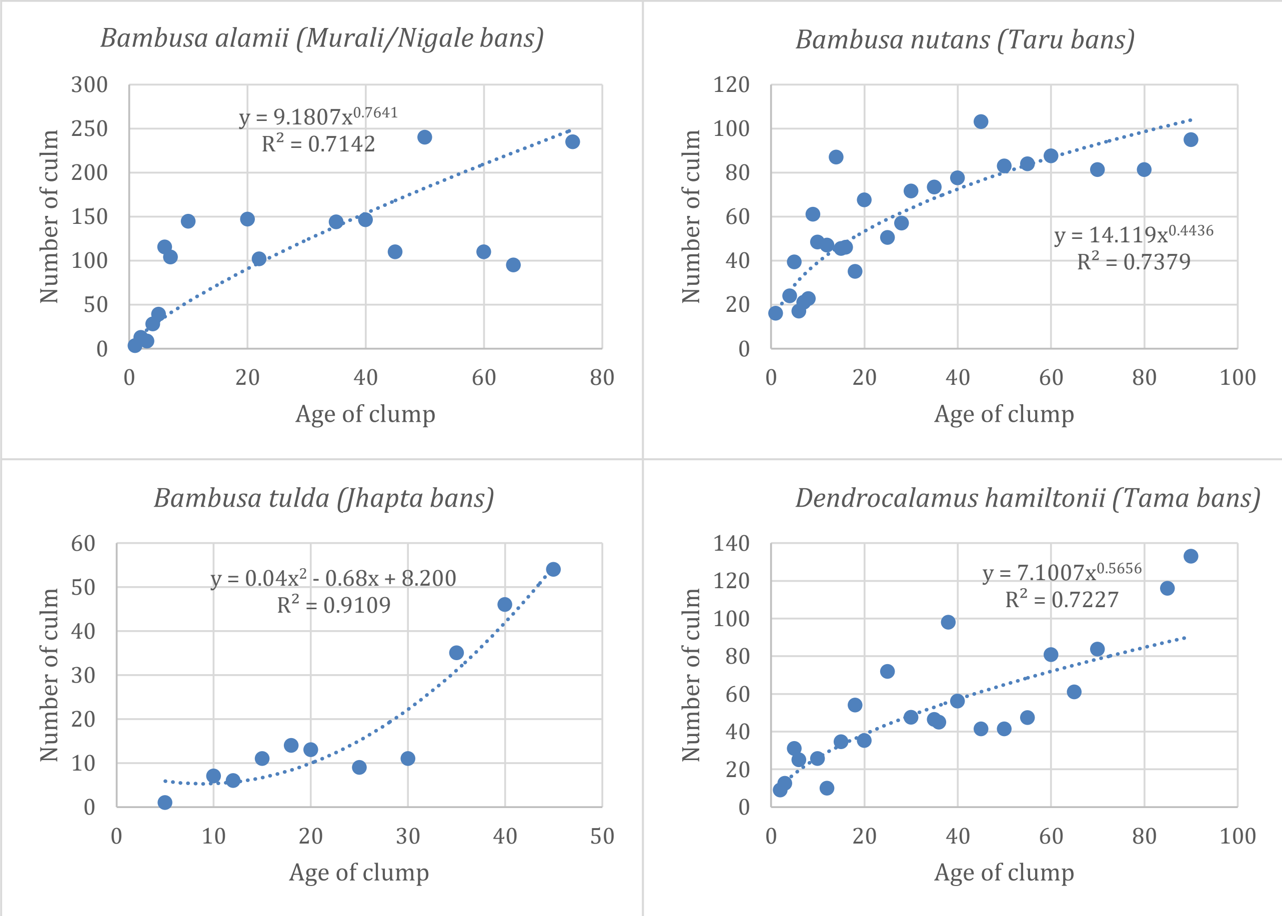


Figure 4: Bamboo culm number and clump age by species

3.3 Taper Models for Bamboo

The following figure (5) shows the distribution of sample bamboo culms of all species along with their diameters measured at different sectional heights for each bamboo culm.

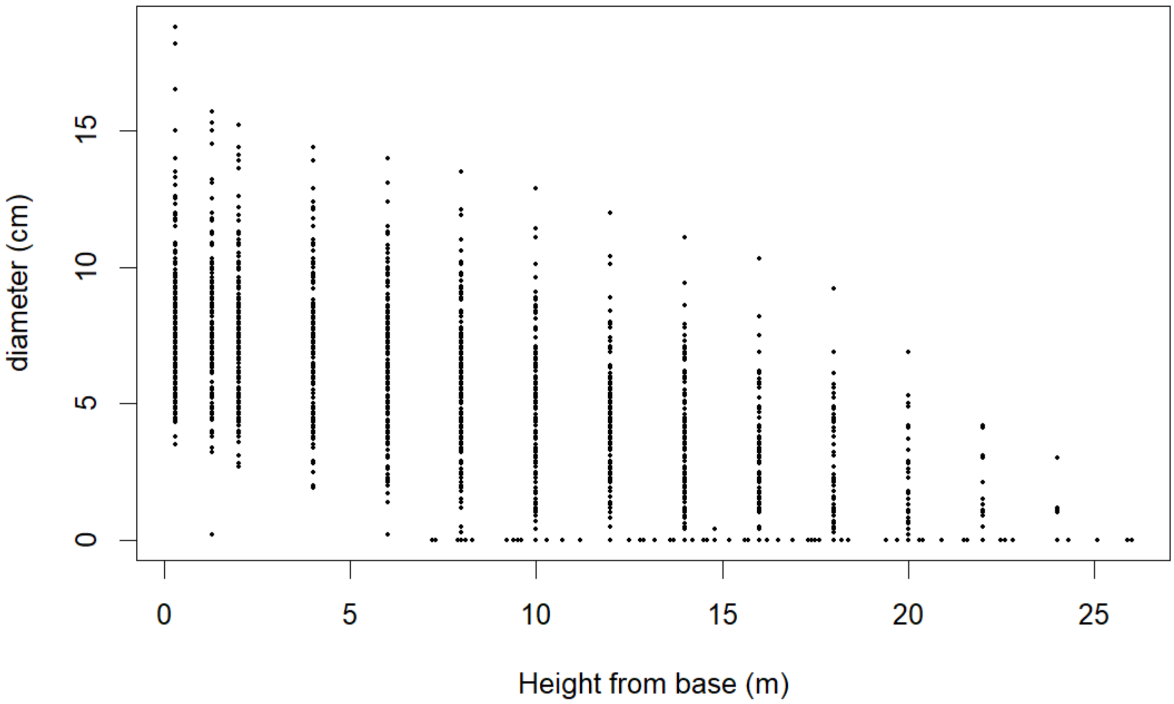


Figure 5: Observation on sectional diameters and heights from base of bamboo culms

The highest number of bamboo culms were from the DBH class 5 to 10 cm (Figure 6). On the other hand, minimum samples of culms were representing the DBH above 10 cm and below 5 cm.

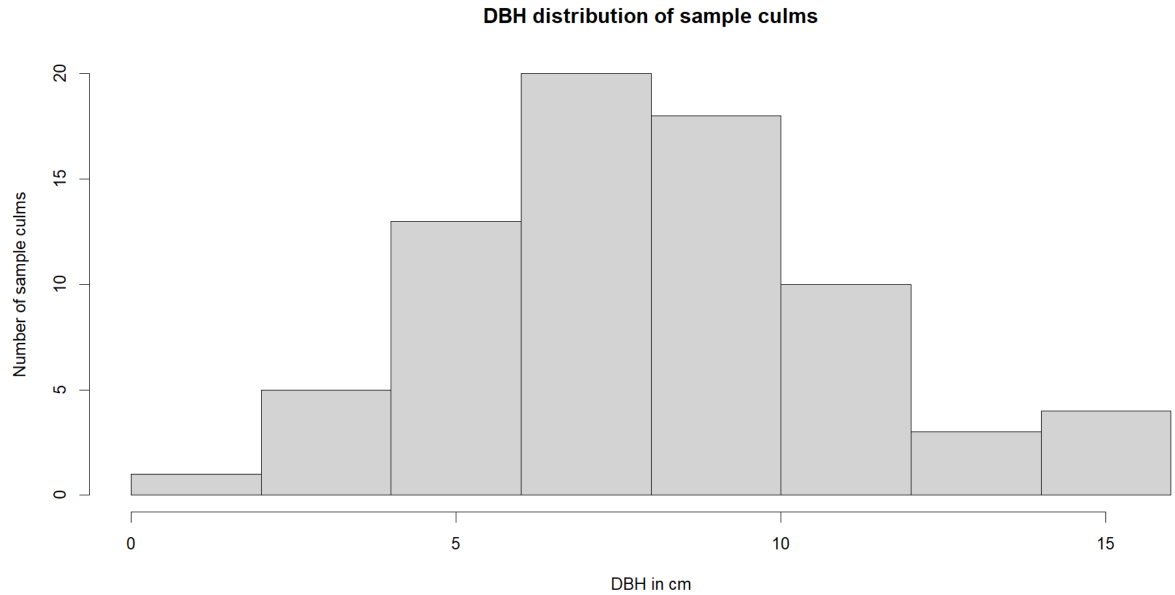


Figure 6: Observation on sectional diameters and heights from base of bamboo culms

The following taper equations (Table 16) have been developed.

Table 16: Taper models and model parameters

SN	Model	Model equation	Parameters	Residual standard error	Adj. R^2
1	Linear	Y=a+b(X) Where, Y=predicted diameter for mean DBH X=hi/ht (hi=sectional height and ht= total height)	a= 9.0051 b=- 7.8016	2.01	0.61
2	Polynomial	$Y=a+b(X)+c(X)^2$ Where, Y=predicted diameter for mean DBH X=hi/ht (hi=sectional height and ht= total height)	a= 8.53 b=- 4.4 c=3.41	1.99	0.63
3	BSpline	$Y=a+b(X)+c(X)^2+d(X)^3$ Where, Y=di/DBH (di=upper stem diameter) X=hi/ht (hi=sectional height and ht= total height)	a= 8 b=- 1.08 c=-13.5 d=-8.04	1.93	0.64
4	5^{th} degree polynomial taper model	$Y=a+b(X)+c(X)^2+d(X)^3+e(X)^4+f(X)^5$ Where, Y=di/DBH (di=upper stem diameter) X=hi/ht (hi=sectional height and ht= total height)	a= 8.86 b=- 17.6 c=76.3 d=-158 e=123 f=-31.4	1.92	0.65

3.3.1 Taper equation in a linear model

The following figure (7) illustrates taper model in a linear form.

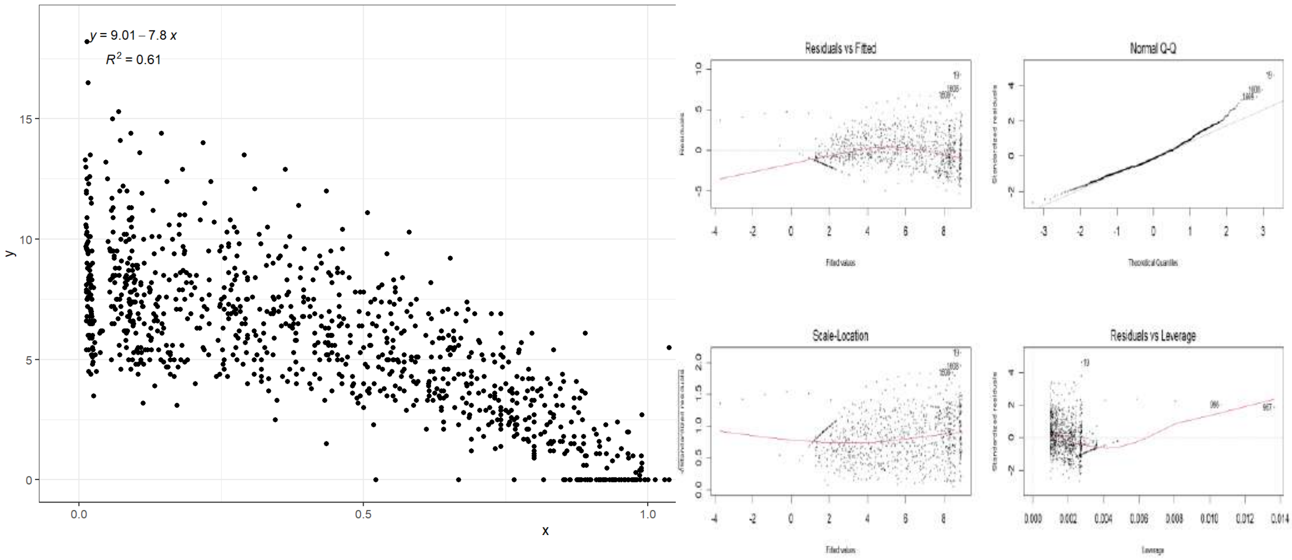


Figure 7: Linear taper model and residuals

3.3.2 Taper equation in a polynomial model

The following figure (8) illustrates taper model in a polynomial form.

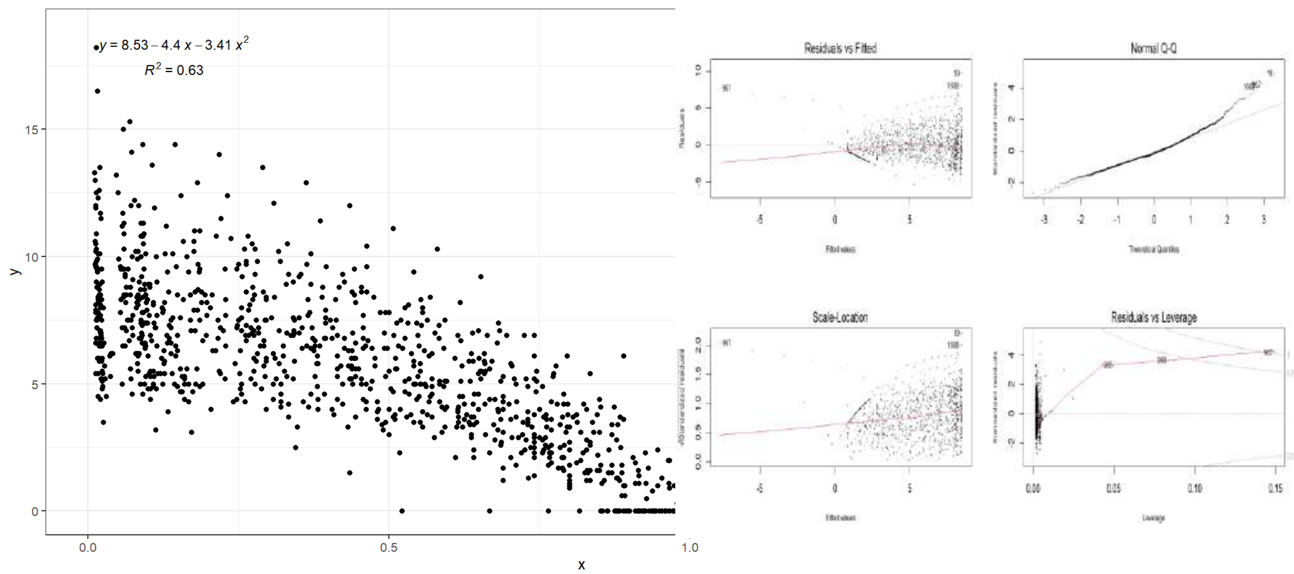


Figure 8: Polynomial taper model and residuals

3.3.3 Taper equation in a BSpline model

The following figure (9) illustrates BSpline taper model.

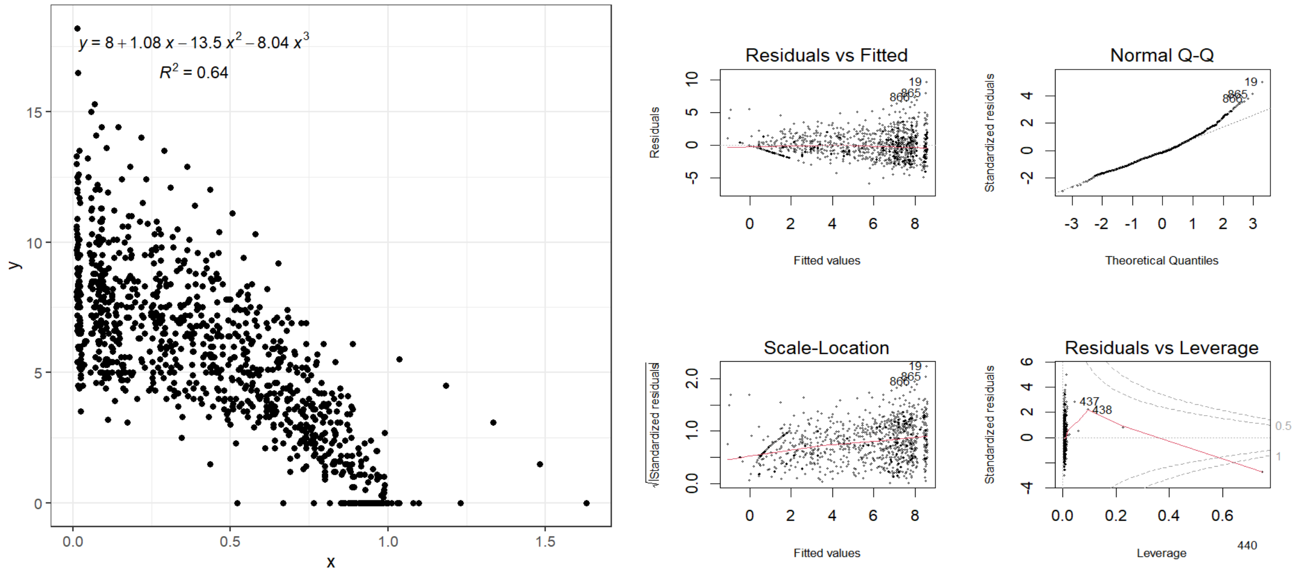


Figure 9: Bspline taper model and residuals

3.3.4 Taper equation in a 5th degree polynomial taper model

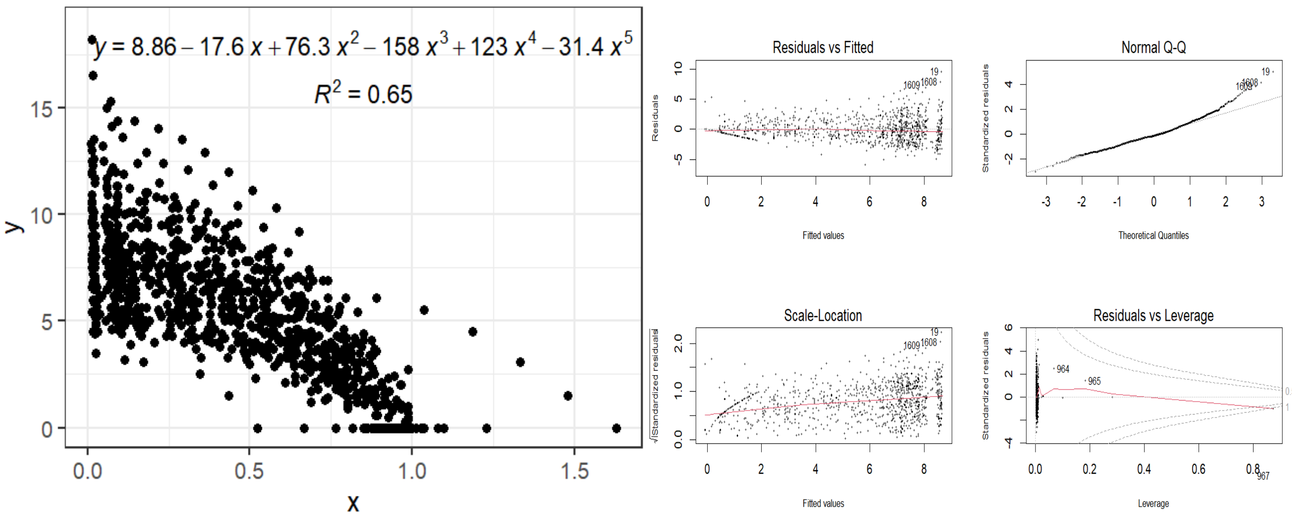


Figure 10: 5th degree polynomial taper model and residuals

3.3.5 Model selection

Taper models were developed in four different equations: linear, polynomial 2nd degree, bSpline (3rd degree) and polynomial 5th degree equations. Nevertheless, all four taper models seemed well performing, however, due to better adjusted R^2 and lesser residual standard errors, the latter two equations namely: (i) bSpline (3rd degree) and (ii) polynomial 5th degree taper models had been found more appropriate for the recommended taper models of bamboo species of Nepal.

3.4 Bamboo Green Mass and Conversion Ratio

3.4.1 Total Green Mass of Culms, Branches and Foliage

The average mass of a bamboo culm is 32.27 kg, with the majority, 26.06 kg attributed to the culm itself. The remaining mass consists of branches at 3.88 kg and foliage at 2.33 kg. Out of all species, the highest mass (42.69 kg) is found in *Dendrocalamus hookeri* of which culm being 36.04 kg, and branches & foliage being 3.71 kg and 2.95 kg respectively. Similarly, the lowest mass (24.86 kg) is found in *Bambusa teres* of which culm being 20.95 kg, and branches & foliage being 2.48 kg and 1.42 kg respectively (Table 17).

Table 17: Green mass of culms, branches, and foliage by species (kg)

Species	Size	Culm	Branch	Foliage	Total
Dendrocalamus hookeri (Bhalu bans)		36.04	3.71	2.95	42.69
	L	49.59	4.47	3.27	57.33
	M	26.54	3.03	2.84	32.41
	S	12.45	2.68	2.18	17.31
Bambusa balcooa (Dhanu bans)		31.35	5.25	2.21	38.81
	L	48.67	7.24	2.47	58.38
	M	21.61	4.40	2.59	28.61
	S	10.79	2.61	1.35	14.75
Bambusa tulda (Jhapta bans)		23.01	6.60	3.55	33.16
	L	38.22	8.75	3.77	50.74
	M	20.39	7.01	4.67	32.07
	S	12.68	4.59	2.60	19.87
Bambusa nepalensis (Khasre/Choya bans)		22.47	3.16	2.08	27.72
	L	41.15	4.83	3.34	49.31
	M	22.51	3.25	2.01	27.77
	S	9.98	1.93	1.34	13.25
Bambusa teres (Mal bans)		20.95	2.48	1.42	24.86
	L	29.52	3.17	1.79	34.48
	M	18.63	2.49	1.60	22.72
	S	12.57	1.62	0.77	14.96
Dendrocalamus hamiltonii (Tama bans)		22.52	2.90	2.11	27.54
	L	42.31	4.11	2.96	49.37
	M	23.40	3.35	2.24	28.99
	S	11.51	1.73	1.53	14.77
Bambusa nutans (Taru bans)		25.59	3.38	1.98	30.94
	L	43.56	4.62	2.77	50.95
	M	22.55	3.19	1.68	27.42
	S	10.81	2.34	1.50	14.64
Average of all		26.06	3.88	2.33	32.27

Note: L: Large; M: Medium; S: Small

3.4.2 Conversion Ratio - Green Weight to Oven Dry Weight

The average green weight to oven dry weight ratio for bamboo culm was 0.45 with the maximum value of 0.7 for *Dendrocalamus hamiltonii* and minimum value of 0.2 for *Dendrocalamus hookeri.* The details of ratio for culms of various species are presented in table 18.

Table 18: Ratio of green weight to oven dry weight for culms

Local name	Scientific name	Average	Minimum	Maximum	sd
Bhalu bans	*Dendrocalamus hookeri*	0.43	0.20	0.64	0.10
Dhanu bans	*Bambusa balcooa*	0.42	0.22	0.65	0.12
Jhapta bans	*Bambusa tulda*	0.43	0.23	0.67	0.11
Khasre/Choya bans	*Bambusa nepalensis*	0.43	0.21	0.68	0.12
Mal bans	*Bambusa teres*	0.50	0.29	0.63	0.08
Tama bans	*Dendrocalamus hamiltonii*	0.45	0.26	0.70	0.11
Taru bans	*Bambusa nutans*	0.47	0.24	0.67	0.10
	Grand Total	**0.45**	**0.20**	**0.70**	**0.11**

Similarly, the average green weight to oven dry weight ratio for bamboo branches was 0.45 with the maximum value of 0.79 for *Bambusa tulda* and minimum value of 0.21 for *Dendrocalamus hookeri.* The details of ratio for branches of various species are presented in table 19.

