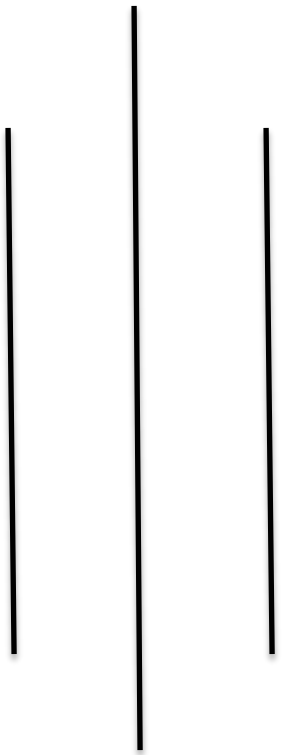
Bamboo Resource Assessment (Outside the Forest Area) of Nepal

Draft Final Report



Government of Nepal

Ministry of Forests and Environment

Forest Research and Training Center

Babarmahal, Kathmandu

September, 2023

Acknowledgements

Bamboo resources occupy a place of pride being closely interwoven with the life of people in several ways since time immemorial. Despite having a significant importance to rural livelihoods, a detailed assessment on this resource was still lacking in our context. Thus, a program on 'Bamboo resource assessment outside the forest area in Nepal' was planned and successfully executed during the fiscal year 2079/080.

I would like to express my sincere gratitude to all those who have contributed to the completion of this program and take this report out at this stage. The dedication and motivation of some personalities have made this happen for whom I am indebted to. Firstly, my sincere thanks go to deputy Director Generals Mr. Nanda Lal Ray Yadav and Ms. Sabitri Aryal Pokharel. Under Secretaries Mr. Bimal Kumar Acharya and Mr. Raj Kumar Giri along with the officers Mr. Ananda Khadka, Mr. Amul Kumar Acharya, Mr. Prakash Lamichhane and Mr. Rajaram Aryal of Forest Survey and Carbon Monitoring Division of this centre, were very crucial for the successful accomplishment of this program and took this report to the final stage. Also, contribution of Ms. Sangita Shakya and Ms. Apsara Paudel during the visual interpretation work has also been recognized. I would also like to acknowledge Officers Mr. Kiran Kumar Pokharel, Mr. Bishnu Prasad Dhakal, Mr. Keshav Ghimire and Mr. Pratik Pandeya for their remarkable role during the Quality Assessment Quality Control of this program. Furthermore, the Account and Admin sections of this Centre also played an important role in this regard.

On the other hand, I am indebted to Genesis Consultancy Pvt. Ltd., the service provider to accomplish this assignment, and all its key technicians who were involved from commencement to the final stage to report preparation. The insightful feedback and constructive criticism of Mr. Hasta Bahadur Thapa, the team leader of the assignment, greatly enriched the quality of this report. Besides, all those forestry offices at district and local levels are also a part of my acknowledgement.

Finally, I would like to acknowledge the Ministry of Forests and Environment for allocating the necessary budget. Without its cooperation, this program would not have been possible.

Thank you all for being part of this journey.

Mr. Yam Prasad Pokharel
Director General

Contents

1. INTRODUCTION

1.1 Background

Bamboo is a fast-growing woody perennial evergreen species falls under grass family Poaceae. There are about 90 genera and 1200 species of bamboo found in the world (Lobovikov et. al., 2005). Among all, 12 genera and 53 species of bamboo have been recorded in Nepal (Das, 2002). The global distribution of bamboo species from tropical to temperate is reflected from its distribution in Nepal from tropical bamboos of South-East Asia to temperate bamboos of Tibet and Bhutan in Terai to High Mountain (50-4000 m from msl) physiographic region both in natural forests as well as farmlands (Karki & Karki, 1995; Ghimire, 2008)

Bamboo, the perennial woody grass, is an important non-timber forest product in Nepal. It belongs to the sub-family Bambusoideae, and is a tribe of the family Poaceae (*Graminae*). Bamboos are widely distributed from Terai (flat plains) to the High Mountain up to 4000 m. They are widely distributed throughout Nepal and are found both in natural forests and on farmlands. Large size bamboos are mainly grown on farmlands. The most widely distributed species belong to genera Bambusa and Dendrocalamus (locally called bans) and are found all over in the Terai and Mid-hills of Nepal (Das, 1988). Distribution of bamboo is more common in the eastern half of the country from Dhaulagiri to Sikkim Border (Stapleton, 1994) because of the favourable climate to the growth of bamboo. Most of the bamboo species of Nepal have Pachymorph type rhizomes and, therefore, are clump-forming (Stapleton, 1994). Nepal has lost many bamboo forests due to over exploitation, gregarious flowering, and extensive forest fires. The forests in Churia, Terai and Mid-hills, once very rich in bamboo, have lost many bamboo species.

Bamboo occupies a place of pride being closely interwoven with the life of people in several ways since time immemorial. Bamboo, an important component of the rural farming systems, plays a crucial role in the rural economy and helps sustain livelihoods of many rural households including social and economically disadvantaged groups. It is difficult to imagine the rural economy without bamboos (Das, 2001). Bamboos are one of the most widely used products nowadays, already in everyday use by about 2.5 billion people in the world (Scurlock *et al*., 2000). People have perceived this species as an alternate to tree species for fulfilling their demand of forest products. It is well-known as the ‘poor man’s timber’, ‘friend of human-being’ and ‘brothers’; some people have considered bamboo as ‘green gold’. The goods and services from bamboo resources both at local and national levels cannot be overlooked in fulfilling basic human needs, such as; employment, fodder, food, shelter, and household-materials. It has been used by the people for construction, paper-making, fishing, agricultural implements, food, handicrafts and woven products for thousands of years. In comparison to timber, the advantage of bamboo culms is its fast growth, short rotation, high straight and

smooth grain, fine color and luster. It has very important ecological, economic and social benefits in many developing countries like Nepal, and has a great potential to reduce poverty, particularly in the rural areas.

1.2 Rationale of the study

Taxonomic work on bamboo started in the early eighties by the Department of Forest Research and Survey (DFRS) with funding from DFID, UK. However, taxonomic work is not complete yet. There are many large size bamboos outside the forest area, as farmers have cultivated them on their farm land for a long time. Still, we lack the information on the types of bamboo species distributed outside the forest area and their density in terms of culm, clump and basal area in each province and Nepal. It is expected that national bamboo inventory outside the forest area fulfills this gap. Through literature review related to bamboo inventories and mapping of bamboo resources in Nepal, it is found that there is almost no information available on statistics of bamboo at the national level. Thus, accurate, comparable, up-to-date, spatially explicit data/maps of bamboo resources for Nepal is important and urgent. Similarly, the resource information of Bamboo in Nepal is not based on scientific studies but only from proxy estimation. There is still a noticeable gap in bamboo cover (spatial map) and total bamboo biomass (bamboo inventory) in Nepal. So, this program was planned to generate various information on Nepal's bamboo resources e.g. types of species, density in terms of culm, clump and basal area, size in terms of diameter and height, biomass, etc..

1.3 Objectives

The main objective of this program was to assess bamboo resources outside the forest area in Nepal. Under this overarching objective, specific objectives were:

1. To conduct field inventory of bamboo resources,
2. To assess the available bamboo species,
3. To prepare maps of bamboo resources,
4. To develop biomass models for major seven bamboo species, and
5. To develop taper equations of bamboo

2. Methodology

2.1 Study Area

This study was conducted outside 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. 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 program 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 3500m. This fact was also supported by the various literatures, e.g., Das,1988; Stapleton, 1994; Shrestha, 1998, etc.

Thus, for this study, the non-forest area (besides area occupied by the forests and other wooded land) that fall under the altitude (elevation from msl) of 3500 m throughout the country has been taken (Figure 1).