Table 19: Ratio of green weight to oven dry weight for branches

Local names	Scientific name	Average	Minimum	Maximum	sd
Bhalu bans	*Dendrocalamus hookeri*	0.43	0.21	0.62	0.08
Dhanu bans	*Bambusa balcooa*	0.47	0.32	0.60	0.08
Jhapta bans	*Bambusa tulda*	0.43	0.21	0.79	0.09
Khasre/Choya bans	*Bambusa nepalensis*	0.47	0.24	0.74	0.11
Mal bans	*Bambusa teres*	0.48	0.33	0.67	0.08
Tama bans	*Dendrocalamus hamiltonii*	0.43	0.25	0.68	0.08
Taru bans	*Bambusa nutans*	0.46	0.22	0.66	0.09
	Grand Total	**0.45**	**0.21**	**0.79**	**0.09**

Also, the average green weight to oven dry weight ratio for bamboo foliage was 0.47 with the maximum value of 0.8 for *Bambusa nepalensis* and minimum value of 0.19 for *Bambusa teres.* The details of ratio for foliage of various species are presented in table 20.

Table 20: Ratio of green weight to oven dry weight for foliage

Local names	Scientific name	Average	Minimum	Maximum	sd
Bhalu bans	*Dendrocalamus hookeri*	0.45	0.33	0.77	0.11
Dhanu bans	*Bambusa balcooa*	0.49	0.25	0.78	0.15
Jhapta bans	*Bambusa tulda*	0.42	0.30	0.74	0.11
Khasre/Choya bans	*Bambusa nepalensis*	0.48	0.22	0.80	0.12
Mal bans	*Bambusa teres*	0.46	0.19	0.75	0.13
Tama bans	*Dendrocalamus hamiltonii*	0.46	0.24	0.78	0.14
Taru bans	*Bambusa nutans*	0.51	0.30	0.78	0.13
	Grand Total	**0.47**	**0.19**	**0.80**	**0.13**

3.5 Bamboo Biomass

Allometric models in **linear**, **exponential** and **power** regression equations were developed for biomass modelling of bamboo species. Initially, allometric models were developed for all bamboo samples irrespective of species and later separate models for seven different species.

3.5.1 Allometric Models

3.5.1.1 Linear Regression Model

Linear models, based on two (a and b) parameters, were developed to estimate bamboo biomass where independent variables were chosen diameter at breast height and height of bamboo independently (Table 21).

Table 21: Model description: linear regression

Description	Linear model based on DBH	Linear model based on Height
Formula	Y = -15.11 + 7.3 * X	Y = -3.76 + 2.11 * X
Residuals: Min Median Max	-33.28 -1.34 39.55	-34.65 -1.79 42.0
Coefficients a (Intercept) (se) b (slope) (se)	 -15.1127 *(2.54)* 7.2993 *(0.39)*	 -3.7566 *(2.44)* 2.1130 *(0.14)*
Residual standard error	*11.46 on 338 degrees of freedom*	*12.73 on 338 degrees of freedom*
Adjusted R-squared:	0.5093 F-statistic: 352.8 on 1 and 338 DF, p-value: < 2.2e-16	0.3966 F-statistic: 222.1 on 1 and 338 DF, p-value: < 2.2e-16

The fitted models on linear regression equation are illustrated in the following figure (12).

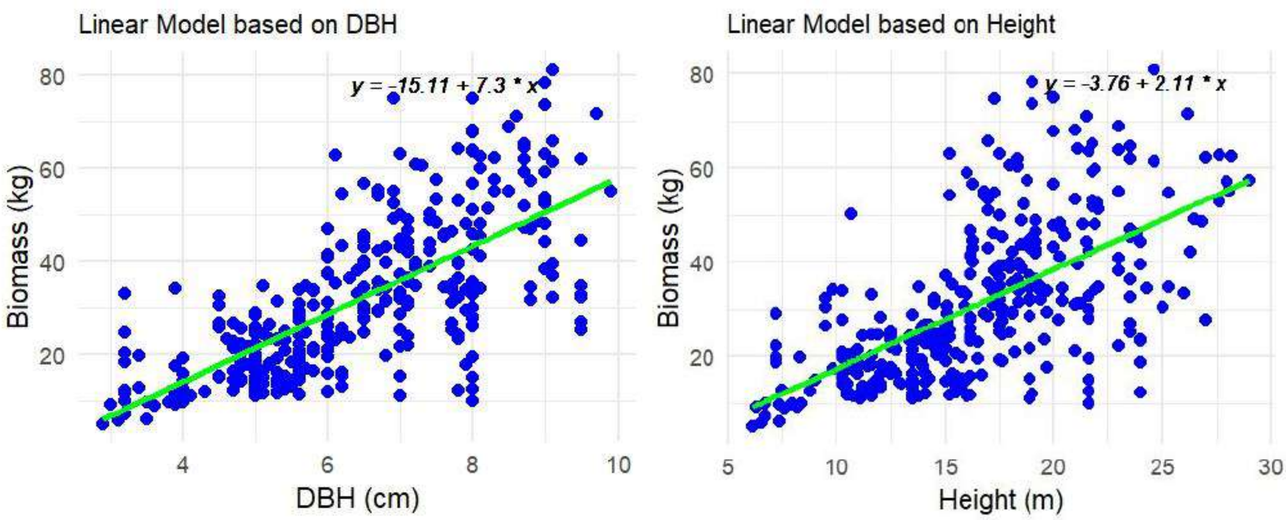


Figure 11: Linear models for bamboo biomass

3.5.1.2 Exponential Regression Model

<u>I. Models Based on DBH and Height Independently</u>

Exponential models, based on two (a and b) parameters, were also developed to estimate bamboo biomass where independent variables were chosen diameter at breast height and height of bamboo independently (Table 22).

Table 22: Model description: exponential regression (independent dbh & height)

Description	Exponential model based on DBH	Exponential model based on Height
Formula	Y = a * exp (b *X)	
Residuals: Min Median Max	-33.53 -1.50 41.52	-34.81 -2.25 43.50
Coefficients a (Intercept) (se) b (slope) (se)	 7.4040 *(0.71)* 0. 2178 *(0.01)*	 11.0019 *(0.97)* 0.06060 (*0.004*)
Residual standard error	*11.64 on 338 degrees of freedom*	*12.97 on 338 degrees of freedom*
Adjusted R-squared:	0.492	0.369

The fitted models on exponential regression equation are illustrated in the following figure (13).

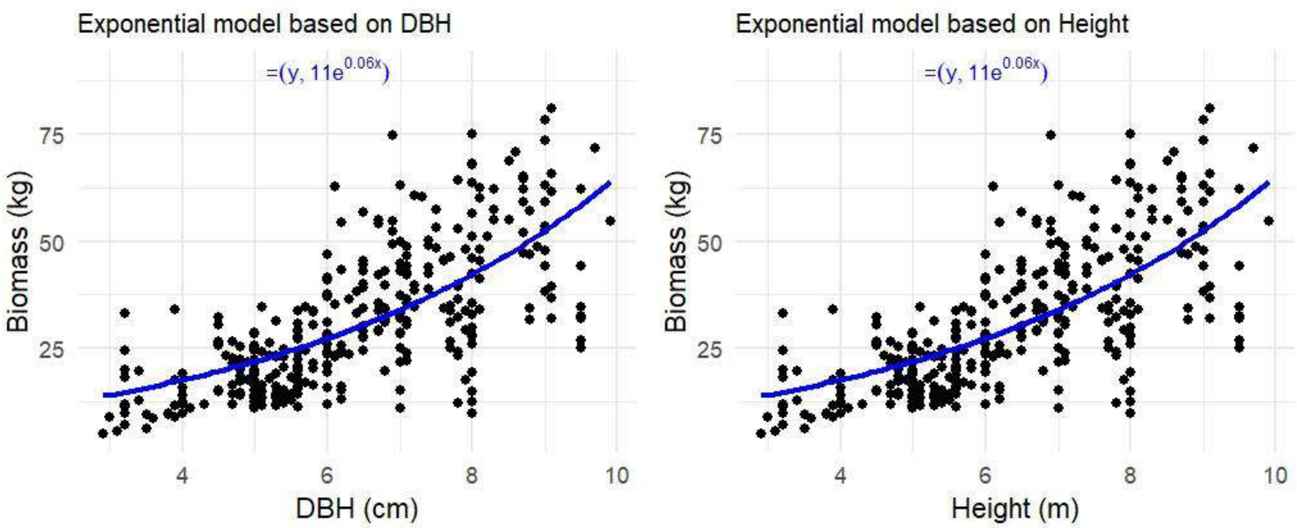


Figure 12: Exponential models for bamboo biomass

<u>II. Models Based on DBH and Height</u>

Exponential model, based on three (a, b, and c) parameters, was also developed to estimate bamboo biomass where both independent variables: diameter at breast height and height of bamboo were taken. The output of this model is illustrated in table (23).

Formula: y ~ a * exp(b * x1 + c * x2)

Table 23: Model description: exponential regression (combined dbh & height)

Parameters	Estimate	Std. Error	t value	Pr(>|t|)	Residual	SE
a	6.912611	0.68	11.033	< 2e-16 ***	11.44, df=337	
b	0.172687	0.01	6.911	< 2e-16 ***		
c	0.021178	0.005	5.496	0.0002 ***		*Adjusted R^2 = 0.51*

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

The fitted model on exponential regression equation based on both diameter at breast height and total height is illustrated in the following figure (14).

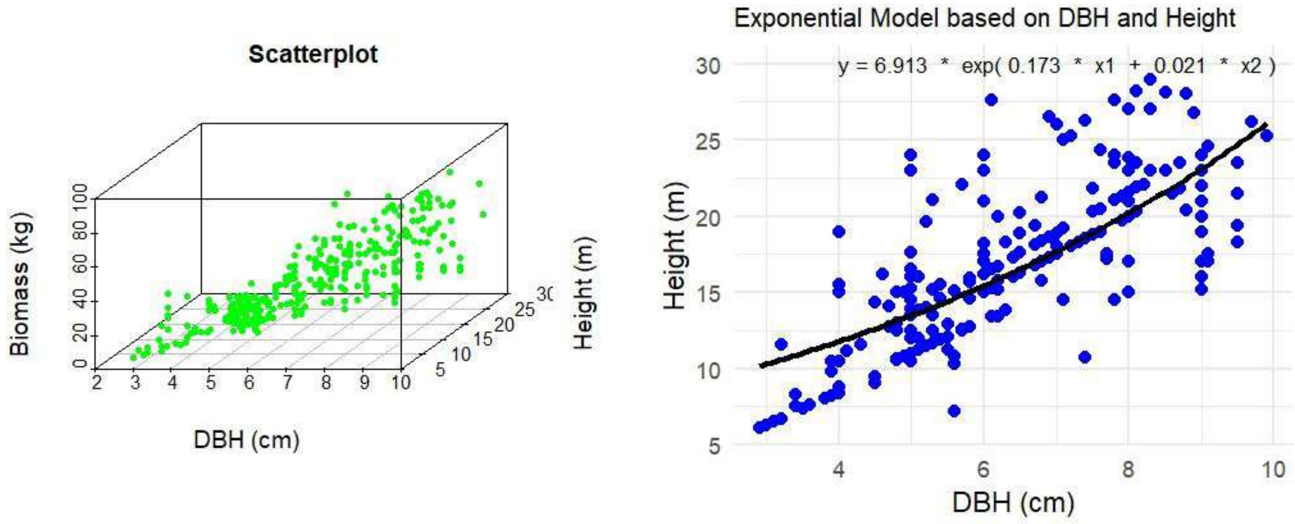


Figure 13: Exponential model based on both DBH and height

3.5.1.3 Power Regression Model

I. Models Based on Independent DBH and Height

Power models, based on two (a and b) parameters, were developed to estimate bamboo biomass where independent variables were chosen diameter at breast height and height of bamboo independently (Table 24).

Table 24: Model description: power regression (independent dbh & height)

Description	Independent variable = DBH	Independent variable = Height
Formula	$(Y = a * X^b)$	
	*Biomass = 1.888 * Diameter^ 1.506*	*Biomass = 1.381 * Height^ 1.11*
Residuals: Min Median Max	-33.22 -1.67 40.20	-34.66 -1.85 42.14
Coefficients a (Intercept) (se) b (slope) (se)	 1.888 *(0.33)* 1.506 *(0.09)*	 1.381 *(0.34)* 1.109 (0.08)
Residual standard error	11.45 on 338 degrees of freedom	12.73 on 338 degrees of freedom
Adjusted R-squared:	0.508	0.392

The fitted models on power regression equation based on two different independent varibales are illustrated in the following figure (15).

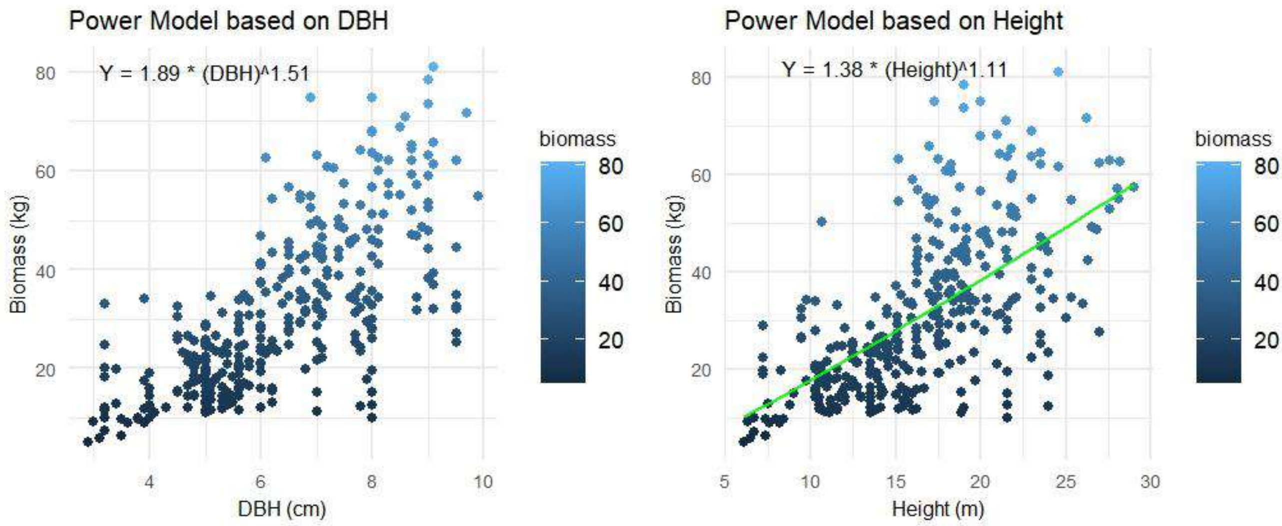


Figure 14: Power models for bamboo biomass

II. Power Model Based on DBH and Height

The following power model (Table 25) was developed to estimate bamboo biomass where both independent variables (diameter at breast height and total height) were taken.

Formula: [Y = a *(DBH)^b* (Height)^c]

Biomass = 1.258 * Diameter^ 1.203 * Height^ 0.345

Table 25: Model description: power regression (combined dbh & height)

Parameters	Estimate	Std. Error	t value	Pr(>|t|)	Residual	SE
a	1.2581	0.28	4.510	8.95e-06 ***	11.3, df=337	
b	1.2027	0.13	9.469	< e-16 ***		
c	0.3449	0.11	3.232	0.00135***		*Adjusted R^2 = 0.522*

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

The fitted model on power regression equation based on both independent varibales (DBH and height) are illustrated in the figure (15).

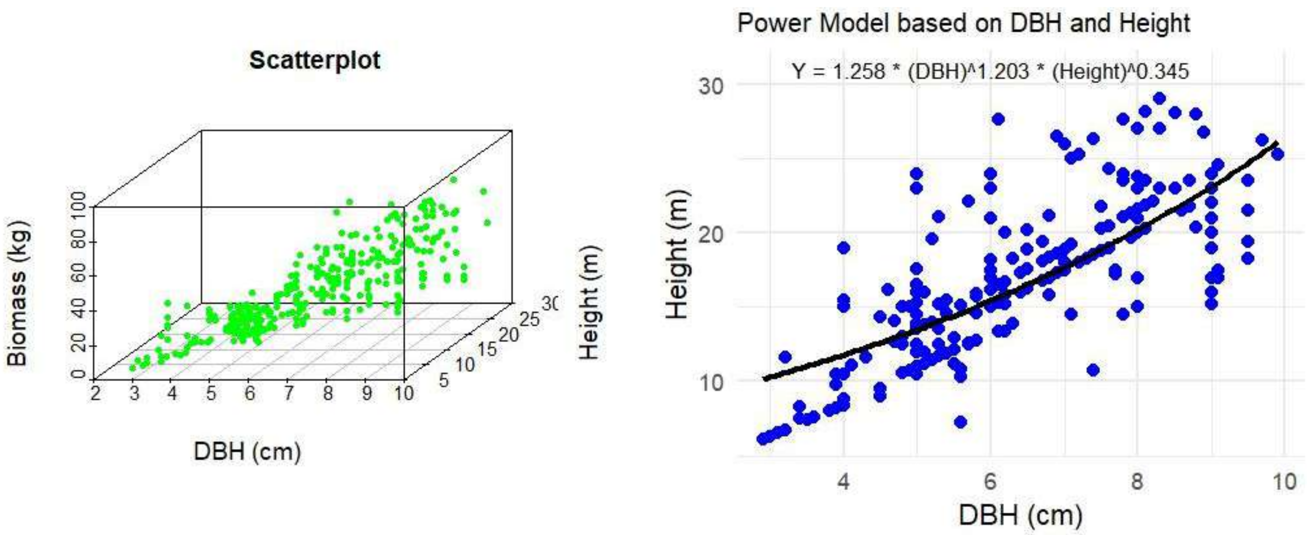


Figure 15: Power biomass model based on DBH and height

3.5.1.4 Allometric Models for Seven Bamboo Species

Allometric models for each seven bamboo species were also developed independently in power function where both diameters at breast height and heights were taken as independent variables against the dependent variable biomass (Table 26).

Table 26: Model description: independent power models for 7 species

Species	Formula: Biomass = a * (dbh^b) * (height^c)	Residual summary Min/Median/Max	Residual standard error	Adjusted R^2	RMSE
Bambusa nepalensis	Biomass = 1.128 * Diameter^ 0.892 * Height^ 0.583	-30.7 -1.58 24.2	9.55 on 49 df	0.950	9.27
Bambusa nutans	Biomass = 0.958 * Diameter^ 0.581 * Height^ 0.854	-24.4 -1.25 26.9	9.22 on 50 df	0.953	8.96
Bambusa teres	Biomass = 4.166 * Diameter^ 0.414 * Height^ 0.384	-20.7 -2.37 21.3	10.11 on 45 df	0.949	9.79
Bambusa balcooa	Biomass = 1.507 * Diameter^ 1.67 * Height^ -0.021	-28.0 -2.03 29.3	12.16 on 44 df	0.928	11.76
Bambusa tulda	Biomass = 1.186 * Diameter^ 1.663 * Height^ 0.09	-24.2 -1.25 36.7	10.92 on 45 df	0.940	10.57
Dendrocalamus hookeri	Biomass = 0.904 * Diameter^ 1.641 * Height^ 0.184	-30.6 -1.87 20.0	11.06 on 44 df	0.940	10.70
Dendrocalamus hamiltonii	Biomass = 3.536 * Diameter^ 0.962 * Height^ 0.09	-24.5 -1.94 29.2	11.72 on 42 df	0.936	11.32

The fitted model on power regression equation, for seven different bamboo species/varieites, based on both independent varibales (DBH and height) are illustrated in the figure (16).

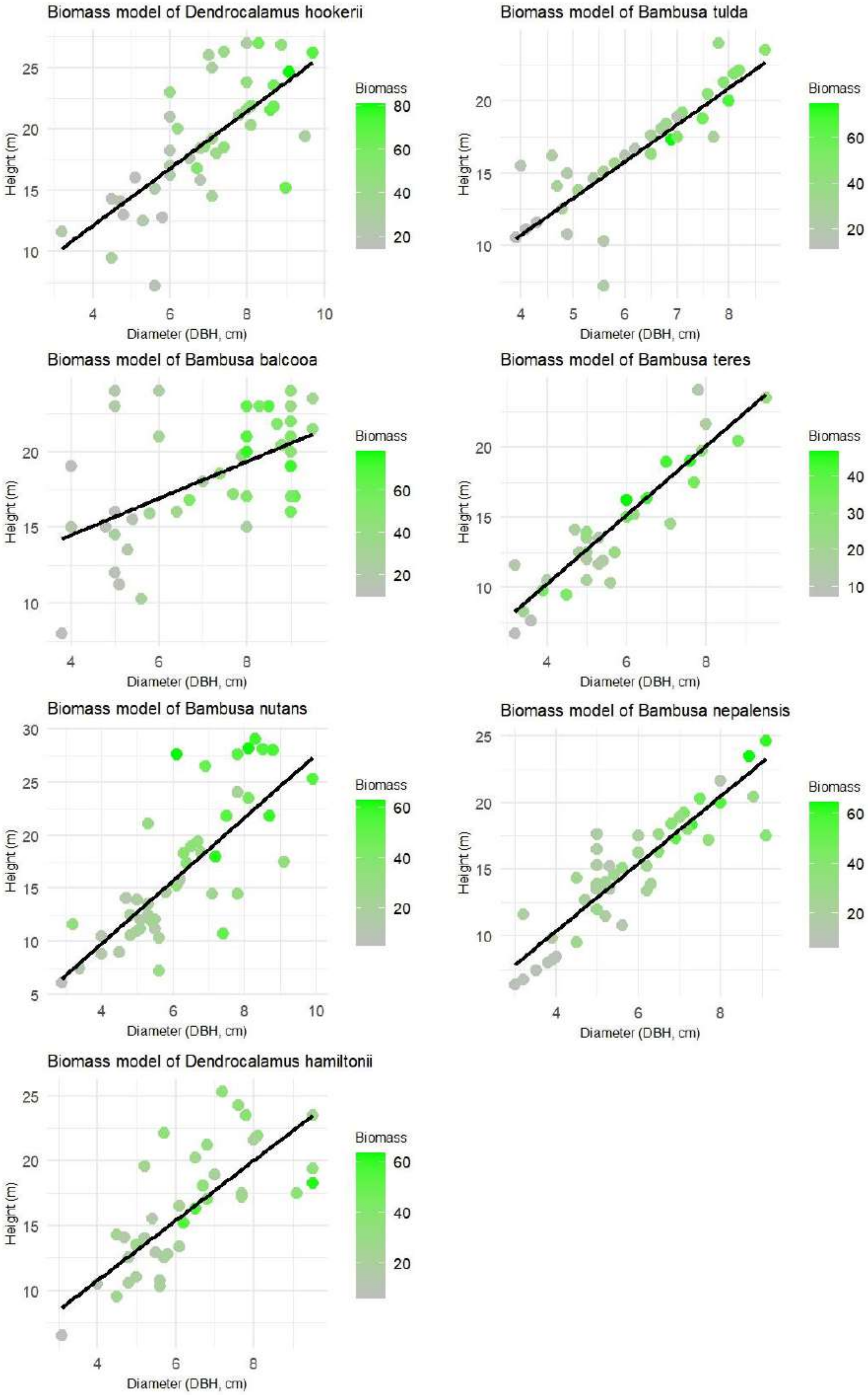


Figure 16: Biomass models for seven bamboo species

3.5.1.5 Model Selection

Biomass allometric models were developed in three different equations: linear, exponential, and power. Biomass models developed in all equations seemed performing well, however, due to better adjusted R^2 and lesser residual standard errors, the models developed in power equations with two independent variables (diameter at breast height and height) were found more appropriate and thus could be recommended as biomass allometric models for bamboo species.