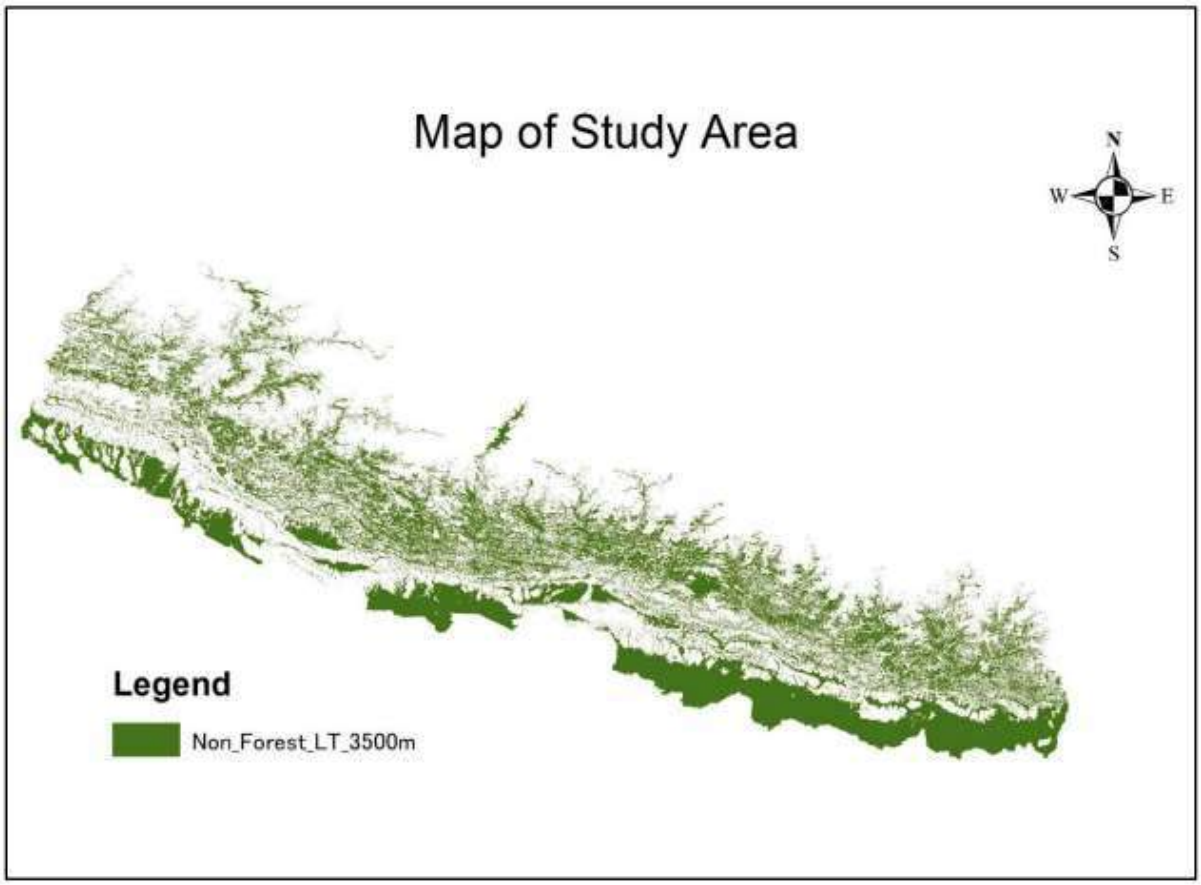


Figure 1 Study area of Bamboo Resources Assessment

2.2 Sample plot allocation (inventory plots)

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 was generated out of which 106,383 plots were found inside the study area i.e., non-forest area below 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). The summary of sample plots generation to the final selection (for field assessment) has been presented in the following table (1).

Table 1: Information on sample plots for bamboo resources assessment

SN	Particulars	No. of sample plots
1	Generation of grids throughout Nepal @ 500m spacing	588,485
2	First stage sampling: selection of plots in the non-forest area	197,108
3	Sample plots below elevation 3500m	106,383
4	Every 4th sample plots taken for visual interpretation (Bamboo present or absent)	26,596
5	Visually interpreted sample plots	26,545
6	Bamboo presence plots	1468
7	Second stage sampling: Selection of plots for field inventory	800

Bamboo clumps were found in 1468 sample plots and for rest of the 25077 sample plots, bamboo clumps were not found.

In the second phase, the following stratification was performed for the allocation of field assessment (Table 2) and in total 800 sample plots were selected finally following systematic sampling with a random start (Figure 2).

Table 2: Stratification and 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

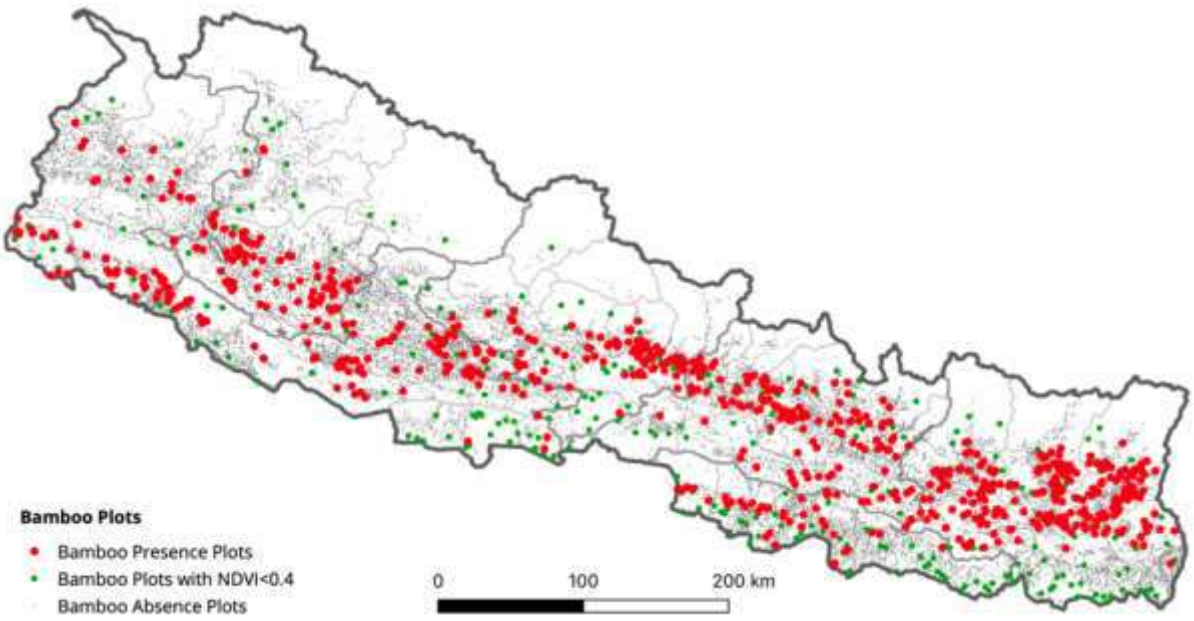


Figure 2: Sample plots for bamboo resource assessment

2.3 Sample plot design and measurement

For the bamboo resource inventory in Nepal, larger sample plots of 1 hectare area size were established (Figure 3) at the identified locations of the plot center. Bamboo clumps within these circular plots were established and inventoried. The details (location, topographic, and other bio-physical data), including the, species, sub species, number and size of each individual clump inside the sample plot was recorded.