3.5.2 Bamboo Biomass Estimation

Across the 616 one-hectare bamboo sample plots, the estimated green biomass per plot (equivalent to tons per hectare) showed substantial variability. The descriptive statistics are presented in the table (27).

Table 27: Mean, median, and maximum biomass

Statistic	Biomass (t/ha)
Minimum	0.07
Q1	3.07
Median	6.01
Mean	8.67
Q3	12.07
Maximum	64.86

These results indicate that while most bamboo-dominated non-forest plots contain between 3 and 12 t/ha, a small number of plots support considerably higher biomass densities, exceeding 60 t/ha.

Species-wise analysis of bamboo biomass revealed substantial variation among the species recorded across sample plots. *Bhalu bans* exhibited the highest mean biomass per plot (over 25 t/ha), indicating its large culm size and dense clump structure. This was followed by *Dhanu bans*, *Mal bans*, and *Tama bans*, each showing moderate biomass levels between 8–12 t/ha. Species such as *Choya bans*, *Taru bans*, and *Jhapta/Chav bans* contributed comparatively lower biomass, reflecting their smaller culm diameters and fewer culms per clump. The rest of the species, showed mid-range biomass values (Figure 17).

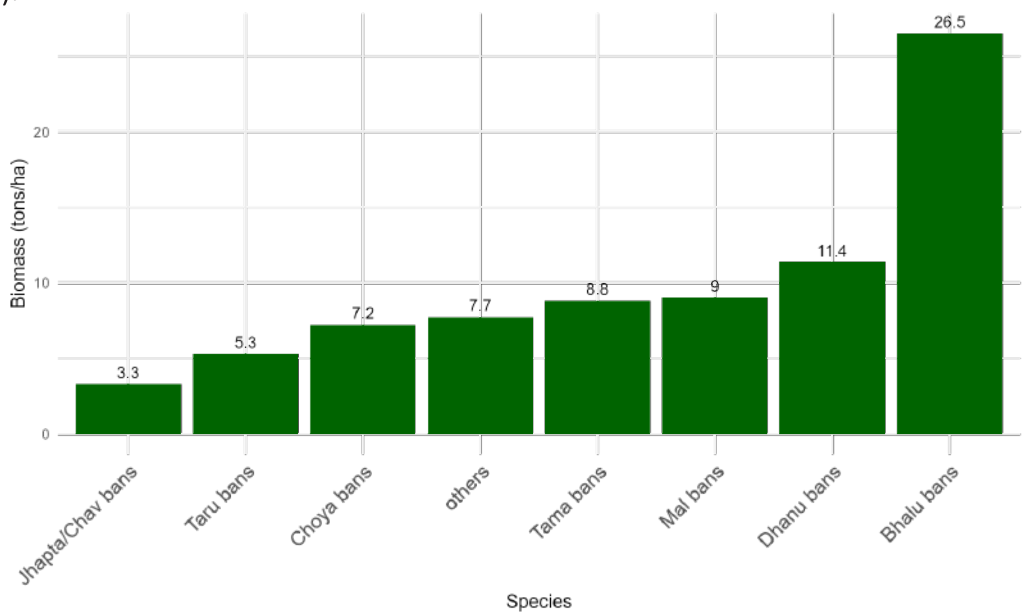


Figure 17: Species wise bamboo biomass per ha

Provincial analysis of bamboo biomass also exhibited remarkable variation. For instance, the highest mean biomass more than 14 t/ha was found in Madhesh province, whereas, the lowest mean biomass below 5 t/ha was found in Sudurpashchim province (Figure 18).

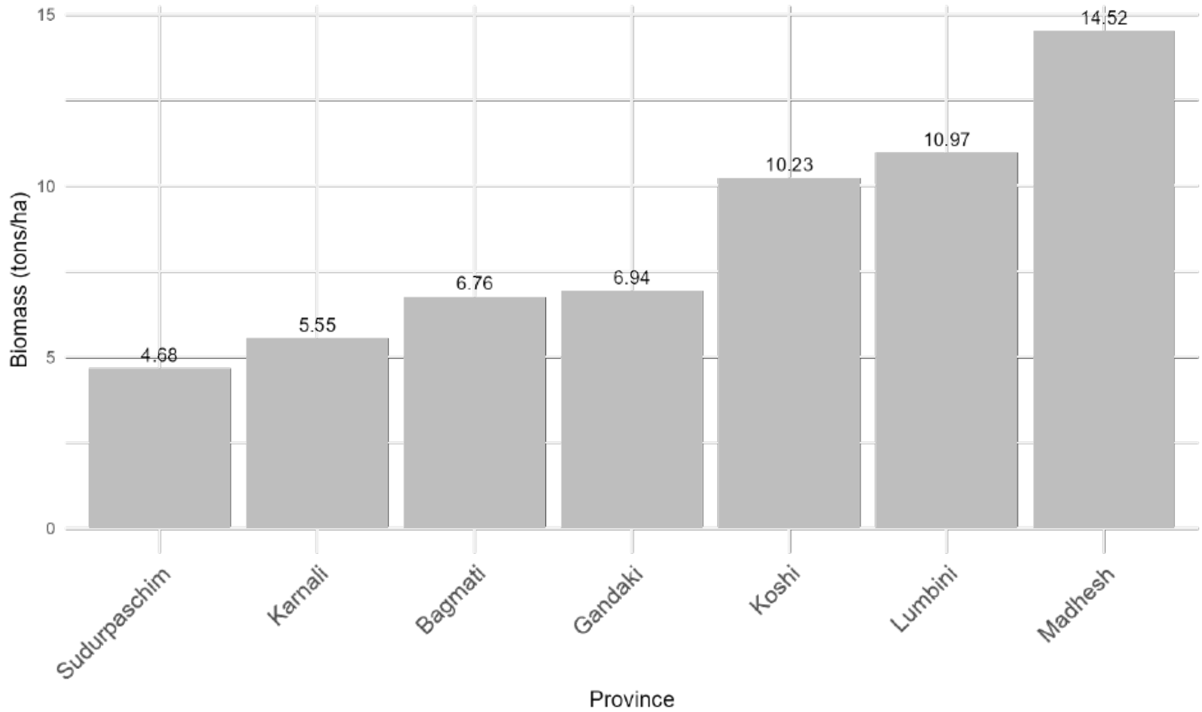


Figure 18: Province wise bamboo biomass per ha

3.6 Bamboo Resource Mapping

Bamboo resource mapping was conducted for bamboo presence plots outside the forest area in Nepal (Annex 3). Furthermore, maps of seven bamboo species were prepared detailing the density of culms and clumps per hectare.

A higher density of clumps of *Bambusa balcooa* was observed in the Bagmati and Gandaki provinces, with similar trends noted for culms per hectare in these regions. In terms of culms per hectare, higher densities were recorded in Madhesh, Gandaki, and Lumbini provinces. For *Bambusa nepalensis*, lower densities (1–5 clumps per hectare) were predominantly found in Koshi and Bagmati provinces, with densities of 11–15 clumps per hectare identified only in a few locations. Notably, densities exceeding 400 culms per hectare were recorded in Bagmati and Koshi provinces for this species.

Bambusa teres was absent in Karnali province, but higher densities (11–15 clumps per hectare) were found in Koshi province. Conversely, Sudurpaschim province exhibited much lower densities (1–5 clumps per hectare) for this species. Densities exceeding 400 culms per hectare were observed in Koshi and Bagmati provinces.

Bambusa nutans was not observed in the sample plots of Koshi province. The lower clump densities (1–5 clumps per hectare) for this species were found in Bagmati, Gandaki, Lumbini, Karnali, and Sudurpaschim provinces. However, densities exceeding 400 culms per hectare were recorded in Bagmati, Lumbini, Karnali, and Sudurpaschim provinces.

For *Bambusa tulda*, clump densities of 6–10 clumps per hectare and culm densities of 200–400 culms per hectare were found in Madhesh province. For *Dendrocalamus hamiltonii*, clump densities were mostly low (1–5 clumps per hectare), while culm densities exceeding 400 culms per hectare were recorded in Gandaki and Bagmati provinces. However, this species was not observed in Madhesh and Sudurpaschim provinces.

Finally, *Dendrocalamus hookeri* was found as low as 1–5 clumps per hectare in Koshi and Bagmati provinces to as high as 100–200 culms per hectare in Koshi province.

4. Discussions

The present assessment provides the first systematic, spatially explicit estimate of bamboo resources outside forest areas in Nepal, integrating visual interpretation, field-based clump measurements, and statistical corrections for classification error. The results indicate that 33,635 hectares of bamboo-covered area exists within the non-forest landscapes of the country, derived from a total potential bamboo-available area of 306,478 hectares. These estimates fill a significant knowledge gap in national-level bamboo statistics and offer insights that have important ecological, economic, and policy implications.

The estimated bamboo cover outside forests in this study is almost in line with the crude estimation performed by MoFSC (2004) cited by Acharya (2023). The commonly cited national figure of 63,000 hectares for bamboo and rattans combined, includes forests land as well which stated bamboo cover share of around 60% within the natural forests. Considering that the present study deliberately excludes forests and focuses solely on non-forest land, the results are consistent with expectations. Earlier studies such as Lobovikov *et al*. (2007), Das (2002, 2004), and Karki & Karki (1995) have documented bamboo presence but lacked comprehensive spatial sampling or remote-sensing integration.

Our findings complement these earlier works by providing statistically adjusted, spatially stratified estimates derived from extensive visual interpretation and large-scale field verification, thereby improving reliability and national representativeness. This study further attempts to provide an improved spatial understanding of bamboo occurrence and offers a valuable baseline for national bamboo resource monitoring, carbon accounting, and sustainable utilization planning.

The use of visual interpretation combined with targeted field verification produced high classification accuracy. The producer’s accuracy (0.984) indicates that land visually labeled as bamboo almost always contained bamboo in the field. The user’s accuracy (0.932) shows some commission error due to mixed vegetation, clumps with small crown signatures, or confusion with other shrubs/plantations.

The inclusion of false negatives (10 out of 150) in the adjustment formula ensured that omission errors were accounted for, resulting in a more realistic estimate of total bamboo area. Compared with global bamboo mapping studies (e.g., Du *et al*., 2018), the achieved accuracy metrics are robust, suggesting that visual interpretation remains a reliable method for bamboo detection in heterogeneous South Asian landscapes where multispectral imagery alone often underperforms.

Biomass analysis across species and provinces revealed notable variation in bamboo productivity. The higher mean biomass across the Madhesh province reflected the occurrence of larger culms with denser clumps whereas moderate biomass levels around Koshi, Bagmati and Lumbini indicated a mixture of both cultivated as well as naturally occurring bamboo resources. Furthermore, the lower biomass in Karnali and Sudurpashchim provinces could be regarded as indicators of lower bamboo availability in non-forest landscapes with smaller clump sizes and dominance of lower biomass potential species. Besides, the variation among the species reflected the differences in species composition, clump density, management practices, and ecological growing conditions across Nepal's non-forest bamboo landscapes. Overall, these results illustrate the uneven spatial distribution of bamboo biomass across Nepal's provinces.

The spatial distribution of bamboo outside forests reflects climatic, ecological, and land-use gradients across Nepal:

- Higher bamboo density was observed in lower-elevation settlements, farmlands, and river corridors.
- Eastern and mid-hill regions exhibited more species diversity, consistent with Stapleton (1994) and Das (2002).
- Provinces differed in bamboo availability mainly due to agricultural land-use patterns and climatic suitability.

These findings support regional studies in India and China (Li *et al*., 2018; Nath *et al*., 2020) that emphasize the influence of microclimate, soil characteristics, and anthropogenic management on bamboo occurrence.

Bamboo plays a crucial role in rural livelihoods, climate mitigation, green construction, and the circular bioeconomy. The quantification of bamboo outside forests provides evidence to:

- integrate bamboo explicitly into provincial and local land-use planning,
- guide regional bamboo enterprise development,
- support carbon accounting frameworks, especially under NDC and BTR reporting,
- prioritize restoration and sustainable harvesting strategies in high-potential areas.

Given the growing demand for bamboo-based industries and nature-based solutions, the documented resource base outside forests offers significant opportunities for economic diversification, especially in rural provinces such as Karnali, Lumbini, and Madhesh.

5. Conclusions

This study represents the first comprehensive bamboo resource assessment outside forest areas in Nepal, providing a national-level baseline of bamboo cover area, distribution, species composition, biomass characteristics, and structural attributes across diverse physiographic regions. This study reveals a total of 306,478 hectares of bamboo-available area in addition to an estimated area of 33,635 hectares as the actual bamboo cover area outside forest.

So far, 53 bamboo species have been reported in Nepal, including 7 endemic and 28 native species. Within the present assessment, 14 bamboo species were recorded across sampled plots outside forests in various districts, reflecting both ecological suitability and human management preferences. Bamboo was observed from a lowest altitude of 57 m in Madhesh province to an altitude of 2,007 m in Koshi province within non-forest areas, although national literature confirms its presence up to 3,500 m—primarily within natural forests.

The study estimated an overall mean green biomass of 8.67 t/ha, with plot-level values ranging up to a maximum of 64.86 t/ha. Among the documented species, *Dendrocalamus hookeri* (*Bhalu bans*) exhibited the highest average biomass potential at approximately 26.5 t/ha, whereas *Bambusa tulda* (*Jhapta/Chav bans*) represented the lower end of the biomass spectrum. Spatially, biomass distribution varied markedly among provinces. Madhesh province recorded the highest provincial biomass, exceeding 14 t/ha, largely influenced by dense clump formations in lowland areas. In contrary, Sudurpashchim province had biomass levels below 5 t/ha, indicating comparatively sparse bamboo occurrence. These findings underscore the significant ecological and geographical gradients shaping bamboo biomass across Nepal and highlight priority areas for resource management, utilization, and conservation planning.

The average mass of a bamboo culm was 32.27 kg, with the culm accounting for the largest share of total biomass. Among assessed species, *Dendrocalamus hookeri* exhibited the highest culm mass (42.69 kg). The green-to-oven-dry weight ratio was estimated at 0.45, which is consistent with previous studies in the Himalayan region and provides a useful conversion factor for biomass and carbon assessments.

Biomass allometric equations for seven species were developed independently in power function where both diameters at breast height and heights were taken as independent variables. These models are recommended for robust biomass predictions, as they demonstrated strong fit and biological interpretability.

The mapping component of the study demonstrated that visual interpretation of satellite imagery, supported by systematic field verification, provided an effective approach for detecting bamboo in non-forest areas.

The findings offer valuable insights for resource planning, policy formulation, and sustainable management of bamboo in non-forest landscapes, where bamboo plays an increasingly important ecological and socioeconomic role. The dataset provides a foundation for improving bamboo management, supporting value-chain development, promoting bamboo-based enterprises, and integrating bamboo resources into climate mitigation and adaptation strategies. The methodology applied—combining stratified sampling, remote sensing, field inventory, and statistical adjustment—demonstrates strong potential for ongoing national monitoring of bamboo resources both inside and outside forest areas.

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Annexes

Annex-1: Various aspects of bamboos (based on focus group discussion)

Annex 1.1 Ways of identifying bamboos

People have good knowledge on features to be applied for identifying bamboo. Based on their opinion in focus group discussion, the ways of identifying bamboo species are as follows:

Leaf size: Size of leaves varies with bamboo species. For instance, Tama bans and Choya bans have long leaves and Mal bans has short and broad (*chepto*) leaves.

Size of culm (diameter or girth): Katha bans has small sized culms, Mal bans has medium sized smooth culms and Bhalu bans has large culms. Similarly, malingo and nigalo are small bamboos.

Nodes: Number of nodes are more in Kharaute bans.

Height of culm: Mal bans, Dhanu bans and Bhalu bans are taller than others.

Leaves: Tama bans has heavy (dense) foliage.

Branch and branching pattern: Tama bans has many branches. Some bamboo species have large branches whereas some bamboo species have thin branches. Again, the number of main and other branches at the node varies with bamboo species.

Use: Tama bans is famous for shoot as a vegetable. Its shoot is very delicious. Taru bans has bitter shoot. Choya bans are good for making *choya*.

Internode length: It varies with bamboo species. Some bamboo species have short internode length e.g., Bhalu bans and Kharaute bans, whereas some bamboo species have long internode length, e.g., Mal bans.

Thorns: All bamboo species have no thorns but some species have thorns e.g., Kande bans and Taru bans.

Size of shoot: Bhalu bans have large shoots and shape of shoot also varies with bamboo species.

Size of clump: Clump height of Bhalu bans is large.

Culm sheath: Type of culm sheath is different for different bamboo species.

Smoothness of culm: Some bamboo culms are smooth e.g., Mal bans while other bamboo culms are rough.

Annex 1.2 Methods for identifying age of bamboo culm

The methods for identifying age of bamboo culm based on focus group discussion are as follows:

Size of culm: In general, the girth or diameter of first year culm is large. The size of mature culms is small.

Colour of culm: Young culms (first year) are deep green and mature culms are light yellow. The second year is green and dull. Old mature culms become red in colour (from 4 to 5 years but 8-10 years in shading places) in some cases. Similarly, a number of mature culms become yellowish. Black colour is found in some mature culms.

Softness and hardness of culms: Matured culms are strong and start to become yellow. Young culms are soft. Third year club is mature and strong.

Bark thickness of culm: Thickness of culm varies with the age of culms.

Foliage: As the age of culm increases, the foliage in culm gradually decreases. Younger culms have dense foliage but older culms have less foliage. No leaves or very few leaves present in the first-year culm, and flushing starts in second year

Size of leaves: With the increase in age of culm, leaves become smaller and less foliage. As the culms become mature, the size of leaves gradually reduces. Young culms have large leaves.

Branch: Very few thin branches arise in first year culm. With the increase in age of culm, branches become thin and small. Branches appear in second year culms.

Culm sheath (Khabata/patyas/dhyangro): Culm sheath is attached with new culms. Presence of culm sheath is found in the first-year culm.

Spots: In some cases, white spots are found in the first-year culm.

Annex 1.3 Recent Advancement in Bamboo Sector

The bamboo sub-sector has contributed notably to rural livelihoods across Nepal. Communities traditionally utilize bamboo for a wide range of household and farm needs, including livestock fodder, fencing, construction of cattle and goat sheds, agricultural tools, and even house construction. In addition to subsistence uses, farmers generate income by selling culms to traders for scaffolding, tunnel construction, and the production of bamboo goods. However, the extent of economic benefit varies by region; for example, farmers in Jhapa district gain significantly more income from bamboo sales and value-added processing compared to those in districts such as Dadeldhura. In Surunga, Jhapa, a number of households are engaged in mat-making, supported by an agreement between Kankaimai Community Forest and Kankaimai Municipality, which has strengthened local enterprise opportunities.

In recent years, Nepal has advanced the bamboo sector through supportive national-level policies. The Government of Nepal has formally endorsed bamboo-based structural construction norms, recognizing bamboo as a viable, sustainable, and safe material for engineered buildings. This is a major step toward mainstreaming bamboo in green construction and expanding its market value.

Similarly, Khotang district—widely regarded as Nepal's bamboo capital—has emerged as a national hub for bamboo-based innovation and livelihood enhancement. The district has implemented a range of livelihood-oriented programs, including hands-on skill-building trainings, enterprise development support, and technical guidance for manufacturing bamboo household items, decorative crafts, engineered products, and construction materials. These initiatives have helped rural communities diversify income sources, strengthen the bamboo value chain, and elevate bamboo from a subsistence material to a significant driver of local economic development.

A major milestone for the sector occurred in Falgun 2081, when Khotang hosted the First National Bamboo Conference, a nation-level event jointly organized by Diktel Majhuwagadhi Municipality, the Forest Research and Training Centre (FRTC), the Ministry of Forests and Environment (Kathmandu), and the Ministry of Tourism, Forests and Environment of Koshi Province, among other partners. The conference brought together national experts, researchers, policymakers, and local governments to formulate a collective vision for bamboo development in Nepal. The event concluded with a set of 35 formal declarations, outlining commitments related to bamboo-based enterprise promotion, sustainable resource management, research enhancement, green construction, and policy harmonization aimed at strengthening Nepal's bamboo sector at scale.