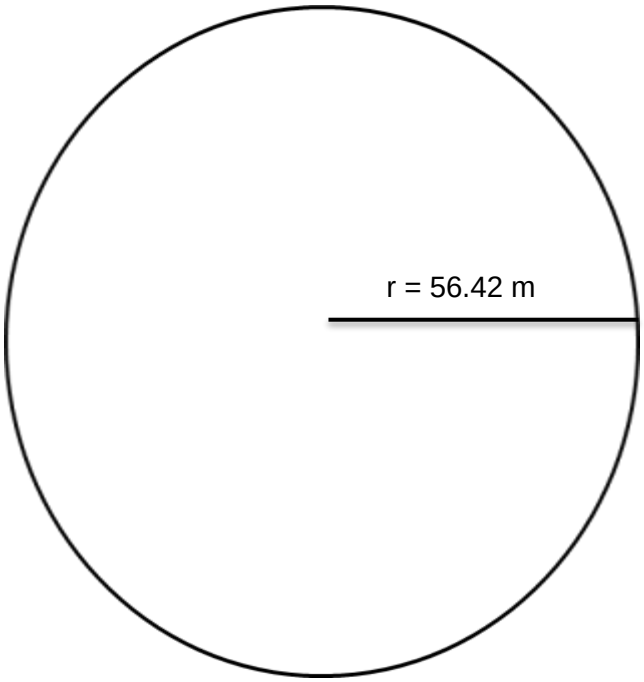


Figure 3 Clump based circular sample plot of 1 ha area

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

2.4 Biomass Assessment

On the basis of people's preferences, usages, abundance and availability, seven major bamboo species were selected. Selected bamboo species along with their distribution for biomass measurement are listed in Table 3.

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 nutans* subsp. *cupulata*	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* subsp. *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.	57
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 hookerii*	600-2000 m	Cultivated mainly in hills of eastern Nepal but rare in central Nepal	51

6	Choya/Tama/Guliyo/Dhungre/Banbans	*Dendrocalamus hamiltonii* vari. *undulatus* and *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/Tamebans	*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	53

Source: Stapleton (1994) and Das (2004)

For biomass study, bamboo samples were collected from different districts. Samples from bamboo culm, branches and foliage were all taken to determine the green and air dry weight. All procedures from sample selection to the laboratory analysis were performed as guided in the field manual (FRTC, 2023).

2.5 Development of biomass and taper equations

Various biomass models were tested for green and dry culm, branch, foliage and total weight of bamboo and selected the best model for prediction of bamboo components and total weight.

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 0.3m, 1.3 m, 2.0 m and so on. Then, consecutive diameters at intervals of 2 m were measured up to the tip of the culm. The length of the culm was also derived.

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.

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.

Focus group discussion in Sankhuwasabha district

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 Mapping of density and distribution of bamboo species

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 Data Analysis

Entered data were analysed in MS Excel program to get the results on number of clumps per unit area, number of culms per unit area, average number of culms per clump for each species, clump diameter, average basal area per unit area, basal area per unit area, average height, diameter, above ground biomass (AGB) per unit area, culm, branches and foliage biomass per unit area. The analysis also included assessment of species distribution and mapping along with biomass equations based on fresh, air dry and oven dry weight, and taper equations through the destructive sampling technique.

2.9 Quality Assurance/Quality Control

Quality Assessment and Quality Control (QAQC) mechanism was used to check the accuracies of data entry. The QAQC process was performed by selecting 10 % of the total data. QAQC was performed in two stages: firstly against the field data & collection procedures in which re-assessment of 80 plots (10% of 800 plots) was conducted and later15 % re-validation in terms of data entry and validation.

3 Results

3.1 Information on bamboo clumps and distribution

3.1.1 Altitude of bamboo presence plots

Bamboo distribution was noticed up to the highest altitude (2007 m) in Koshi province to the lowest altitude (57 m) in Madhesh province (Table 5).

Table 5: Altitudinal distribution of bamboo

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

3.1.2 Bamboo clumps per plot by land use

Distribution of bamboo clumps per plot in different types of land use revealed that bamboo distribution in different land use classes does not vary significantly, however the number of clumps was lesser in built-up area (Table 6).

Table 6: 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
	Overall mean	4

3.1.3 Province wise distribution of bamboo species

Altogether 15 bamboo species were found in sample plots in different districts and physiographic regions. Major species were *Bambusa nutans* subsp. *cupulata* (Mal bans), *Bambusa nutans* subsp. nutans (Taru bans), *Bambusa balcooa* (Dhanu bans), *Bambusa nepalensis* (Khasre/Fusre bans), Bambusa tulda (Chab/Jhapta bans) and Dendrocalamus hamiltonii (Tama bans) (Table 7).

Table 7: Province wise distribution of bamboo species (*Available)

SN	Local name	Latin name	Province						
			Koshi	Madhesh	Bagmati	Gandaki	Lumbini	Karnali	Sudur paschim
1	Mal bans	*Bambusa nutans* subsp. *Cupulata*	*	*	*	*	*	-	*
2	Taru bans	*Bambusa nutans* subsp. *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* sp.	*	-	*	-	-	-	-
11	Nigale bans	*Bamnbusa alamii*	-	-	*	*	*	-	*
12	Pahelo bans	*Bambusa vulgaris 'vitata'*	-	-	*	-	-	-	-
13	Murali bans	*Cephalostachyum latifolium*	-	-	*	-	-	-	-
14	Paryang/Padang	*Himalayacalamus hookerianus*	-	-	*	-	-	-	-
15	Kali bans	*Dendrocalamus* sp.	*	-	-	-	-	-	-

3.1.4 Clump diameters

Average clump diameter at the base of *B. nutans* subsp. *cupulata* was found to be the highest, which was followed by *D. hookeri.* It indicates that the culms regeneration in these two species is higher than other bamboo species (Table 8).

Table 8: Clump base diameter of major seven bamboo species

SN	Local name	Latin name	Clump diameter (m)		
			D1	D2	Mean
1	Dhanu bans	*Bambusa balcooa*	5.44	3.97	4.71
2	Khasre/Phusre bans	*Bambusa nepalensis*	4.46	3.49	3.98
3	Mal bans	*Bambusa nutans* subsp. *cupulata*	8.59	5.36	6.98
4	Taru bans	*Bambusa nutans* subsp. *nutans*	4.68	3.60	4.14
5	Chab/Jhapta bans	*Bambusa tulda*	3.90	2.87	3.38
6	Tama bans	*Dendrocalamus hamiltonii*	6.56	3.21	4.88
7	Bhalu bans	*Dendrocalamus hookerii*	7.12	5.08	6.10

The bamboos found in Koshi and Madhesh provinces had larger clump diameter than the clump diameter of bamboos in other provinces. It indicates that the culms regeneration is higher in these two provinces. The mean clump diameter of bamboos in Sudurpaschim and Gandaki was smaller than other provinces, which indicates the lower number of culms regeneration in these provinces (Table 9).

Table 9: Province wise clump base diameter of bamboo species

SN	Province	Clump base diameter (m)		
		D1	D2	Mean
1	Bagmati	6.2	3.5	4.9
2	Gandaki	4.2	2.9	3.6
3	Karnali	4.4	3.5	4.0
4	Koshi	8.4	5.5	7.0
5	Lumbini	4.9	3.6	4.3
6	Madhesh	7.4	5.5	6.5
7	Sudurpaschim	3.6	3.1	3.4
	Overall mean	6.4	4.3	5.4

Average clump diameter at the crown of *Dendrocalamus hookerii* was found to be the highest, which was followed by *B. nutans* subsp. *cupulata* (Table 10).

Table 10: **Clump crown diameter of different bamboo species**

SN	Local name	Latin name	Crown diameter (m)		
			CD1	CD2	Mean
1	Dhanu bans	*Bambusa balcooa*	9.19	7.21	8.20
2	Khasre/Phusre bans	*Bambusa nepalensis*	7.40	5.96	6.68
3	Mal bans	*Bambusa nutans* subsp. *cupulata*	11.52	8.26	9.89
4	Taru bans	*Bambusa nutans* subsp. *nutans*	7.43	6.29	6.86
5	Chab/Jhapta bans	*Bambusa tulda*	6.88	5.15	6.02
6	Tama bans	*Dendrocalamus hamiltonii*	8.41	5.91	7.16
7	Bhalu bans	*Dendrocalamus hookeri*	11.17	9.46	10.31

The bamboo clumps found in Koshi and Madhesh provinces had larger crown diameters than that in other provinces. Clump and crown sizes are interrelated to each other, larger of clump base indicating the 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)		
		CD1	CD2	Mean
1	Bagmati	6.22	3.48	4.85
2	Gandaki	4.22	2.92	3.57
3	Karnali	4.39	3.48	3.93
4	Koshi	8.43	5.52	6.98
5	Lumbini	4.86	3.64	4.25
6	Madhesh	7.38	5.54	6.46
7	Sudurpaschim	3.56	3.05	3.30
	Overall mean	6.35	4.29	5.32

3.1.5 Diameters (D30, DBH), internode length and culmination height

The large size bamboos, *D. hookerii* and *Dendrocalamus hamiltonii* had attained the greater D30 and DBH (Table 12). The mean internode length of seven major bamboo species varied from 28.92 cm for *D. hamiltonii* to 40.22 cm for *B. nutans* subsp. *cupulata.* As expected, in large bamboos, internode length at 1.3 m was the highest for *B. nutans* subsp. *cupulata* (Table 16). Average culmination height of culm was the highest (16.27 m) *for D. hookerii* and the lowest (9.19 m) for *B. tulda* (Table 12).