Annex-2: Bamboo species reported from Nepal

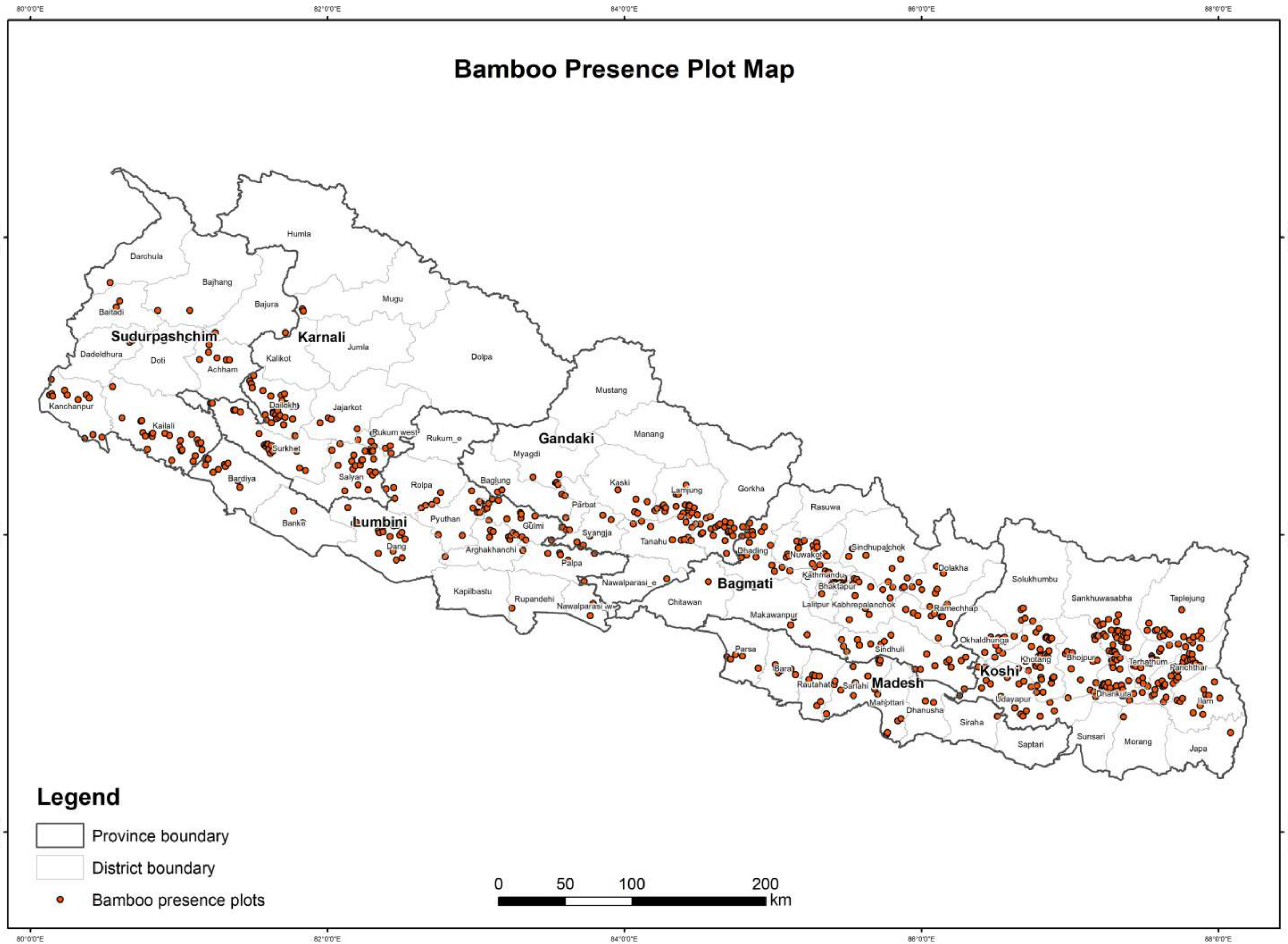
		Endemic Bamboo Species		
S.N	**Scientific name**	**Nepali name**	**Common name**	**References**
1	*Himalayacalamus asper* Stapleton	Ghode nigalo (Kaski), Malinge Nigalo, Baa ma (Tamang)	Tibetan Princess Bamboo	Stapleton, 1994
2	*Himalayacalamus cupreus* Stapleton	Malinge Nigalo		Stapleton, 1994
3	*Himalayacalamus fimbriatus* Stapleton	Tite Nigalo		Stapleton, 1994
4	*Himalayacalamus planatus* Stapleton	Malinge nigalo, Bra Ma (Tamang)		Rajbhandari *et al.*, 2016
5	*Himalayacalamus porcatus* Stapleton	Seto Nigalo, Bra ma (Tamang)		Stapleton, 1994
6	*Thamnocalamus chigar* (Stapleton) Stapleton	Chigar		Stapleton, 1994
7	*Yushania emeryi* (Stapleton) Demoly	Kalo Malingo, Kalo Nigalo		Stapleton, 1994
		Native Bamboo species		
8	*Ampelocalamus patellaris* (Gamble) Stapleton	Nibha (Eastern Nepal), Gopi bans (Pokhara), Lewas Bans (Palpa, Salyan)		Stapleton, 1994
9	*Bambusa balcooa* Roxb.	Dhanu bans, Bhalu bans, Bhalkhu bans, Harod bans, Bholka, Harouti, Ban Bans, Fayar bans, Phor Bans	Balcooa bamboo	Stapleton, 1994
10	*Bambusa jaintiana* R.B.Majumdar	Mugi Bans, Murali Bans		Stapleton, 1994
11	*Bambusa nepalensis* Stapleton	Tama Bans (Kathmandu), Khosre Bans, Phusre Bans (East Nepal)		Stapleton, 1994
12	*Bambusa nutans* Wall. ex Munro	Tharu bans (Kathmandu), Sate bans (Pokhara), Taaru bans	Nodding bamboo	Stapleton, 1994
13	*Bambusa teres* Buch.-Ham. ex Munro	Mal bans		Stapleton, 1994
14	*Bambusa tulda* Roxb.	Chab Bans (Rupandehi), Koraincho bans (Chitwan), Kada bans (Kathmandu), Jephtha bans,	Bengal bamboo, Smooth bamboo	Stapleton, 1994
15	*Cephalostachyum capitatum* Munro	Gohiya Bans		Malla *et al.*, 1986
16	*Cephalostachyum latifolium* Munro	Gopi Bans, Murali Bans		Stapleton, 1994
17	*Dendrocalamus giganteus* Munro	Dhungre Bans, Rachhasi Bans, Burra Bans	Giant Bamboo	Stapleton, 1994
18	*Dendrocalamus hamiltonii* Nees & Arn. ex Munro	Tama Bans, Choya Bans, Dhungre Bans	Tama bamboo, Tufted bamboo	Stapleton, 1994
19	*Dendrocalamus hookeri* Munro	Bhalu Bans, Kalo Bans	Bhalu Bans, Bhutan Green Bamboo	Stapleton, 1994
20	*Dendrocalamus sikkimensis* Gamble ex Oliv.	Bhalu Bans, Dhungre Bans		Stapleton, 1994

21	*Dendrocalamus strictus* (Roxb.) Nees	Kat Bans, Geniya Bans, Latthi Bans, Male Bans	Male bamboo, solid bamboo	Stapleton, 1994
22	*Drepanostachyum annulatum* Stapleton	Nigalo		Stapleton, 1994
23	*Drepanostachyum falcatum* (Nees) Keng f..	Sano Nigalo, Diu Nigalo	Himalayan weeping bamboo	Stapleton, 1994
24	*Drepanostachyum intermedium* (Munro) Keng f..	Tite Nigalo		Stapleton, 1994
25	*Drepanostachyum khasianum* (Munro) Keng f.	Tite Nigalo		Stapleton, 1994
26	*Himalayacalamus brevinodus* Stapleton.	Malinge Nigalo		Stapleton, 1994
27	*Himalayacalamus falconeri* (Munro) Keng f.	SinghaneThudi Nigalo	Candy Cane Bamboo	Stapleton, 1994
28	*Himalayacalamus hookerianus* (Munro) Stapleton.	Padang, Paryang	Blue Bamboo	Stapleton, 1994
29	*Melocanna baccifera* (Roxb.) Kurz	Filim Bans (Jhapa), Lahure Bans (Palpa), Muli Bans		Stapleton, 1994
30	*Sarocalamus racemosus* (Munro) Stapleton	Sano Malingo		Stapleton, 1994
31	*Thamnocalamus crassinodus* (T.P.Yi) Demoly	Ghunre Nigalo		Stapleton, 1994
32	*Thamnocalamus spathiflorus* (Trin.) Munro	Malingo, Rato Nigalo, Jarbutto		Stapleton, 1994
33	*Yushania maling* (Gamble) R.B.Majumdar & Karthik.	Khosre Malingo		Stapleton, 1994
34	*Yushania microphylla* (Munro) R.B. Majumdar	Malingo		Stapleton, 1994
35	*Yushania pantlingii* (Gamble) R.B.Majumdar			Stapleton, 1994
Cultivated and Ornamental Bamboo Species				
36	*Bambusa bambos* (L.) Voss.	Kaade Bans	Indian thorny bamboo	Stapleton, 1994
37	*Bambusa lako* Widjaja	Timor Bans	Timor Black	Poudyal, 2006
38	*Bambusa multiplex* (Lour.) Raeusch. ex Schult.	Chinese Bamboo, Thulo nigalo, Pahelo nigalo	Hedge Bamboo	Stapleton, 1994

39	*Bambusa pallida* Munro	Deu Bans, Mungeri Bans		Poudyal, 2006
40	*Bambusa sinospinosa* McClure	Chiniya Kade Bans	Chinese thorny bamboo	Poudyal, 2006
41	*Bambusa tuldoides* Munro	Buddha Bans	Buddha's Belly	Poudyal, 2006
42	*Bambusa vulgaris* f. *waminii* T.H.Wen	Lota Bans		Poudyal, 2006
43	*Bambusa vulgaris* Schrad. ex J.C.Wendl.	Singare Bans		Poudyal, 2006
44	*Bambusa vulgaris var. vittata*	Pahenlo Bans	Golden Bamboo	Poudyal, 2006
45	*Chimonobambusa marmorea* (Mitford) Makino	Kalo Nigalo	Blakish Bamboo	Poudyal, 2006
46	*Chimonobambusa tumidissinoda* Ohrnb.			Poudyal, 2006
47	*Dendrocalamus asper* (Schult. & Schult.f.) Backer	Thal Tama Bans	Giant Bamboo, Rough Bamboo	Stapleton, 1994
48	*Dendrocalamus longispathus* (Kurz) Kurz		Long-sheath bamboo	Poudyal, 2006
49	*Dendrocalamus pendulus* Ridl.			Ayer *et al*., 2023
50	*Phyllostachys edulis* (Carrière) J.Houz.	Moso bamboo, Chiniya Bhalu Bans	Moso bamboo, Tortoise Shell Bamboo	Stapleton, 1994
51	*Phyllostachys nidularia* Munro			Poudyal, 2006
52	*Phyllostachys nigra* (Lodd. ex Lindl.) Munro	Japani/Kalo Nigalo		Stapleton, 1994
53	*Phyllostachys reticulata* (Rupr.) K.Koch	Pahenlo Nigale Bans, Madake, Japani Bans		Poudyal, 2006

by: Rajesh Tamang, Scientific Officer, Ministry of Tourism, Forests, and Environment, Koshi Province

Annex-3: Maps



Bamboo Presence Plot Map
Sudurpashchim
Karnali
Lumbini
Gandaki
Bagmati
Madesh
Koshi
Darchula
Bajhang
Baitadi
Bajura
Humla
Mugu
Jumla
Dolpa
Kalikot
Achham
Doti
Dadeldhura
Kanchanpur
Kailali
Dailekh
Jajarkot
Surkhet
Bardiya
Banke
Salyan
Rukum west
Rukum_e
Rolpa
Pyuthan
Dang
Mustang
Manang
Myagdi
Baglung
Kaski
Lamjung
Gorkha
Parbat
Gulmi
Syangja
Tanahu
Arghakhanchi
Palpa
Kapilbastu
Rupandehi
Nawalparasi_w
Nawalparasi_e
Chitawan
Rasuwa
Dhading
Nuwakot
Sindhupalchok
Dolakha
Kathmandu
Bhaktapur
Lalitpur
Kabhrepalanchok
Ramechhap
Makawanpur
Parsa
Bara
Rautahat
Sarlahi
Sindhuli
Mahottari
Dhanusha
Siraha
Saptari
Solukhumbu
Okhaldhunga
Khotang
Udayapur
Bhojpur
Sankhuwasabha
Dhankuta
Terhathum
Taplejung
Panchthar
Ilam
Sunsari
Morang
Japa
80°0'0"E
82°0'0"E
84°0'0"E
86°0'0"E
88°0'0"E
30°0'0"N
28°0'0"N
26°0'0"N
Legend
Province boundary
District boundary
Bamboo presence plots
0
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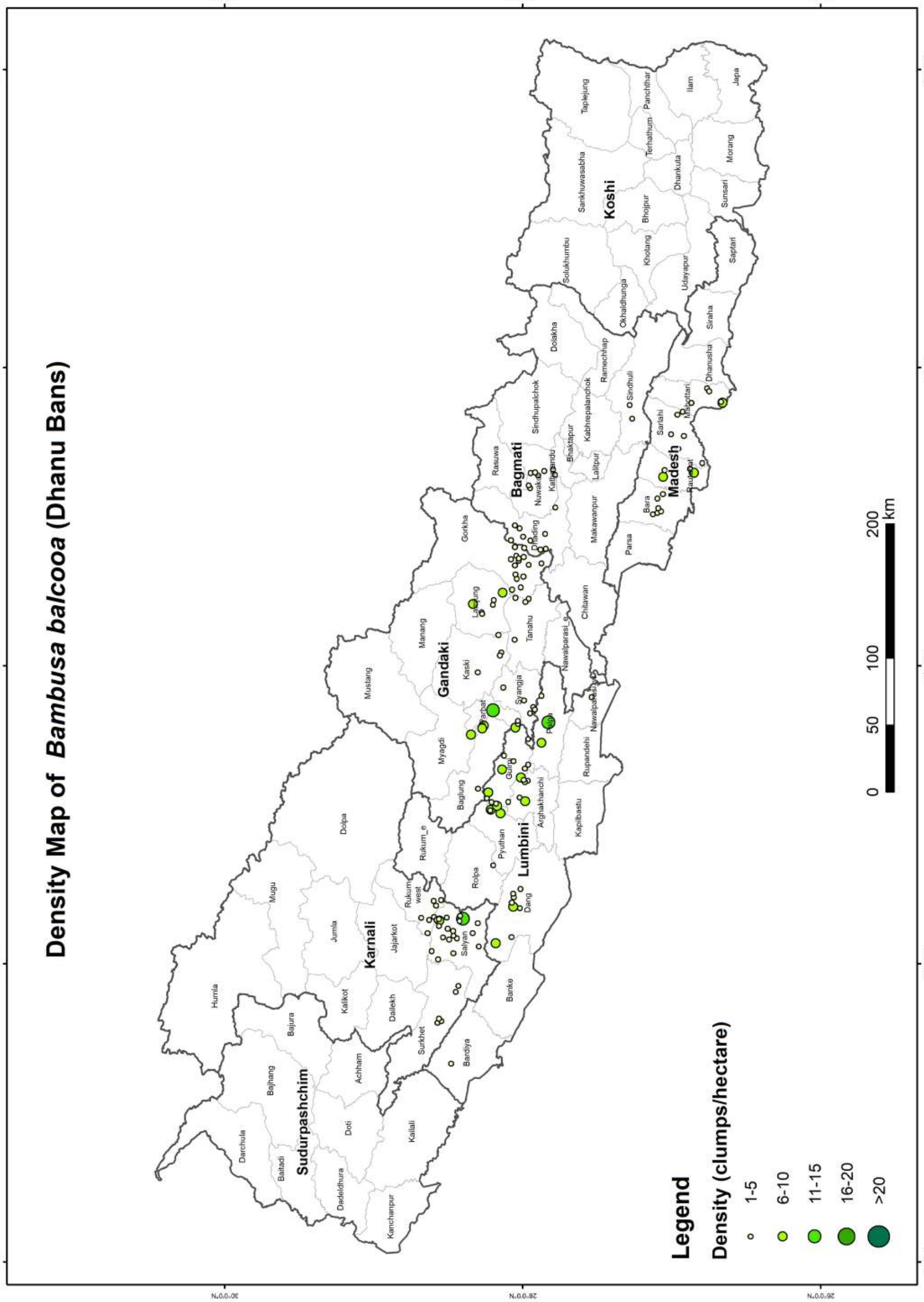
100
200
km


Density Map of Bambusa balcooa (Dhanu Bans)
Legend
Density (clumps/hectare)
1-5
6-10
11-15
16-20
>20
0
50
100
200
km
Sudurpashchim
Karnali
Lumbini
Gandaki
Bagmati
Madesh
Koshi
Darchula
Baitadi
Bajhang
Bajura
Humla
Dadeldhura
Doti
Achham
Kanchanpur
Kailali
Bardiya
Surkhet
Dailekh
Kalikot
Jumla
Mugu
Dolpa
Jajarkot
Banke
Salyan
Dang
Rolpa
Pyuthan
Rukum_e
Baglung
Myagdi
Mustang
Manang
Kaski
Lamjung
Gorkha
Tanahu
Syangja
Parbat
Gulmi
Arghakhanchi
Kapilbastu
Rupandehi
Palpa
Nawalparasi_e
Chitawan
Makawanpur
Parsa
Bara
Rautahat
Sarlahi
Mahottari
Dhanusha
Siraha
Saptari
Rasuwa
Nuwakot
Dhading
Sindhupalchok
Kathmandu
Bhaktapur
Lalitpur
Kabhrepalanchok
Dolakha
Ramechhap
Sindhuli
Okhaldhunga
Solukhumbu
Khotang
Udayapur
Bhojpur
Sankhuwasabha
Dhankuta
Sunsari
Morang
Terhathum
Taplejung
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80°0'0"E
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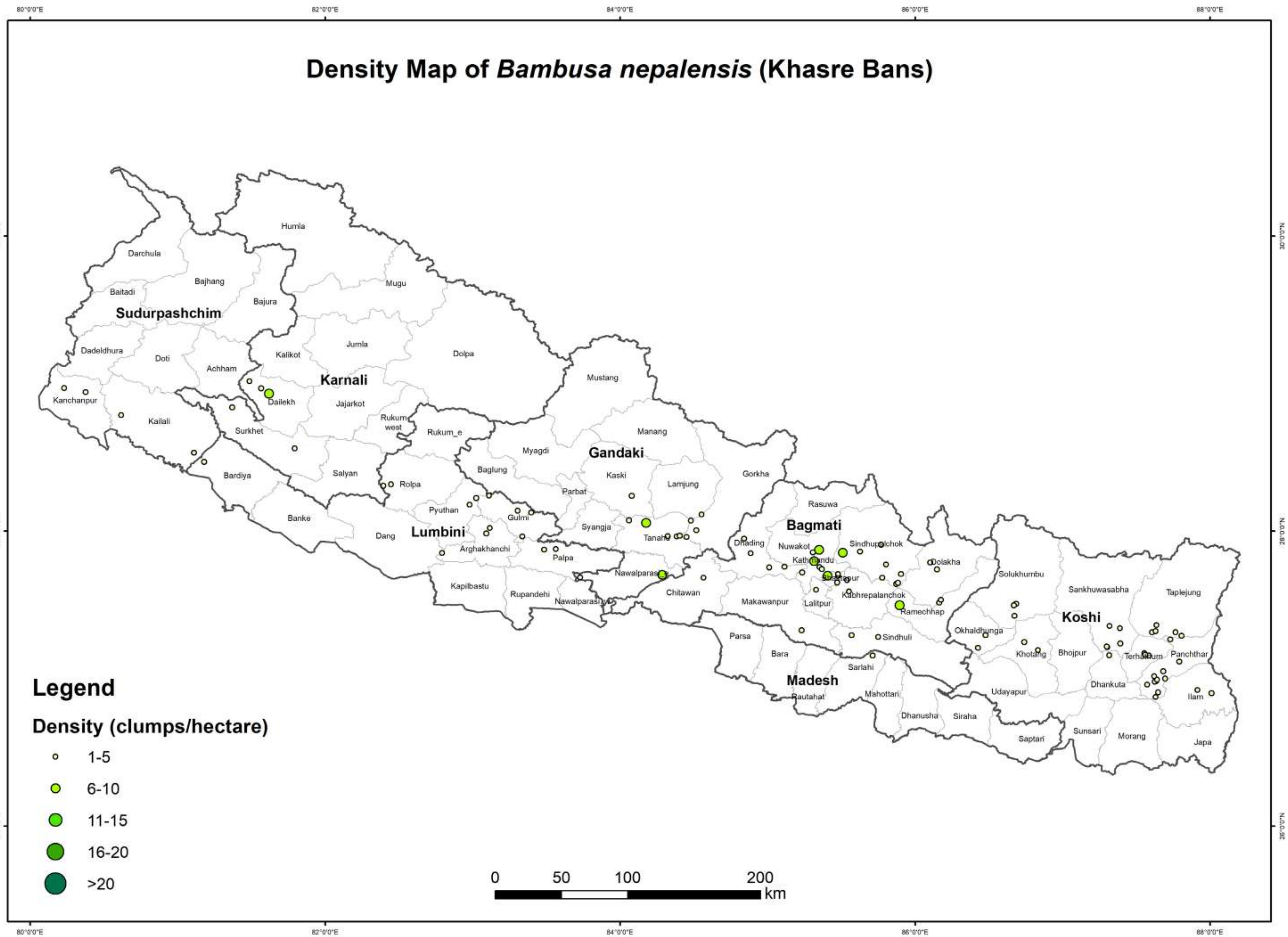
30°0'0"N


Density Map of *Bambusa nepalensis* (Khasre Bans)
80°0'0"E
82°0'0"E
84°0'0"E
86°0'0"E
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30°0'0"N
28°0'0"N
26°0'0"N
Sudurpashchim
Karnali
Gandaki
Lumbini
Bagmati
Madesh
Koshi
Darchula
Baitadi
Bajhang
Bajura
Humla
Mugu
Dadeldhura
Doti
Achham
Kalikot
Jumla
Dolpa
Kanchanpur
Kailali
Dailekh
Jajarkot
Surkhet
Rukum west
Rukum_e
Bardiya
Salyan
Rolpa
Banke
Pyuthan
Dang
Gulmi
Arghakhanchi
Palpa
Kapilbastu
Rupandehi
Nawalparasi
Mustang
Myagdi
Baglung
Manang
Kaski
Parbat
Syangja
Lamjung
Tanahu
Gorkha
Chitawan
Rasuwa
Dhading
Nuwakot
Kathmandu
Sindhupalchok
Dolakha
Bhaktapur
Lalitpur
Kabhrepalanchok
Ramechhap
Makawanpur
Sindhuli
Parsa
Bara
Rautahat
Sarlahi
Mahottari
Dhanusha
Siraha
Solukhumbu
Okhaldhunga
Khotang
Udayapur
Saptari
Sankhuwasabha
Bhojpur
Dhankuta
Terhathum
Taplejung
Panchthar
Ilam
Sunsari
Morang
Japa
Legend
Density (clumps/hectare)
1-5
6-10
11-15
16-20
>20
0
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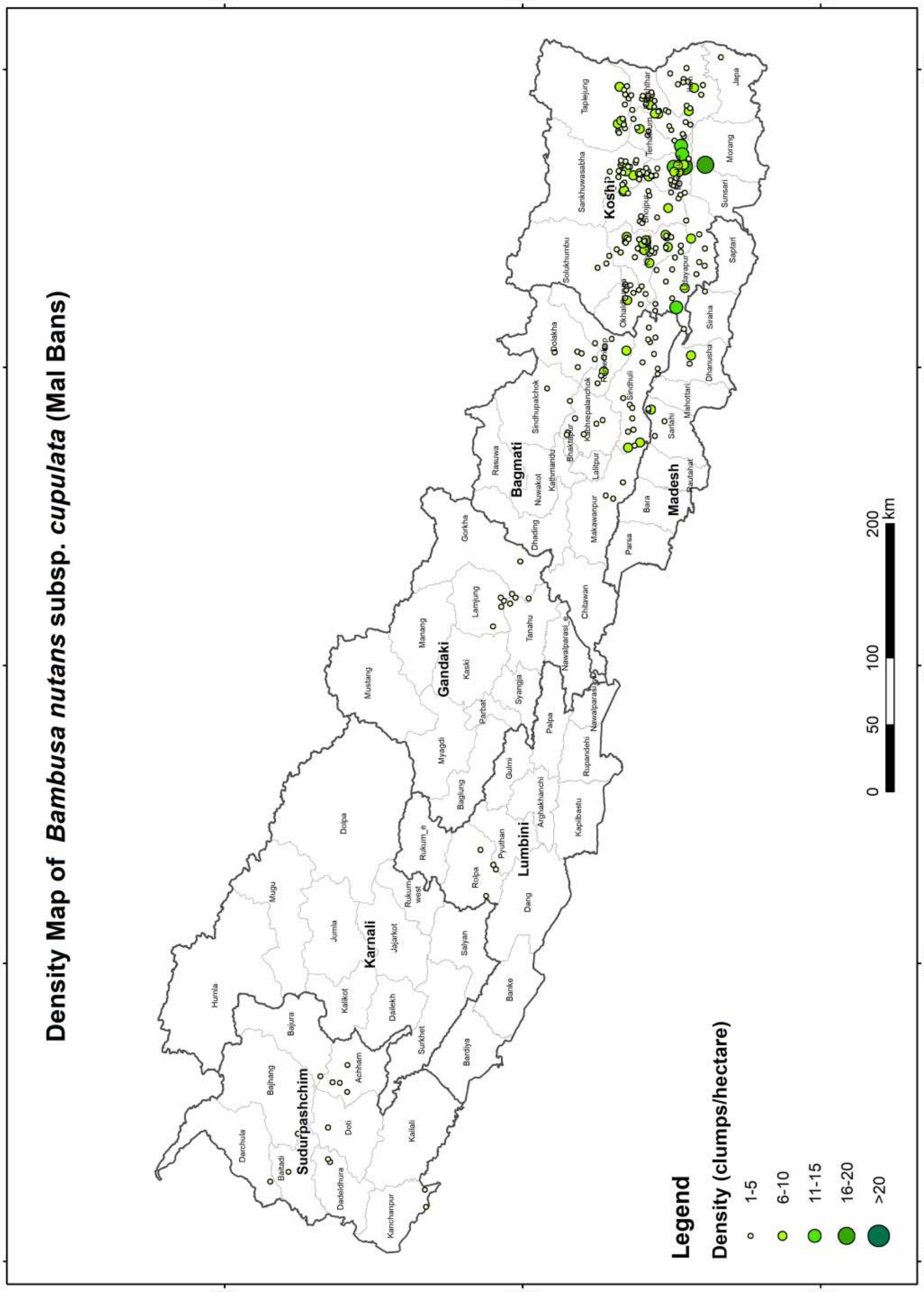
km