Table 12: Diameters, internode length and culmination height of 7 major bamboo species

SN	Latin name	Mean D30 (cm)	Mean DBH (cm)	Mean internode length at 1.3 (cm)	Culmination height (m)	Number of samples
1	*Bambusa balcooa*	7.55 (2.76)	7.05 (2.19)	29.66 (10.84)	13.30	3885
2	*Bambusa nepalensis*	7.13 (3.34)	6.62 (2.60)	31.40 (11.83)	11.38	2198
3	*Bambusa nutans* subsp. *cupulata*	6.39 (1.86)	6.24 (2.35)	40.22 (12.86)	13.43	8025
4	*Bambusa nutans* subsp. *nutans*	6.36	5.83 (1.55)	31.10 (13.96)	12.29	2572
5	*Bambusa tulda*	6.04 (1.28)	5.90 (1.24)	30.29 (4.09)	9.19	82
6	*Dendrocalamus hamiltonii*	8.92	8.33	28.92 (12.77)	12.12	1135
7	*Dendrocalamus hookeri*	10.82 (3.94)	10.28 (2.99)	34.02 (8.23)	16.27	261

Figures in parenthesis indicate standard deviation

3.1.6 Green, dead/dry and broken culms

Green culm per clump was found the highest for bamboos assessed in Madhesh province, followed by Koshi province (Table 13). Dead/dry culms per clump was not found significantly differing in all provinces, which ranged from 3 culms per clump in Koshi and Sudurpaschim provinces to 7 culms per clump in Gandaki province.

Table 13: Province wise mean green, dead/dry and broken culms

SN	Province	Mean (culms per clump)		
		Green culms	Dead/dry culms	Broken culms
1	Bagmati	65	5	5
2	Gandaki	61	7	8
3	Karnali	50	5	7
4	Koshi	84	3	3
5	Lumbini	64	5	17*
6	Madhesh	105	4	5
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 to be cut at the top 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 14).

Table 14: Province and district wise average number of clumps

SN	Province and district	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

3.2 Mapping of bamboos

Mapping was done for bamboo presence plots outside the forest area in Nepal (Annex 2). Furthermore, maps of seven bamboo species were prepared for culms and clumps per ha. Higher density of clumps of *B. balcooa* was found in Bagmati and Gandaki provinces. Similar trends remained for culms per ha foir these provinces. Higher density in terms of culms per ha was found in Madhesh, Gandaki and Lumbini provinces. Mostly the lower density (1-5 clumps per ha) of *B. nepalensis* was found in Koshi and Bagmati provinces. The density (11-15 clumps per ha) was found only in a few places. For this species, more than 400 culms per ha was found in Bagmati and Koshi provinces. *B. nutans* subsp. *cupulata* was not recorded in Karnali province. As expected, higher density (11-15 clumps/ha) of this species was found in Koshi province. On the contrary, Sudurpaschim province had only 1-5 clumps per ha for this species. More than 400 culms per ha was found in Koshi and Bagmati provinces for this species. *B. nutans* subsp. *Nutans* was not recorded in Koshi province. In most cases, the density of culms of this species was found lower (1-5 clumps /ha) in Bagmati, Gandaki, Lumbini, Karnali and Sudurpaschim provinces. More than 400 culms per ha was found in four provinces (Bagmati, Lumbini, Karnali and Sudurpaschim). For *B. tulda*, 6-10 clumps per ha and 200-400 clumps per ha were found in Madhesh province. Mostly, 1-5 clumps per ha were found for *D. hamiltonii* and more than 400 culms per ha in Gandaki and Bagmati provinces. It is not recorded in Madhesh and Sudurpaschim provinces. As expected, *D. hookerii* were found in Koshi and Bagmati provinces. The clump density of this species was lower (1-5 clumps per ha) in these provinces. Similarly, the culm density (100-200 culms per ha) was only in Koshi provinces**.**

4. Conclusions

Bamboo resource assessment outside the forest area has been carried out for the first time in Nepal. This assessment has revealed some of the very valuable information on bamboo species, availability, spatial location and other bio physical attributes.

The information generated can be crucial for planners, policy makers, farmers, entrepreneurs, and concerned stakeholders. Out of all visually interpreted bamboo presence sample plots (650) error was found only on 6% out of all. Thus, the present assessment methodology seems promising to identify bamboo availability in different location.

References

1. Das, A. N. 1988. Bamboo research in Nepal. In Bamboos: Current Research (eds.) Rao, I. V. R., Ganaharan, R.and Sastry, C. B. Proceedings of the International Bamboo Workshop, 14–18 November 1988, Cochin, India, 1–5.
2. Das, A. N. 2001. "Bamboo craft making in the Terai and Mid-hills of Eastern Nepal", paper presented at the Training Workshop on Bamboo Handicraft Technique and its Tools and Small Machines, 6–19 October, 2001, Zhejiang, China.
3. Das, A. N. 2004. Manual on Bamboos of Nepal. Tree Improvement and Silviculture, Ministry of Forests and Soil Conservation, Department of Forests, Kathmandu, Nepal, 112 pp.
4. Das, A.N. 2002. Bamboo growing and its marmet development potential for sustaining rural livelihoods and poverty reduction in eastern Nepal. Banko Janakari, 12 (1) (2002), pp. 8-19, 10.3126/banko.v12i1.17226
5. FRTC. 2022. National Land Cover Monitoring System of Nepal. Forest Research and Training Centre (FRTC). Kathmandu, Nepal. https://frtc.gov.np/uploads/files/Study%20Report%20Inner-final.pdf.
6. FRTC. 2023. Bamboo Resource Assessment outside the Forest Area, Field Manual. Forest Research and Training Centre (FRTC). Kathmandu, Nepal. https://frtc.gov.np/downloadfile/Bamboo_Assessment_Field_Manual_1697737694.pdf.
7. Ghimire, A. 2008. An assessment of the dependency of farmers on bamboo resource for rural livelihood in Lalitpur District, Nepal.
8. Karki, M.B. & Karki, J.B.S. 1995. National bamboo and rattan information database 1995.
9. Lobovikov M, Paudel S, Piazza M. 2005. *Non wood forest products, World bamboo resources, a thematic study prepared in the framework of the Global Forest Resources Assessment 2005*. China: INBAR publication.
10. Scurlock, J. M., Dayton, D. C. & Hames, B. 2000. Bamboo: An Overlooked Biomass Resource? ORNL/TM1999/264. Oak Ridge Laboratory, Oak Ridge, Tennessee, 34 pp.
11. Shrestha, K. 1998. Distribution and status of bamboos in Nepal (May). In Proceedings of a Training Course Cum Workshop (1998), pp. 10-17.
12. Stapleton, C. 1994. Bamboos of Nepal: An Illustrated Guide. Royal Botanic Gardens, Kew, 67 pp.

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, *D. hamiltonii* (Tama bans) and *B. nepalensis* (choya bans) have long leaves and *B. nutans* subsp. *cupulata* (Mal bans) has short and broad (*chepto*) leaves.

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

Nodes: Number of nodes are many in Kharaute band.

Height of culm: Mal, *B. balcooa* (Dhanu) and Bhalu bans are taller than other bamboo species

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 beans 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 band, 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: Mature 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: Y 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 (khabata) is found in first year culm.

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

Annex 1.3 Livelihood support

The bamboo sub-sector has supported livelihood, to some extent. They have used bamboo for their own purpose such as fodder for cattle, fencing, construction of cattle and goat sheds, house construction. Further they have generated income by selling bamboo culms to the traders for the use of scaffolding, tunnel construction and for making bamboo products. But it varied from district to district. The farmers in Jhapa district have been more benefitted than the farmers in Dadeldhura district. In Surunga, Jhapa, some people are involved in making mats in which Kankaimai community forest has made an agreement with Kankaimai Municipality.

Annex-2: Maps

Bamboo Presence Plot Map

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

Humla
Darchula
Bajhang
Bajura
Mugu
Baitadi
Sudurpashchim
Karnali
Jumla
Dadeldhura
Doti
Achham
Kalikot
Dolpa
Mustang
Kanchanpur
Dailekh
Jajarkot
Kailali
Rukum west
Rukum_e
Gandaki
Manang
Surkhet
Myagdi
Bardiya
Salyan
Rolpa
Baglung
Kaski
Lamjung
Gorkha
Parbat
Rasuwa
Bankē
Lumbini
Pyuthan
Gulmi
Syangja
Tanahu
Dang
Arghakhanchi
Palpa
Dhading
Nuwakot
Sindhupalchok
Dolakha
Kathmandu
Bhaktapur
Solukhumbu
Bagmati
Nawalparasi_e
Kapilbastu
Rupandehi
Nawalparasi_w
Chitawan
Lalitpur
Kabhrepalanchok
Ramechhap
Sankhuwasabha
Taplejung
Makawanpur
Okhaldhunga
Parsa
Sindhuli
Khotang
Bhojpur
Terhathum
Panchthar
Bara
Rautahat
Sarlahi
Madesh
Koshi
Dhankuta
Udayapur
Ilam
Mahottari
Dhanusha
Siraha
Saptari
Sunsari
Morang
Japa

Legend

- Province boundary
- District boundary
- Bamboo presence plots

0 50 100 200 km

Density Map of *Bambusa balcooa* (Dhanu Bans)