Density Map of Bambusa nutans subsp. cupulata (Mal Bans)
Legend
Density (clumps/hectare)
1-5
6-10
11-15
16-20
>20
0
50
100
200
km
Sudurpashchim
Karnali
Lumbini
Gandaki
Bagmati
Madesh
Koshi
Darchula
Baitadi
Dadeldhura
Kanchanpur
Bajhang
Doti
Kailali
Bajura
Achham
Humla
Kalikot
Dailekh
Surkhet
Bardiya
Mugu
Jumla
Jajarkot
Salyan
Banke
Dolpa
Rukum west
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Rolpa
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Arghakhanchi
Kapilbastu
Baglung
Gulmi
Rupandehi
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Parbat
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Syangja
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Lamjung
Tanahu
Gorkha
Chitawan
Dhading
Makawanpur
Parsa
Nuwakot
Rasuwa
Kathmandu
Lalitpur
Bhaktapur
Bara
Rautahat
Sindhupalchok
Kabhrepalanchok
Sindhuli
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Mahottari
Dolakha
Dhanusha
Siraha
Okhaldhunga
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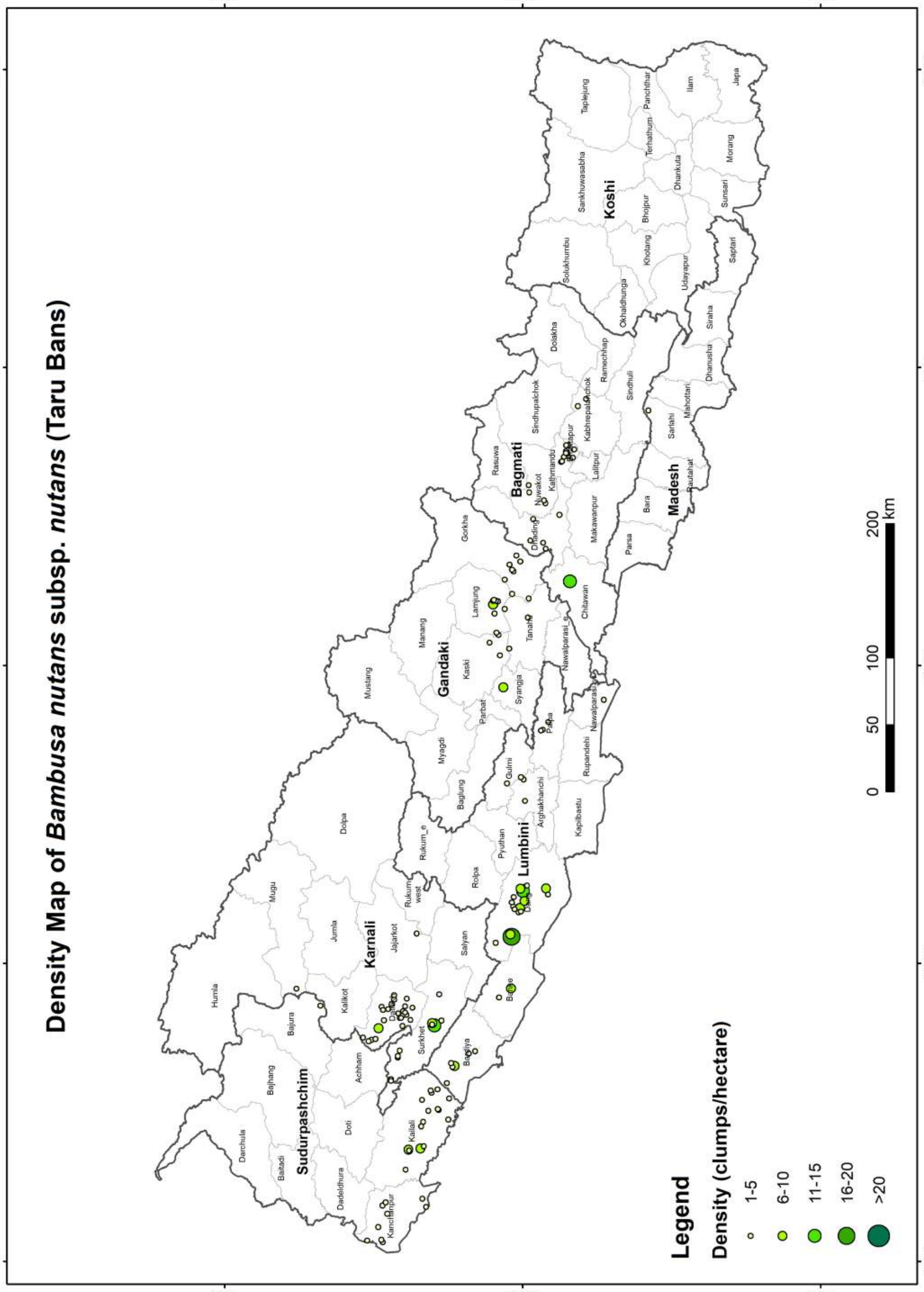
Sunsari
Sankhuwasabha
Morang
Taplejung
Terhathum
Japa


Density Map of Bambusa nutans subsp. nutans (Taru Bans)
Legend
Density (clumps/hectare)
1-5
6-10
11-15
16-20
>20
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km
Sudurpashchim
Karnali
Lumbini
Gandaki
Bagmati
Madesh
Koshi
80°0'0"E
82°0'0"E
84°0'0"E
86°0'0"E
88°0'0"E
26°0'0"N
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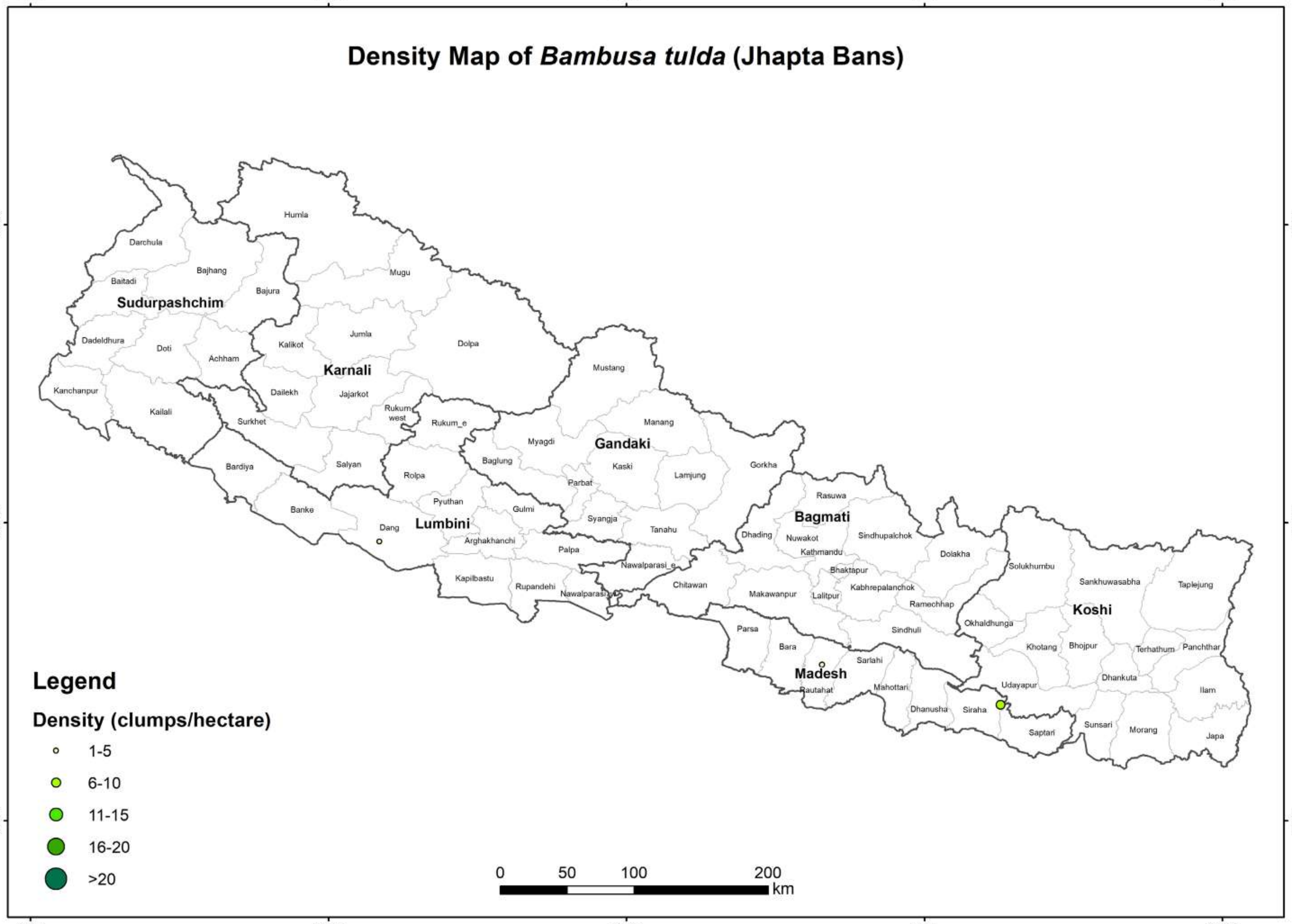
Density Map of *Bambusa tulda* (Jhapta Bans)
Sudurpashchim
Karnali
Lumbini
Gandaki
Bagmati
Madesh
Koshi
Darchula
Baitadi
Bajhang
Bajura
Dadeldhura
Doti
Achham
Kanchanpur
Kailali
Humla
Mugu
Jumla
Kalikot
Dolpa
Dailekh
Jajarkot
Rukum west
Surkhet
Salyan
Bardiya
Banke
Rukum_e
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Gulmi
Arghakhanchi
Palpa
Kapilbastu
Rupandehi
Nawalparasi_w
Mustang
Myagdi
Baglung
Manang
Kaski
Parbat
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Tanahu
Gorkha
Nawalparasi_e
Chitawan
Rasuwa
Dhading
Nuwakot
Kathmandu
Bhaktapur
Lalitpur
Sindhupalchok
Kabhrepalanchok
Makawanpur
Dolakha
Ramechhap
Sindhuli
Parsa
Bara
Rautahat
Sarlahi
Mahottari
Dhanusha
Siraha
Saptari
Solukhumbu
Okhaldhunga
Khotang
Udayapur
Bhojpur
Sankhuwasabha
Taplejung
Terhathum
Panchthar
Dhankuta
Ilam
Sunsari
Morang
Japa
Legend
Density (clumps/hectare)
1-5
6-10
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16-20
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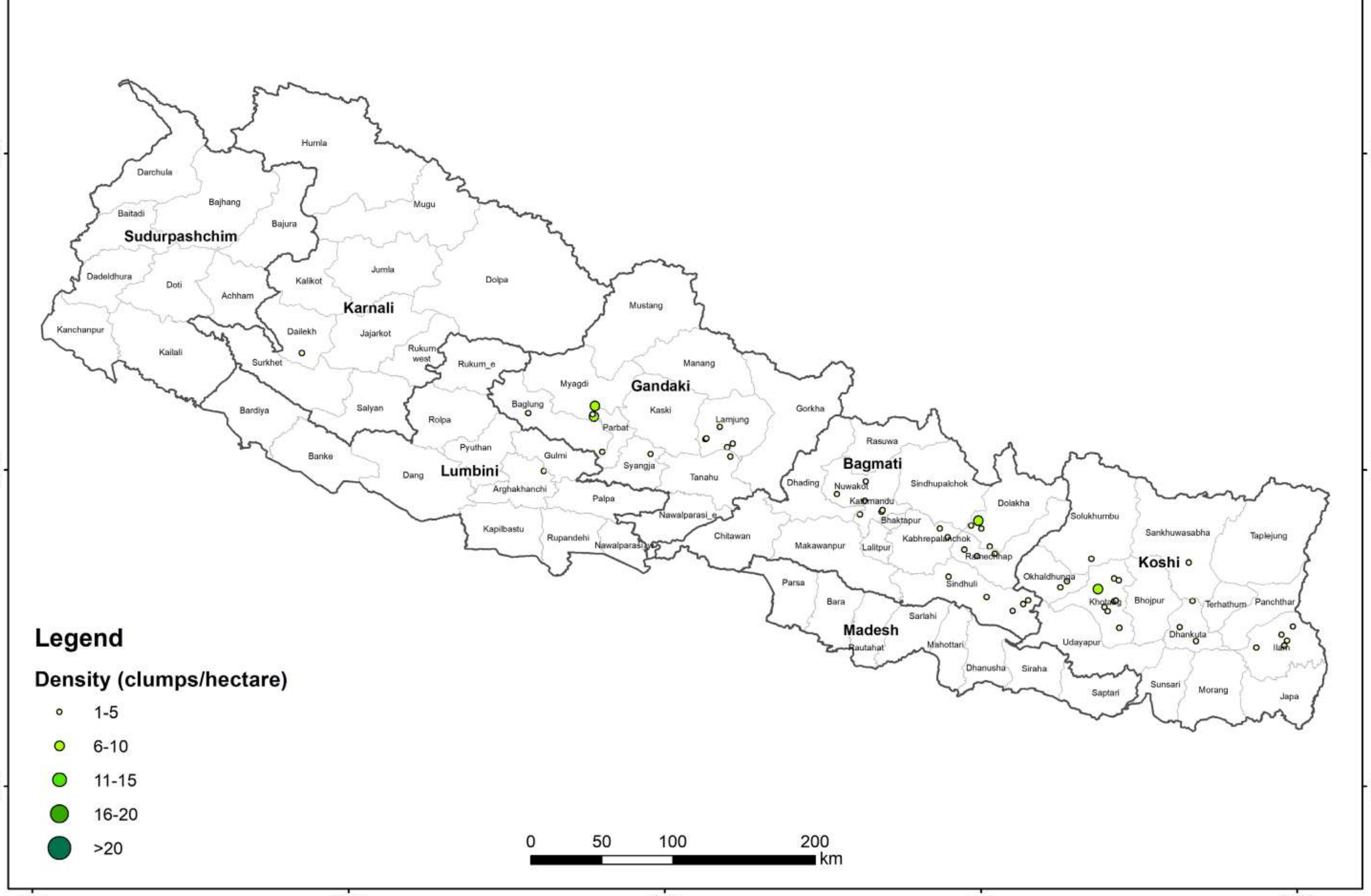
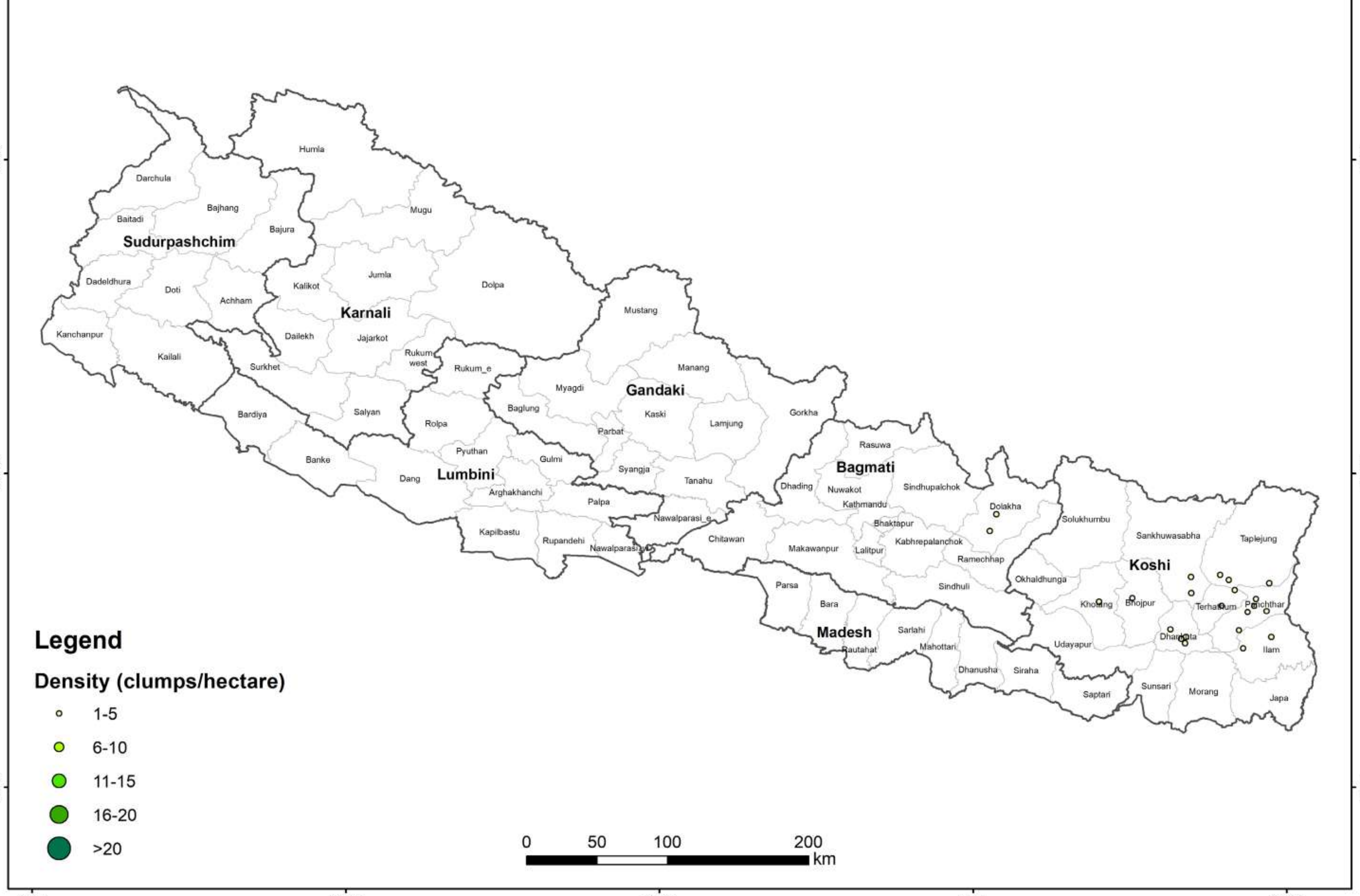
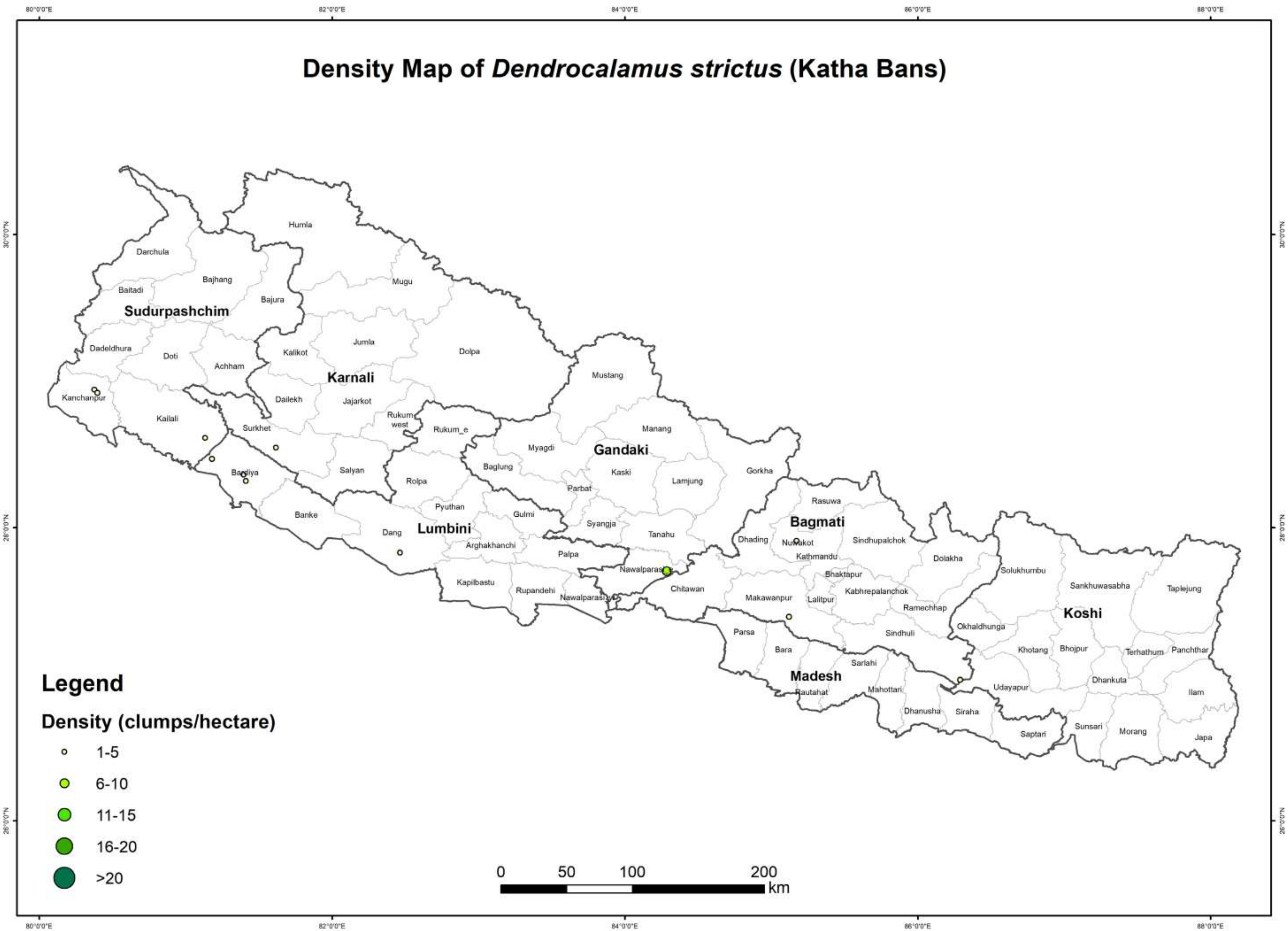
km
80°0'0"E
82°0'0"E
84°0'0"E
86°0'0"E
88°0'0"E
30°0'0"N
28°0'0"N
26°0'0"N

Density Map of *Dendrocalamus hamiltonii* (Tama Bans)

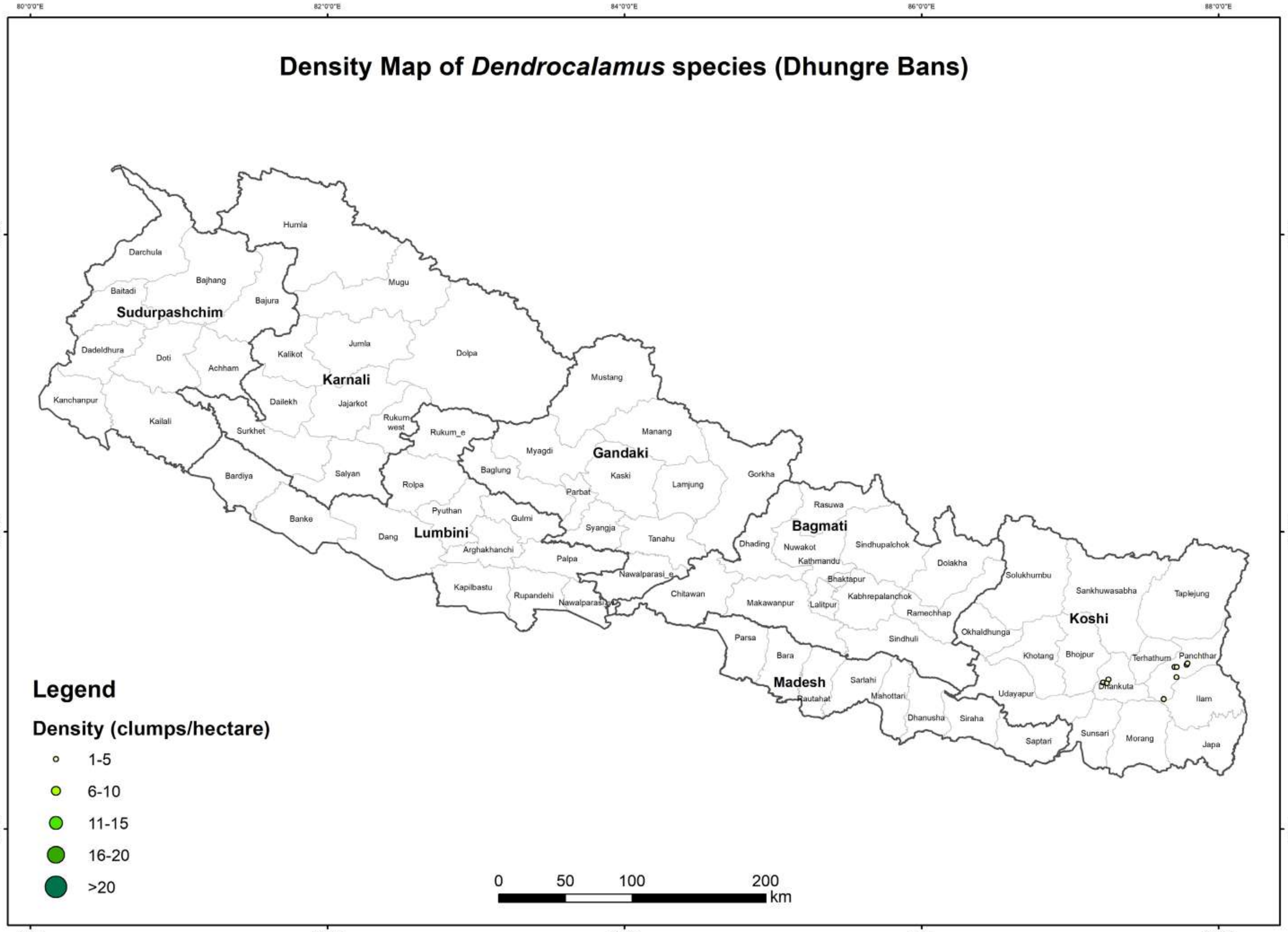


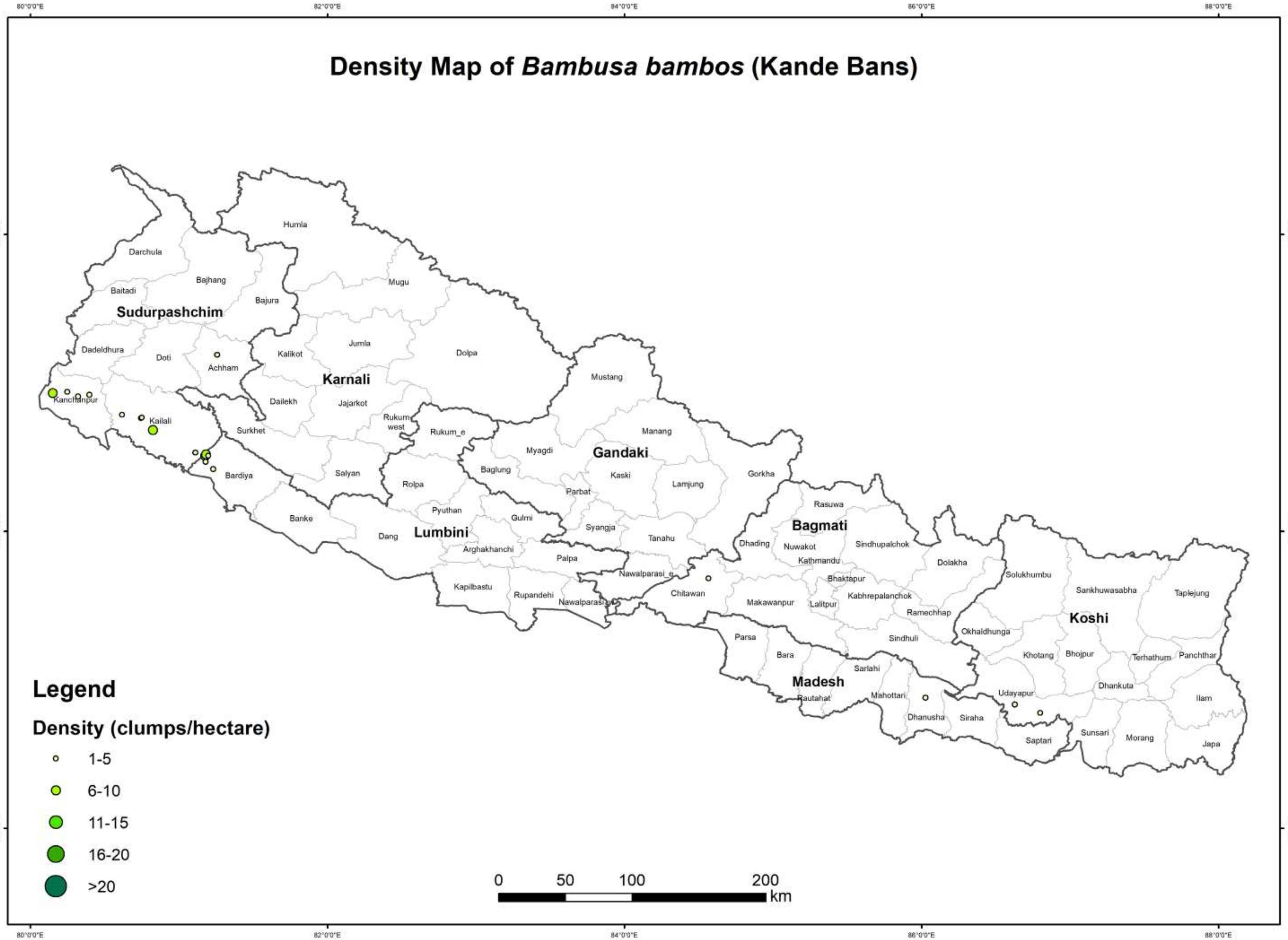
Density Map of *Dendrocalamus hookeri* (Kalo Bans)

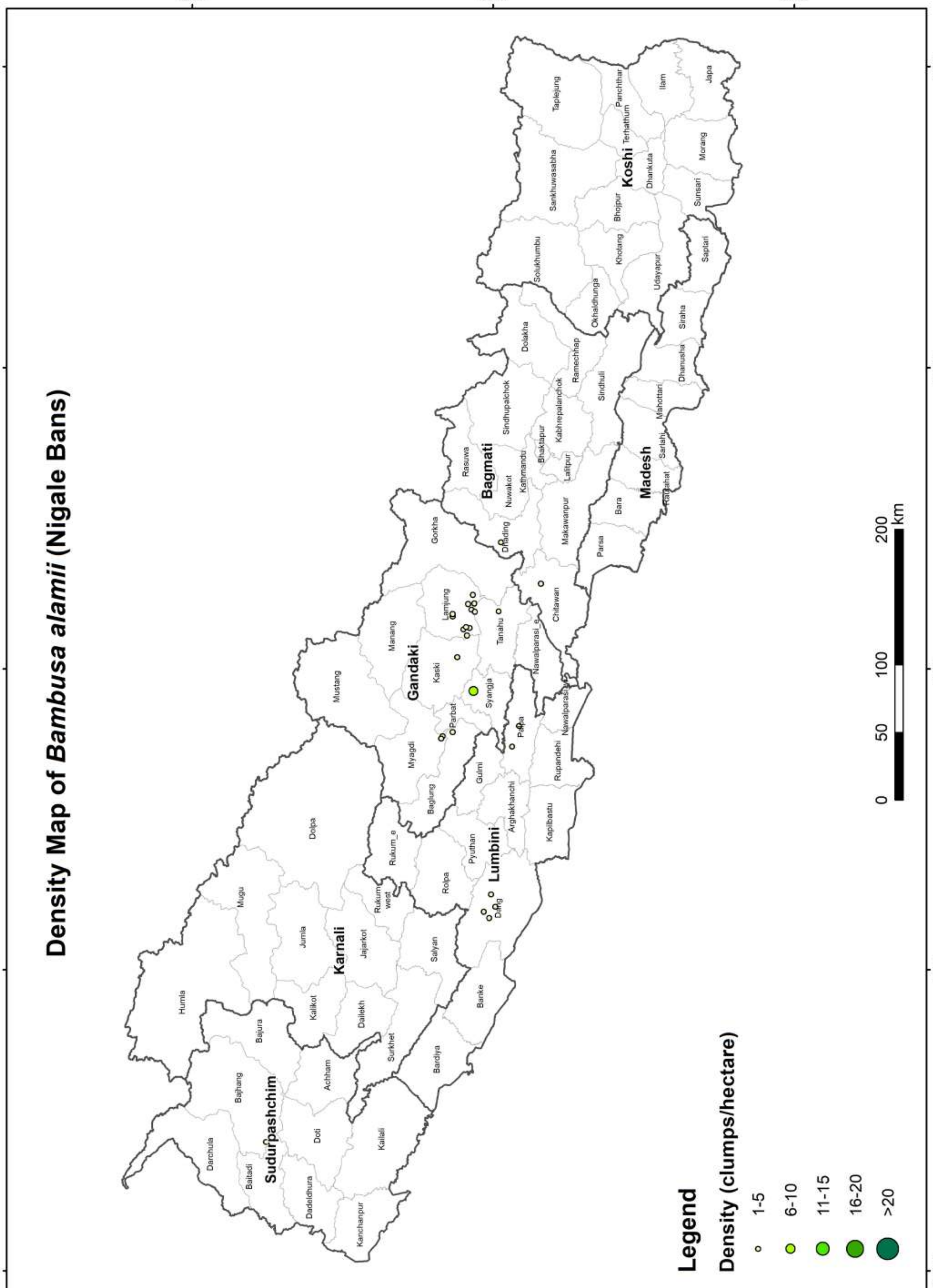




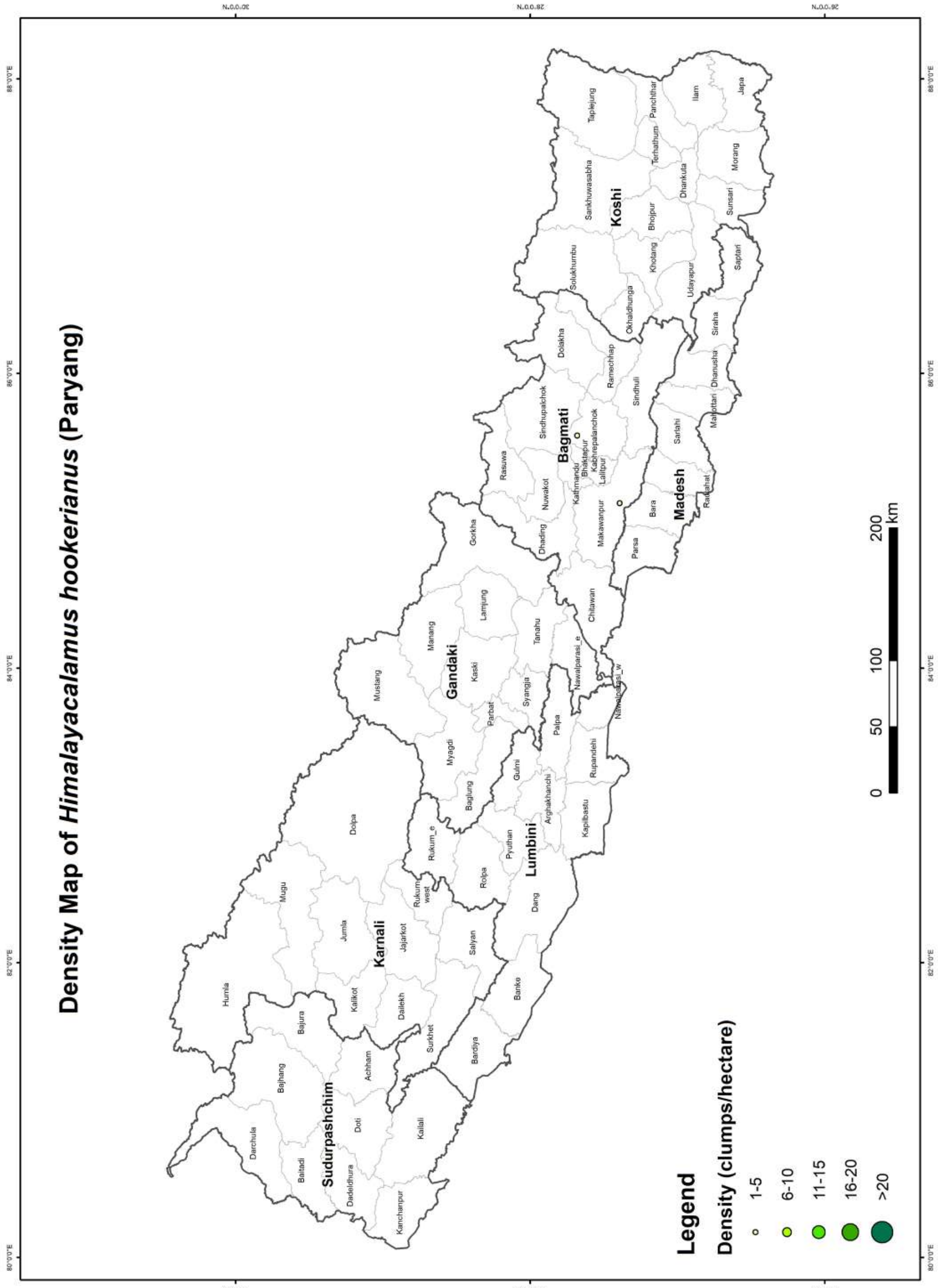
Density Map of Dendrocalamus strictus (Katha Bans)
Sudurpashchim
Karnali
Lumbini
Gandaki
Bagmati
Madesh
Koshi
Darchula
Baitadi
Bajhang
Bajura
Dadeldhura
Doti
Achham
Kanchanpur
Kailali
Humla
Mugu
Jumla
Kalikot
Dolpa
Dailekh
Jajarkot
Rukum west
Surkhet
Salyan
Bardiya
Banke
Rukum_e
Rolpa
Pyuthan
Dang
Gulmi
Arghakhanchi
Palpa
Kapilbastu
Rupandehi
Nawalparasi
Mustang
Manang
Myagdi
Baglung
Kaski
Parbat
Lamjung
Syangja
Tanahu
Gorkha
Chitawan
Rasuwa
Dhading
Nuwakot
Kathmandu
Bhaktapur
Lalitpur
Sindhupalchok
Kabhrepalanchok
Dolakha
Ramechhap
Makawanpur
Sindhuli
Parsa
Bara
Rautahat
Sarlahi
Mahottari
Dhanusha
Siraha
Saptari
Solukhumbu
Okhaldhunga
Khotang
Udayapur
Sankhuwasabha
Bhojpur
Dhankuta
Sunsari
Taplejung
Terhathum
Panchthar
Ilam
Morang
Japa
Legend
Density (clumps/hectare)
1-5
6-10
11-15
16-20
>20
0
50
100
200
km
80°0'0"E
82°0'0"E
84°0'0"E
86°0'0"E
88°0'0"E
30°0'0"N
28°0'0"N
26°0'0"N

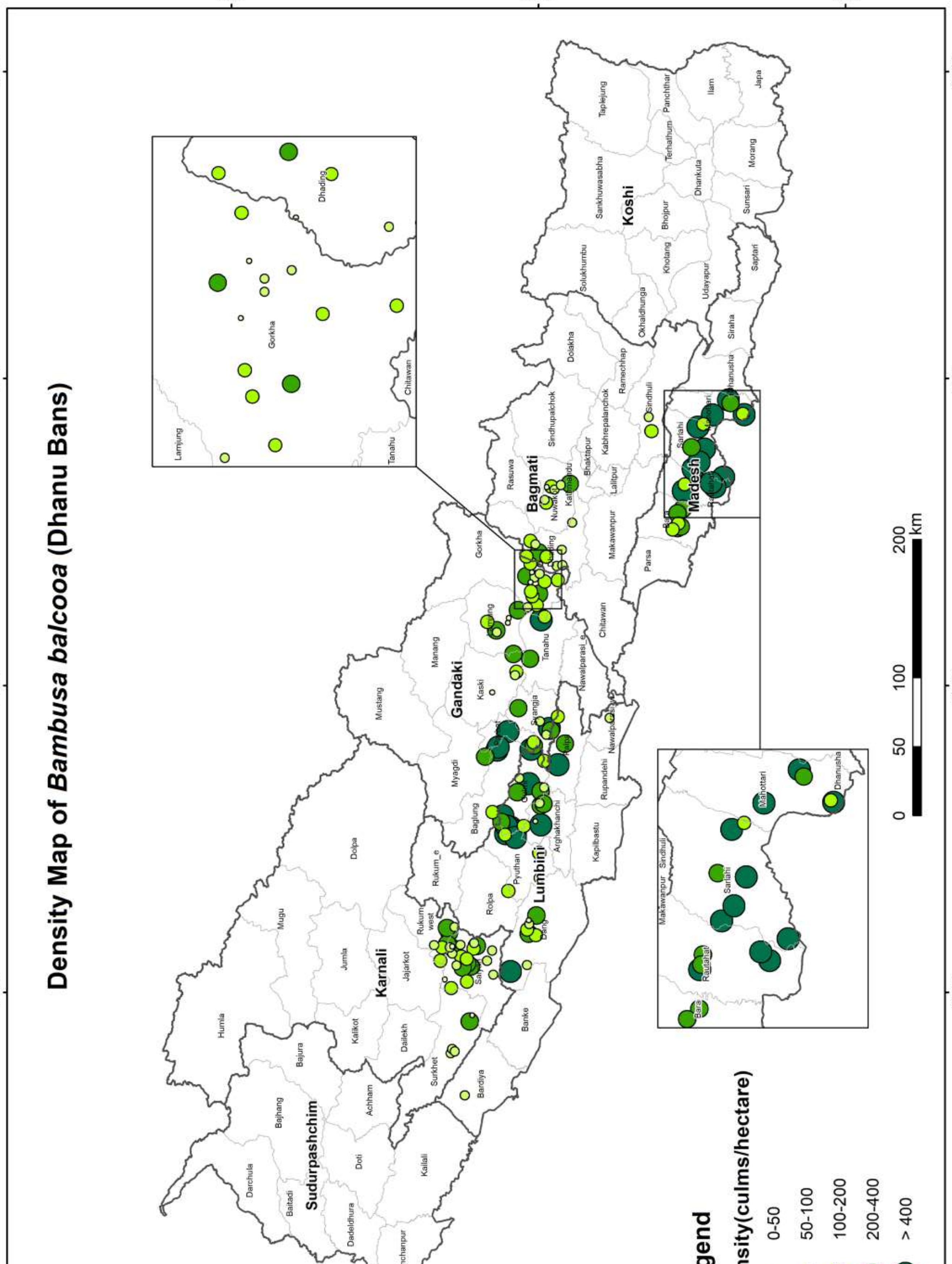

Density Map of Dendrocalamus species (Dhungre Bans)
Sudurpashchim
Karnali
Gandaki
Lumbini
Bagmati
Madesh
Koshi
Legend
Density (clumps/hectare)
1-5
6-10
11-15
16-20
>20
0
50
100
200
km


Density Map of Bambusa bambos (Kande Bans)
Sudurpashchim
Karnali
Lumbini
Gandaki
Bagmati
Madesh
Koshi
Darchula
Baitadi
Bajhang
Bajura
Humla
Mugu
Dadeldhura
Doti
Achham
Kalikot
Jumla
Dolpa
Kanchanpur
Kailali
Surkhet
Dailekh
Jajarkot
Rukum west
Rukum_e
Salyan
Bardiya
Banke
Dang
Rolpa
Pyuthan
Gulmi
Arghakhanchi
Kapilbastu
Rupandehi
Palpa
Nawalparasi_w
Mustang
Myagdi
Baglung
Parbat
Kaski
Manang
Lamjung
Gorkha
Syangja
Tanahu
Nawalparasi_e
Chitawan
Parsa
Bara
Rautahat
Sarlahi
Mahottari
Dhanusha
Siraha
Saptari
Makawanpur
Dhading
Nuwakot
Rasuwa
Kathmandu
Bhaktapur
Lalitpur
Sindhupalchok
Kabhrepalanchok
Dolakha
Ramechhap
Sindhuli
Okhaldhunga
Solukhumbu
Khotang
Udayapur
Bhojpur
Sankhuwasabha
Taplejung
Terhathum
Panchthar
Dhankuta
Ilam
Sunsari
Morang
Japa
Legend
Density (clumps/hectare)
1-5
6-10
11-15
16-20
>20
0
50
100
200
km
80°0'0"E
82°0'0"E
84°0'0"E
86°0'0"E
88°0'0"E
30°0'0"N
28°0'0"N
26°0'0"N

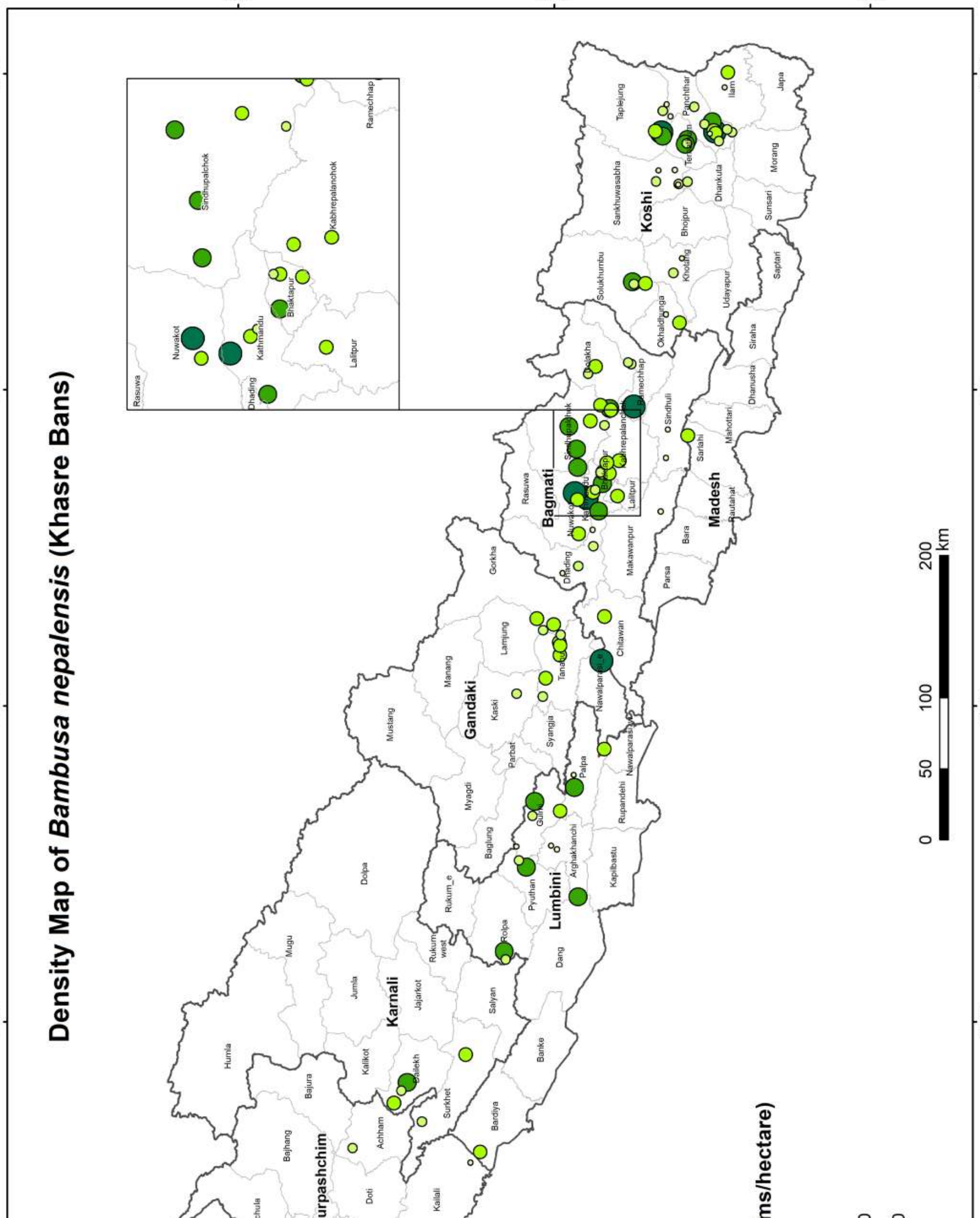


Density Map of Bambusa alamii (Nigale Bans)
Legend
Density (clumps/hectare)
1-5
6-10
11-15
16-20
>20
0 50 100 200 km

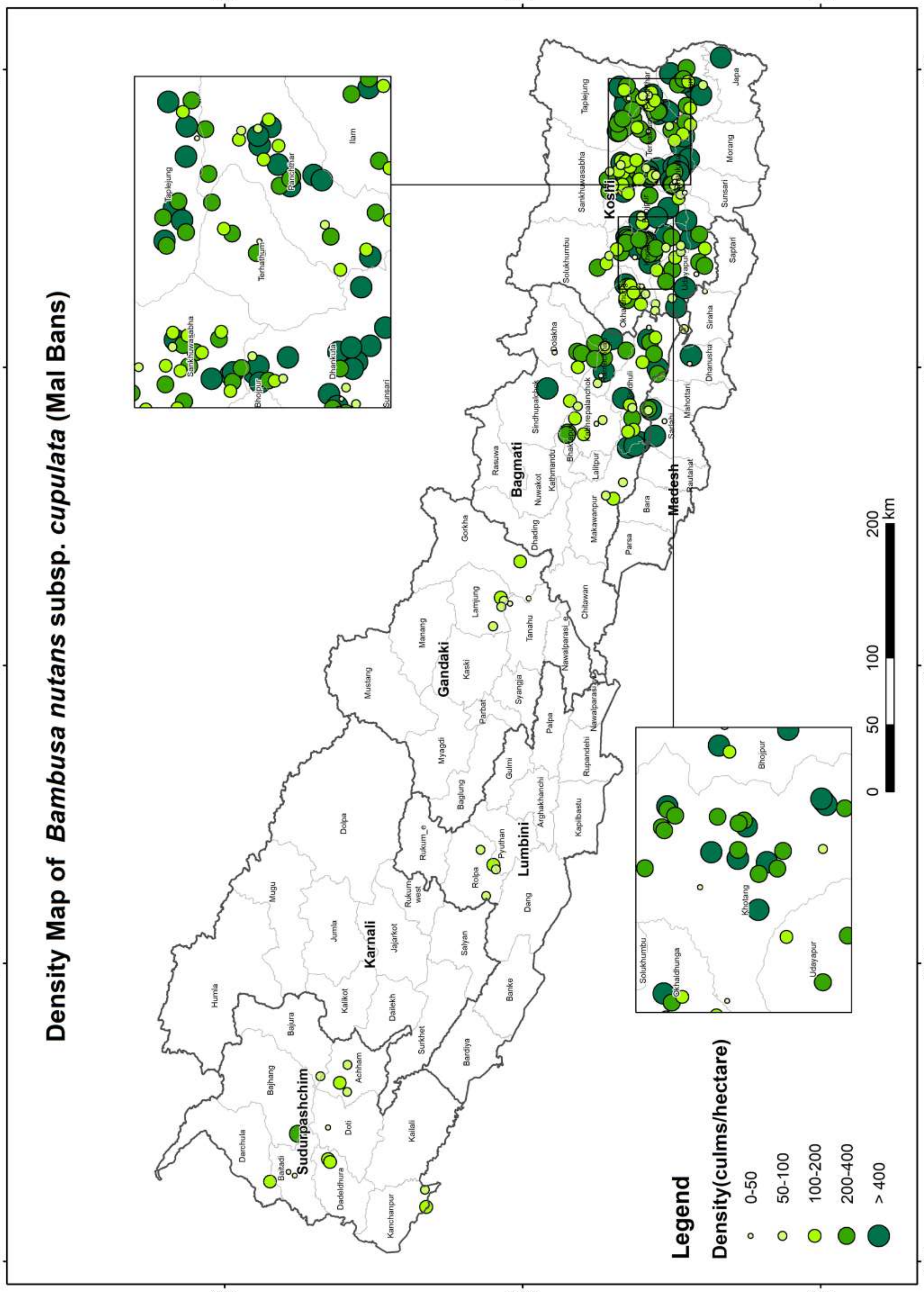

Density Map of Himalayacalamus hookerianus (Paryang)
Legend
Density (clumps/hectare)
1-5
6-10
11-15
16-20
>20
0
50
100
200
km
Koshi
Bagmati
Madesh
Gandaki
Lumbini
Karnali
Sudurpashchim
Taplejung
Panchthar
Ilam
Japa
Sankhuwasabha
Terhathum
Dhankuta
Morang
Bhojpur
Sunsari
Solukhumbu
Khotang
Udayapur
Saptari
Okhaldhunga
Dolakha
Ramechhap
Sindhuli
Siraha
Dhanusha
Mahottari
Sarlahi
Sindhupalchok
Kabhrepalanchok
Bhaktapur
Kathmandu
Lalitpur
Rasuwa
Nuwakot
Dhading
Makawanpur
Rautahat
Bara
Parsa
Chitawan
Gorkha
Lamjung
Manang
Tanahu
Kaski
Mustang
Syangja
Parbat
Myagdi
Baglung
Nawalparasi_e
Nawalparasi_w
Palpa
Rupandehi
Gulmi
Arghakhanchi
Kapilbastu
Pyuthan
Rolpa
Rukum_e
Rukum west
Dang
Dolpa
Mugu
Jumla
Jajarkot
Salyan
Banke
Humla
Kalikot
Dailekh
Surkhet
Bardiya
Bajura
Bajhang
Achham
Doti
Kailali
Darchula
Baitadi
Dadeldhura
Kanchanpur
30°0'0"N
28°0'0"N
26°0'0"N
80°0'0"E
82°0'0"E
84°0'0"E
86°0'0"E
88°0'0"E

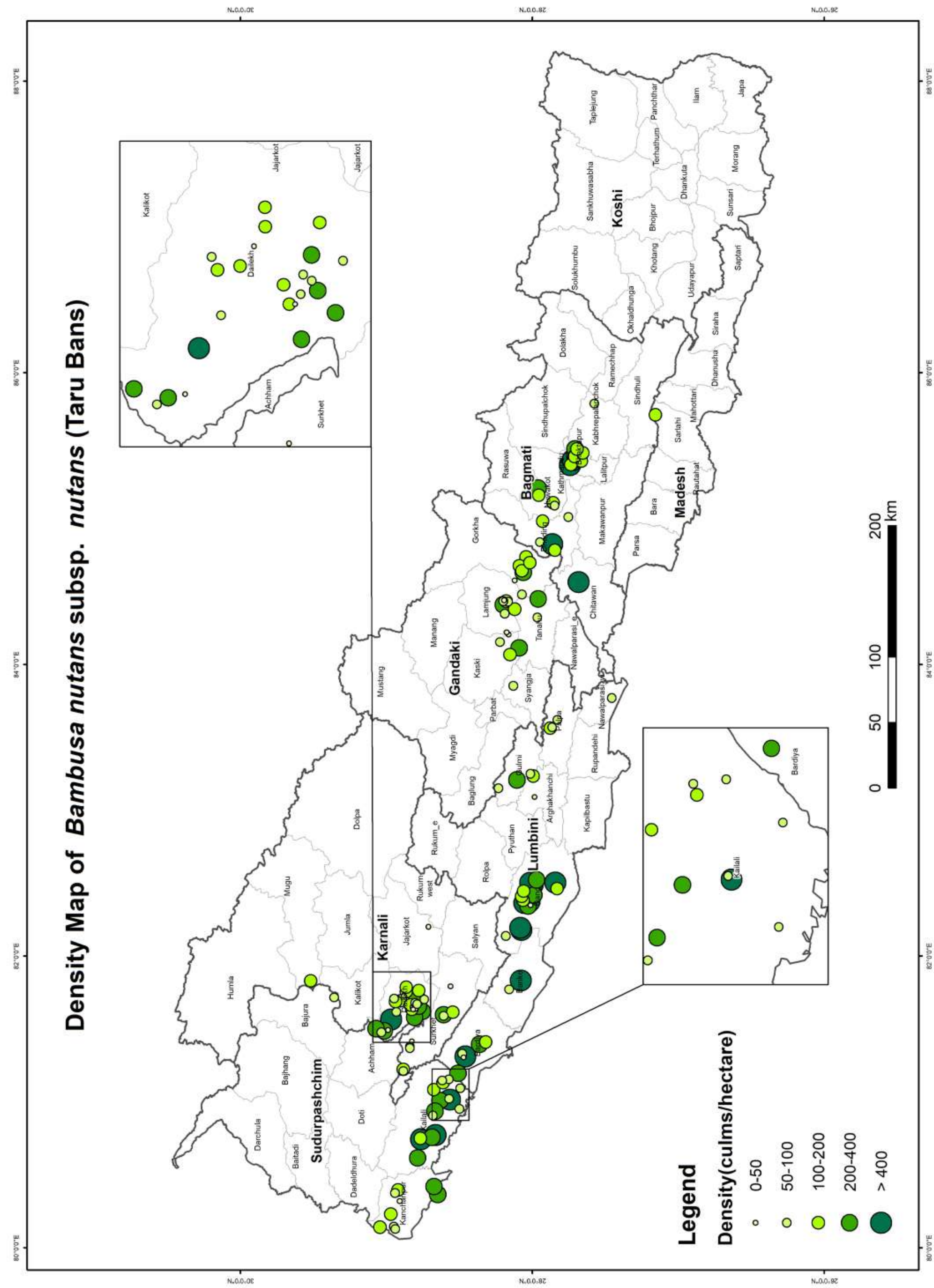


Density Map of Bambusa balcooa (Dhanu Bans)
Legend
Density(culms/hectare)
0-50
50-100
100-200
200-400
> 400
0 50 100 200 km
Sudurpashchim
Karnali
Lumbini
Gandaki
Bagmati
Madesh
Koshi
Darchula
Baitadi
Dadeldhura
Kanchanpur
Bajhang
Doti
Kailali
Bajura
Achham
Humla
Kalikot
Dailekh
Surkhet
Bardiya
Mugu
Jumla
Jajarkot
Dolpa
Banke
Rolpa
Pyuthan
Baglung
Myagdi
Mustang
Manang
Kaski
Gorkha
Tanahu
Chitawan
Syangja
Rupandehi
Kapilbastu
Arghakhanchi
Rasuwa
Dolakha
Sindhupalchok
Kabhrepalanchok
Bhaktapur
Lalitpur
Makawanpur
Parsa
Ramechhap
Sindhuli
Okhaldhunga
Solukhumbu
Sankhuwasabha
Taplejung
Panchthar
Ilam
Japa
Terhathum
Dhankuta
Bhojpur
Khotang
Udayapur
Siraha
Saptari
Sunsari
Morang
Dhanusha
Mahottari
Sarlahi
Rautahat
Bara
Makawanpur
Sindhuli
Dhading
Lamjung
30°0'0"N
28°0'0"N
26°0'0"N
80°0'0"E
82°0'0"E
84°0'0"E
86°0'0"E
88°0'0"E

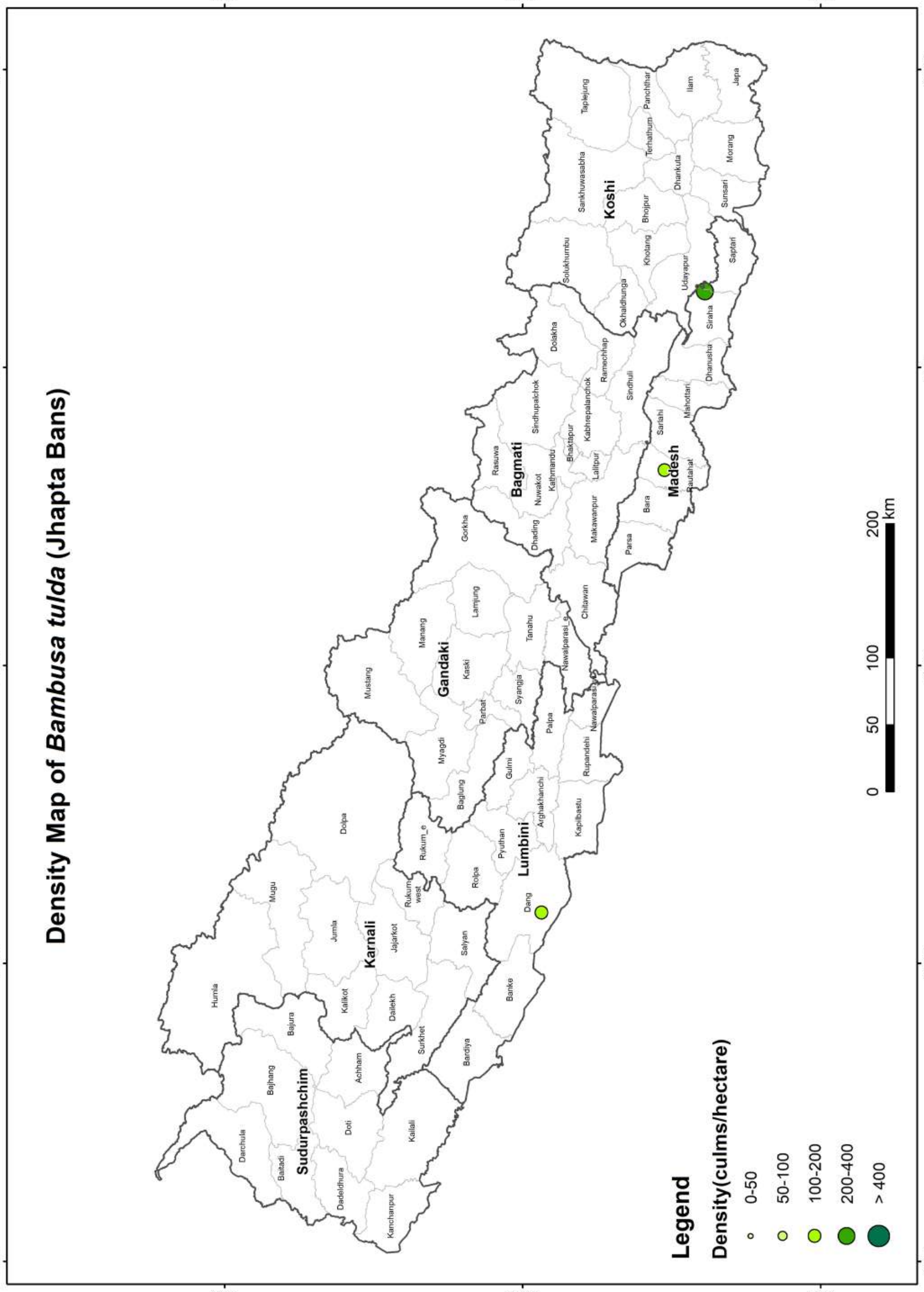


Density Map of Bambusa nepalensis (Khasre Bans)
Legend
Density(culms/hectare)
0-50
50-100
100-200
200-400
> 400
0 50 100 200 km
Sudurpashchim
Karnali
Lumbini
Gandaki
Bagmati
Madesh
Koshi

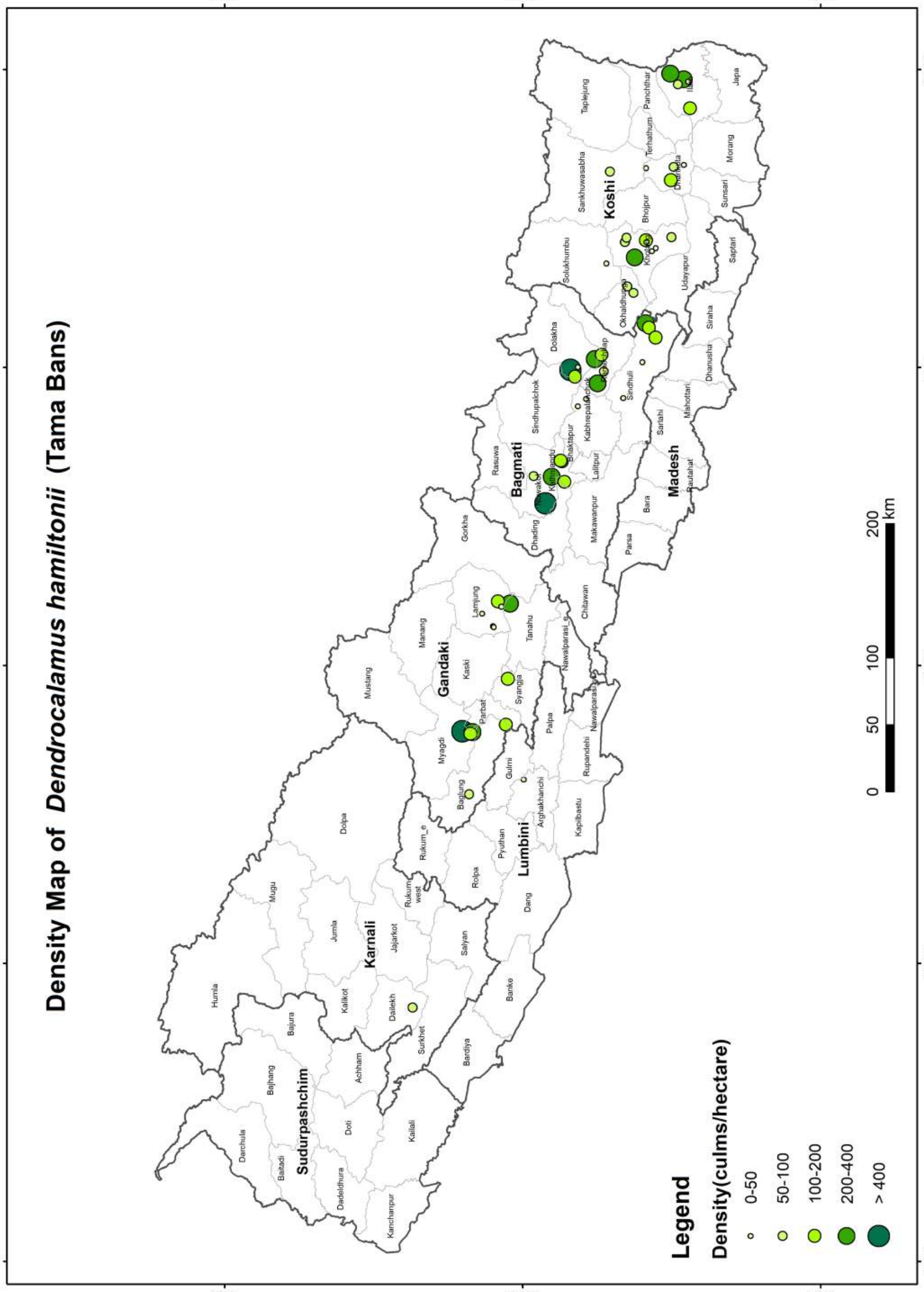

Density Map of Bambusa nutans subsp. cupulata (Mal Bans)
Legend
Density(culms/hectare)
0-50
50-100
100-200
200-400
> 400
0
50
100
200
km
Sudurpashchim
Karnali
Lumbini
Gandaki
Bagmati
Madesh
Koshi
Darchula
Baitadi
Dadeldhura
Kanchanpur
Bajhang
Bajura
Doti
Achham
Kailali
Humla
Mugu
Jumla
Kalikot
Dailekh
Surkhet
Bardiya
Jajarkot
Dolpa
Rukum_e
Rukum west
Salyan
Banke
Rolpa
Pyuthan
Dang
Baglung
Gulmi
Arghakhanchi
Kapilbastu
Rupandehi
Palpa
Nawalparasi_w
Myagdi
Mustang
Parbat
Syangja
Kaski
Manang
Lamjung
Tanahu
Gorkha
Nawalparasi_e
Chitawan
Dhading
Nuwakot
Rasuwa
Kathmandu
Makawanpur
Parsa
Bara
Rautahat
Lalitpur
Sindhupalchok
Dolakha
Sarlahi
Mahottari
Dhanusha
Siraha
Saptari
Okhaldhunga
Udayapur
Solukhumbu
Sankhuwasabha
Taplejung
Sunsari
Morang
Jhapa
Panchthar
Terhathum
Ilam
Dhankuta
Bhojpur
Khotang
80°0'0"E
82°0'0"E
84°0'0"E
86°0'0"E
88°0'0"E
26°0'0"N
28°0'0"N
30°0'0"N

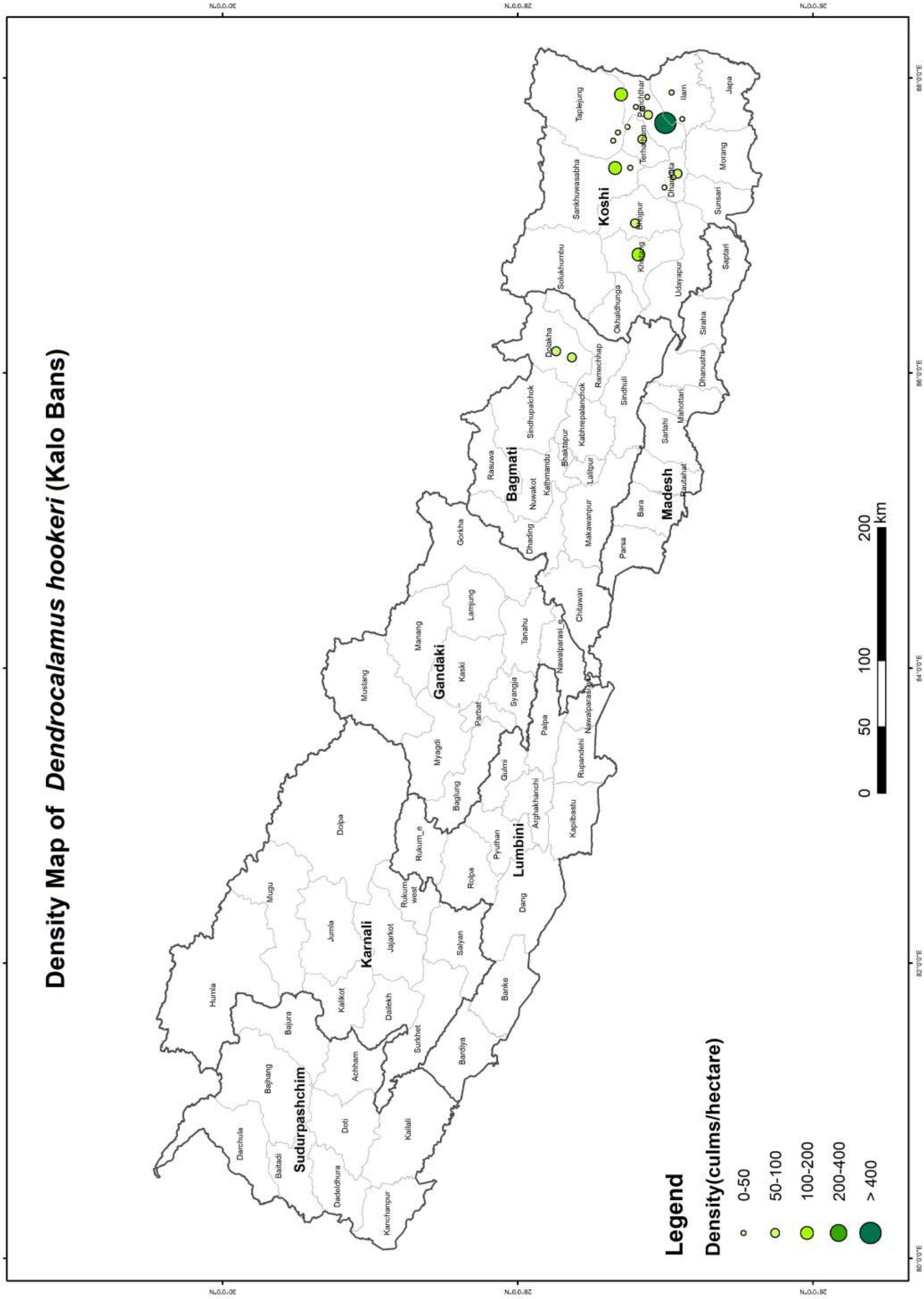


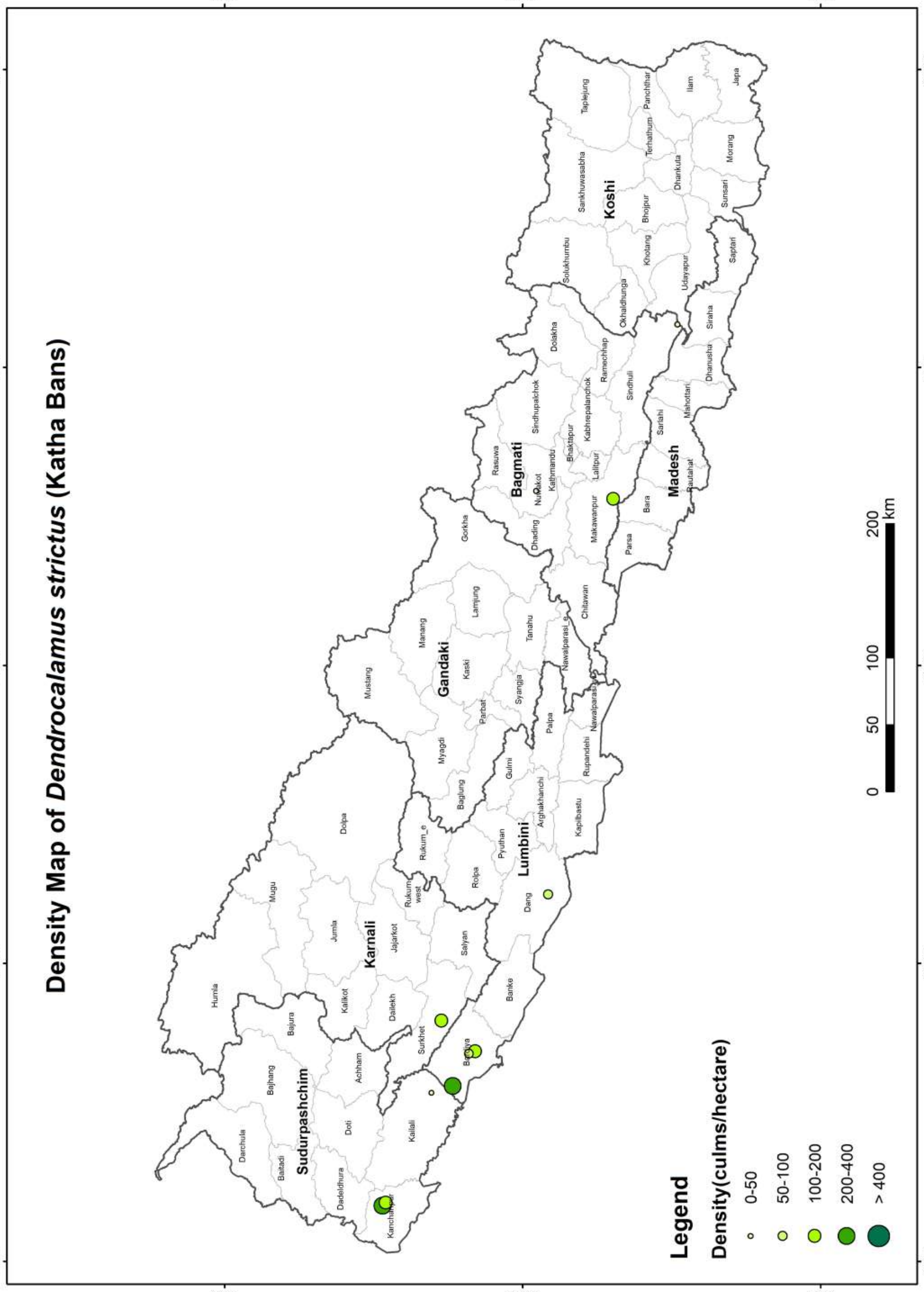
Density Map of Bambusa nutans subsp. nutans (Taru Bans)
Legend
Density(culms/hectare)
0-50
50-100
100-200
200-400
> 400
0
50
100
200
km
Sudurpashchim
Karnali
Lumbini
Gandaki
Bagmati
Madesh
Koshi



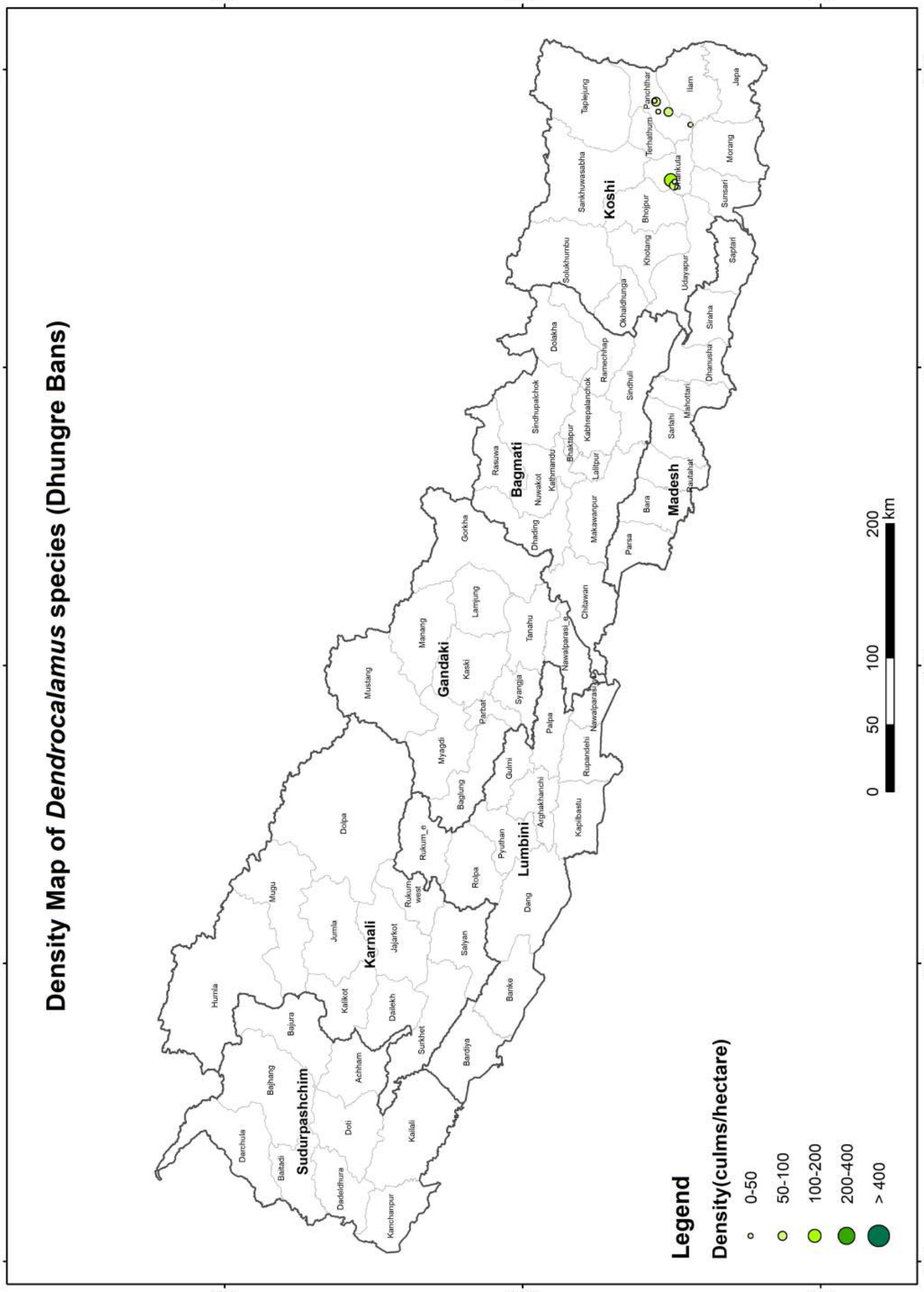
Density Map of Bambusa tulda (Jhapta Bans)
Legend
Density(culms/hectare)
0-50
50-100
100-200
200-400
> 400
0
50
100
200
km
Koshi
Madesh
Bagmati
Gandaki
Lumbini
Karnali
Sudurpashchim
Taplejung
Panchthar
Ilam
Japa
Terhathum
Morang
Sankhuwasabha
Dhankuta
Sunsari
Bhojpur
Solukhumbu
Khotang
Saptari
Udayapur
Okhaldhunga
Siraha
Dolakha
Ramechhap
Dhanusha
Sindhuli
Mahottari
Sindhupalchok
Kabhrepalanchok
Sarlahi
Bhaktapur
Rasuwa
Lalitpur
Kathmandu
Rautahat
Nuwakot
Bara
Makawanpur
Dhading
Parsa
Gorkha
Chitawan
Lamjung
Manang
Tanahu
Nawalparasi_e
Mustang
Kaski
Syangja
Nawalparasi_w
Parbat
Palpa
Myagdi
Rupandehi
Gulmi
Baglung
Arghakhanchi
Kapilbastu
Dolpa
Rukum_e
Pyuthan
Rolpa
Mugu
Rukum west
Dang
Jumla
Jajarkot
Salyan
Humla
Kalikot
Dailekh
Banke
Bajura
Surkhet
Bardiya
Bajhang
Achham
Darchula
Doti
Kailali
Baitadi
Dadeldhura
Kanchanpur
80°0'0"E
82°0'0"E
84°0'0"E
86°0'0"E
88°0'0"E
26°0'0"N
28°0'0"N
30°0'0"N

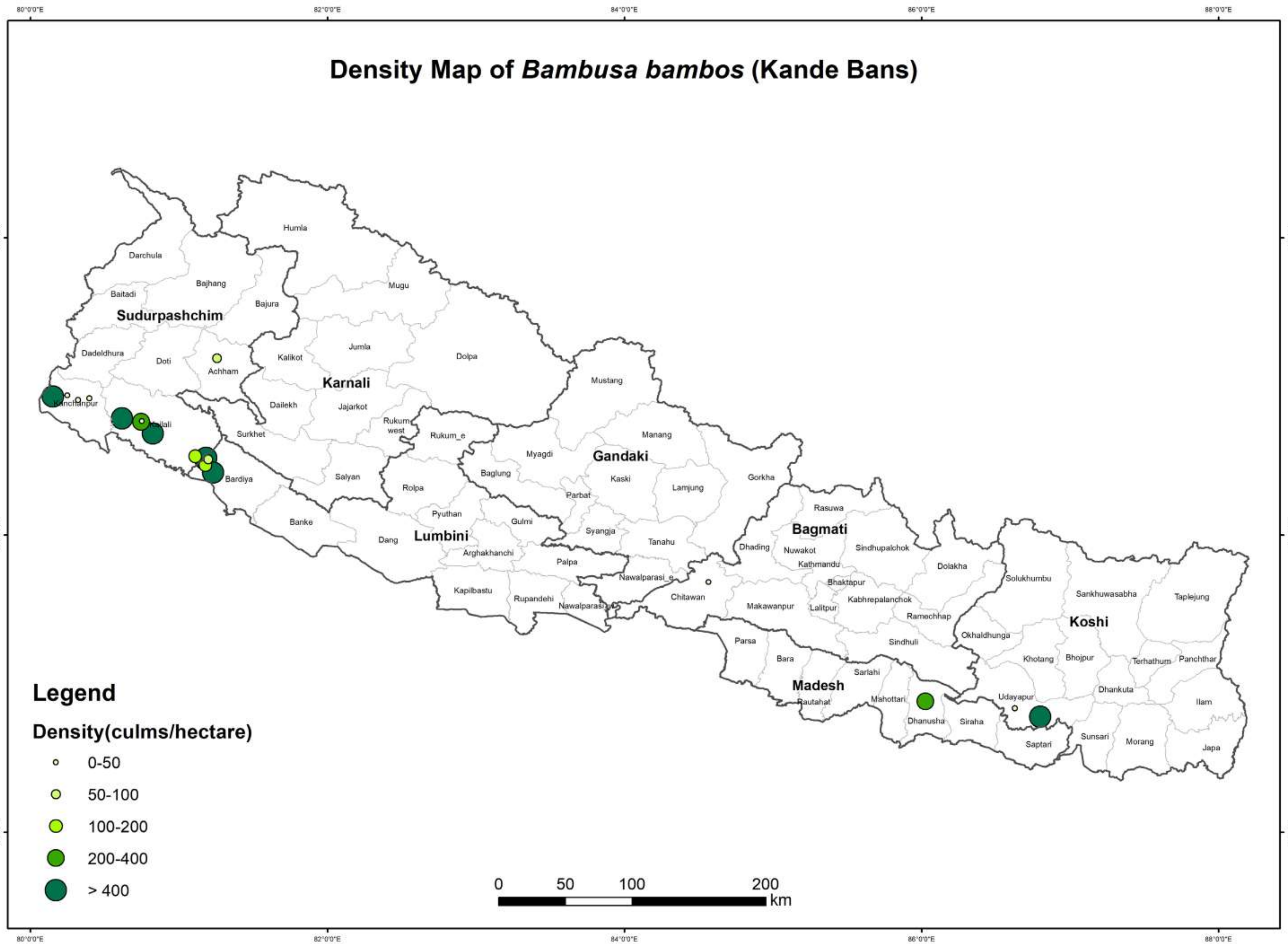

Density Map of Dendrocalamus hamiltonii (Tama Bans)
Legend
Density(culms/hectare)
0-50
50-100
100-200
200-400
> 400
0 50 100 200 km
Sudurpashchim
Karnali
Lumbini
Gandaki
Bagmati
Madesh
Koshi
Darchula
Baitadi
Dadeldhura
Kanchanpur
Bajhang
Doti
Kailali
Bajura
Achham
Humla
Kalikot
Dailekh
Surkhet
Bardiya
Banke
Mugu
Jumla
Jajarkot
Salyan
Dolpa
Rukum west
Rukum_e
Rolpa
Dang
Pyuthan
Arghakhanchi
Kapilbastu
Baglung
Gulmi
Rupandehi
Myagdi
Parbat
Palpa
Nawalparasi_w
Mustang
Kaski
Syangja
Manang
Lamjung
Tanahu
Nawalparasi_e
Chitawan
Gorkha
Dhading
Makawanpur
Parsa
Bara
Rautahat
Rasuwa
Lalitpur
Bhaktapur
Sarlahi
Sindhupalchok
Kabhrepalanchok
Sindhuli
Mahottari
Dolakha
Dhanusha
Siraha
Solukhumbu
Okhaldhunga
Udayapur
Saptari
Sankhuwasabha
Bhojpur
Sunsari
Terhathum
Morang
Taplejung
Panchthar
Jhapa
Ilam
80°0'0"E
82°0'0"E
84°0'0"E
86°0'0"E
88°0'0"E
26°0'0"N
28°0'0"N
30°0'0"N

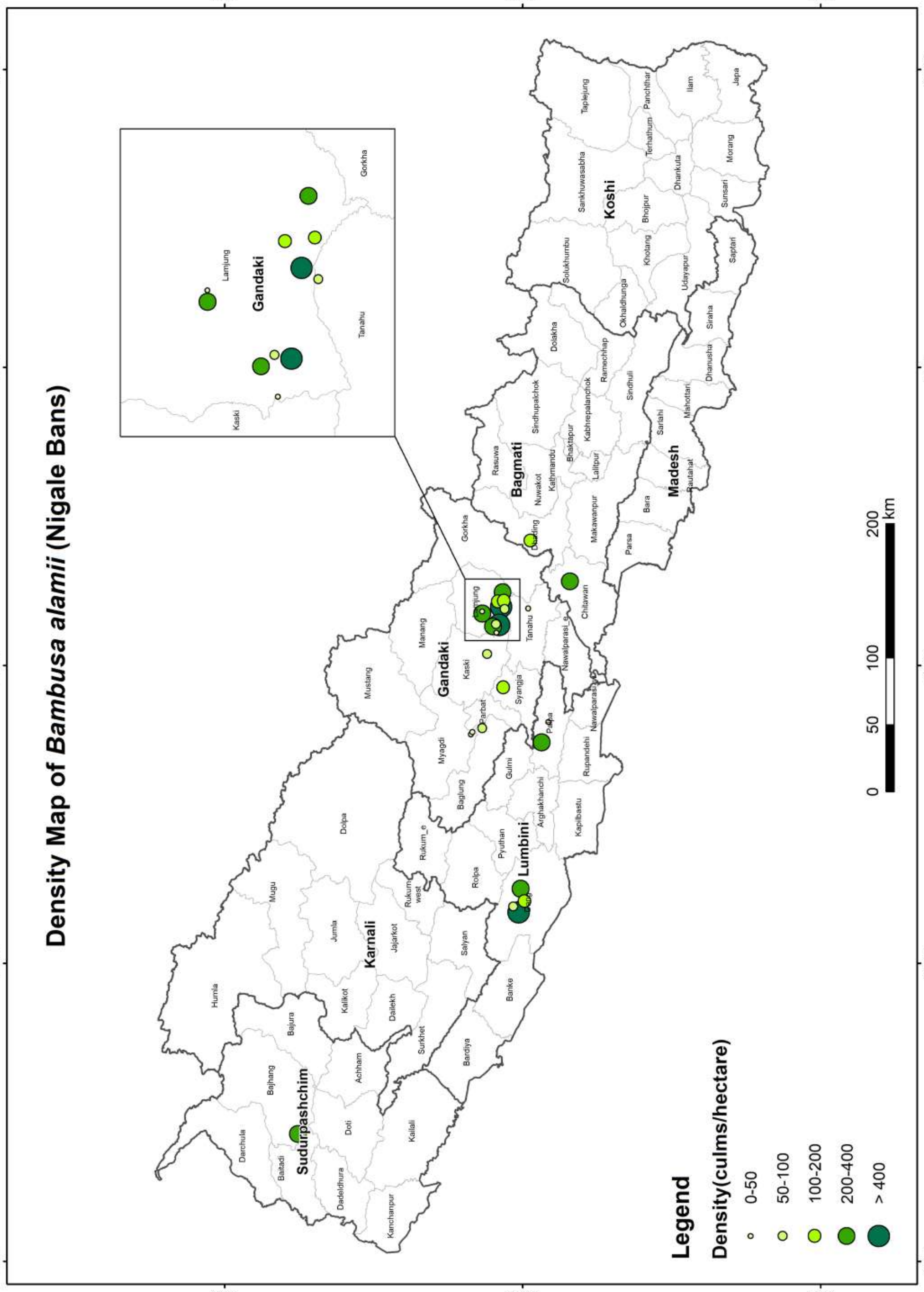

Density Map of Dendrocalamus hookeri (Kalo Bans)
Legend
Density(culms/hectare)
0-50
50-100
100-200
200-400
> 400
0 50 100 200 km



Density Map of Dendrocalamus strictus (Katha Bans)
Legend
Density(culms/hectare)
0-50
50-100
100-200
200-400
> 400
0
50
100
200
km
Sudurpashchim
Karnali
Lumbini
Gandaki
Bagmati
Madesh
Koshi
Darchula
Baitadi
Dadeldhura
Kanchanpur
Bajhang
Bajura
Achham
Doti
Kailali
Humla
Mugu
Dolpa
Jumla
Kalikot
Dailekh
Jajarkot
Surkhet
Salyan
Rukum west
Rukum_e
Rolpa
Pyuthan
Dang
Banke
Bardiya
Arghakhanchi
Gulmi
Kapilbastu
Rupandehi
Palpa
Nawalparasi_w
Nawalparasi_e
Baglung
Myagdi
Mustang
Manang
Parbat
Syangja
Kaski
Lamjung
Tanahu
Gorkha
Chitawan
Dhading
Nuwakot
Rasuwa
Kathmandu
Bhaktapur
Lalitpur
Makawanpur
Parsa
Bara
Rautahat
Sarlahi
Mahottari
Dhanusha
Siraha
Saptari
Sindhupalchok
Kabhrepalanchok
Sindhuli
Ramechhap
Dolakha
Okhaldhunga
Udayapur
Solukhumbu
Khotang
Bhojpur
Sankhuwasabha
Dhankuta
Sunsari
Morang
Terhathum
Taplejung
Panchthar
Ilam
Japa
80°0'0"E
82°0'0"E
84°0'0"E
86°0'0"E
88°0'0"E
26°0'0"N
28°0'0"N
30°0'0"N


Density Map of Dendrocalamus species (Dhungre Bans)
Legend
Density(culms/hectare)
0-50
50-100
100-200
200-400
> 400
0 50 100 200 km
Sudurpashchim
Karnali
Lumbini
Gandaki
Bagmati
Madesh
Koshi
Darchula
Baitadi
Dadeldhura
Kanchanpur
Bajhang
Bajura
Achham
Doti
Kailali
Humla
Mugu
Jumla
Kalikot
Dailekh
Surkhet
Bardiya
Banke
Jajarkot
Salyan
Rukum west
Dolpa
Rukum_e
Rolpa
Pyuthan
Dang
Arghakhanchi
Kapilbastu
Gulmi
Baglung
Myagdi
Parbat
Syangja
Palpa
Rupandehi
Nawalparasi_w
Nawalparasi_e
Mustang
Manang
Kaski
Lamjung
Tanahu
Gorkha
Chitawan
Dhading
Nuwakot
Rasuwa
Kathmandu
Bhaktapur
Lalitpur
Makawanpur
Parsa
Bara
Rautahat
Sarlahi
Mahottari
Dhanusha
Siraha
Saptari
Sindhupalchok
Kabhrepalanchok
Dolakha
Ramechhap
Sindhuli
Okhaldhunga
Solukhumbu
Udayapur
Khotang
Bhojpur
Sankhuwasabha
Dhankuta
Sunsari
Morang
Terhathum
Taplejung
Panchthar
Ilam
Japa
80°0'0"E
82°0'0"E
84°0'0"E
86°0'0"E
88°0'0"E
26°0'0"N
28°0'0"N
30°0'0"N


Density Map of Bambusa bambos (Kande Bans)
Legend
Density(culms/hectare)
0-50
50-100
100-200
200-400
> 400
0
50
100
200
km
Sudurpashchim
Karnali
Lumbini
Gandaki
Bagmati
Madesh
Koshi
Darchula
Baitadi
Bajhang
Bajura
Dadeldhura
Doti
Achham
Kanchanpur
Kailali
Humla
Mugu
Jumla
Kalikot
Dolpa
Dailekh
Jajarkot
Surkhet
Rukum west
Salyan
Bardiya
Banke
Rukum_e
Rolpa
Pyuthan
Dang
Gulmi
Arghakhanchi
Kapilbastu
Rupandehi
Palpa
Nawalparasi_w
Mustang
Myagdi
Baglung
Parbat
Kaski
Manang
Lamjung
Syangja
Tanahu
Gorkha
Nawalparasi_e
Chitawan
Rasuwa
Dhading
Nuwakot
Kathmandu
Bhaktapur
Lalitpur
Sindhupalchok
Kabhrepalanchok
Dolakha
Ramechhap
Makawanpur
Sindhuli
Parsa
Bara
Rautahat
Sarlahi
Mahottari
Dhanusha
Siraha
Saptari
Udayapur
Okhaldhunga
Solukhumbu
Khotang
Bhojpur
Sankhuwasabha
Taplejung
Terhathum
Panchthar
Dhankuta
Ilam
Sunsari
Morang
Japa
80°0'0"E
82°0'0"E
84°0'0"E
86°0'0"E
88°0'0"E
30°0'0"N
28°0'0"N
26°0'0"N


Density Map of Bambusa alamii (Nigale Bans)
Legend
Density(culms/hectare)
0-50
50-100
100-200
200-400
> 400
0
50
100
200
km
Sudurpashchim
Karnali
Lumbini
Gandaki
Bagmati
Madesh
Koshi

ISBN 993719508-X

9789937195089