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

Humla
Darchula
Bajhang
Baitadi
Bajura
Mugu
Sudurpashchim
Dadeldhura
Doti
Achham
Kalikot
Jumla
Dolpa
Karnali
Mustang
Kanchanpur
Kailali
Dailekh
Jajarkot
Rukum west
Rukum_e
Surkhet
Manang
Myagdi
Gandaki
Bardiya
Salyan
Baglung
Kaski
Gorkha
Rolpa
Parbat
Lamjung
Rasuwa
Pyuthan
Banke
Gulmi
Syangja
Bagmati
Dang
Lumbini
Tanahu
Dhading
Nuwakot
Sindhupalchok
Arghakhanchi
Palpa
Kathmandu
Dolakha
Nawalparasi_e
Bhaktapur
Solukhumbu
Kapilbastu
Rupandehi
Chitawan
Kabhrepalanchok
Sankhuwasabha
Taplejung
Nawalparasi_w
Makawanpur
Lalitpur
Ramechhap
Koshi
Okhaldhunga
Parsa
Sindhuli
Khotang
Bhojpur
Terhathum
Panchthar
Bara
Sarlahi
Madesh
Dhankuta
Rautahat
Mahottari
Udayapur
Ilam
Dhanusha
Siraha
Sunsari
Morang
Saptari
Japa

Legend

Density (clumps/hectare)

- 1-5
- 6-10
- 11-15
- 16-20
- >20

0 50 100 200 km

Density Map of *Bambusa nepalensis* (Khasre Bans)

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

Humla
Darchula
Bajhang
Baitadi
Bajura
Mugu
Sudurpashchim
Dadeldhura
Doti
Achham
Kalikot
Jumla
Dolpa
Karnali
Kanchanpur
Dailekh
Jajarkot
Kailali
Rukum west
Rukum_e
Surkhet
Mustang
Manang
Myagdi
Gandaki
Bardiya
Salyan
Baglung
Kaski
Lamjung
Gorkha
Rolpa
Parbat
Rasuwa
Pyuthan
Gulmi
Banke
Syangja
Tanahu
Bagmati
Dang
Lumbini
Arghakhanchi
Palpa
Dhading
Nuwakot
Sindhupalchok
Kathmandu
Dolakha
Nawalparasi_e
Solukhumbu
Kapilbastu
Rupandehi
Nawalparasi_w
Chitawan
Kabhrepalanchok
Sankhuwasabha
Taplejung
Makawanpur
Lalitpur
Ramechhap
Koshi
Okhaldhunga
Parsa
Sindhuli
Khotang
Bhojpur
Terhathum
Panchthar
Bara
Sarlahi
Madesh
Dhankuta
Rautahat
Mahottari
Udayapur
Ilam
Dhanusha
Siraha
Saptari
Sunsari
Morang
Japa

Legend

Density (clumps/hectare)

- 1-5
- 6-10
- 11-15
- 16-20
- >20

0 50 100 200 km

Density Map of *Bambusa nutans subsp.cupulata* (Mal Bans)

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

Humla
Darchula
Bajhang
Baitadi
Bajura
Mugu
Sudurpashchim
Dadeldhura
Doti
Achham
Kalikot
Jumla
Dolpa
Karnali
Kanchanpur
Kailali
Dailekh
Jajarkot
Rukum west
Rukum_e
Surkhet
Mustang
Manang
Myagdi
Gandaki
Bardiya
Salyan
Baglung
Kaski
Lamjung
Gorkha
Rolpa
Parbat
Pyuthan
Gulmi
Syangja
Tanahu
Banke
Dang
Lumbini
Arghakhanchi
Palpa
Rasuwa
Bagmati
Dhading
Nuwakot
Sindhupalchok
Kathmandu
Dolakha
Solukhumbu
Kapilbastu
Rupandehi
Nawalparasi_w
Nawalparasi_e
Chitawan
Bhaktapur
Kabhrepalanchok
Sankhuwasabha
Taplejung
Makawanpur
Lalitpur
Ramechhap
Koshi
Parsa
Sindhuli
Okhaldhunga
Bara
Sarlahi
Bhojpur
Terhathum
Madesh
Rautahat
Mahottari
Udayapur
Dhanusha
Siraha
Saptari
Sunsari
Morang
Japa

Legend

Density (clumps/hectare)

- 1-5
- 6-10
- 11-15
- 16-20
- >20

0 50 100 200 km

Density Map of *Bambusa nutans subsp.nutans* (Taru Bans)

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

Humla
Darchula
Bajhang
Baitadi
Bajura
Mugu
Sudurpashchim
Dadeldhura
Doti
Achham
Kalikot
Jumla
Dolpa
Karnali
Mustang
Kanchanpur
Kailali
Dailekh
Jajarkot
Rukum west
Rukum_e
Surkhet
Manang
Myagdi
Gandaki
Bardiya
Salyan
Baglung
Kaski
Gorkha
Rolpa
Parbat
Lamjung
Rasuwa
Pyuthan
Gulmi
Banke
Syangja
Bagmati
Dang
Lumbini
Tanahu
Dhading
Nuwakot
Sindhupalchok
Arghakhanchi
Palpa
Kathmandu
Dolakha
Nawalparasi_e
Solukhumbu
Kapilbastu
Chitawan
Kabhrepalanchok
Sankhuwasabha
Taplejung
Rupandehi
Nawalparasi_w
Makawanpur
Lalitpur
Ramechhap
Koshi
Parsa
Okhaldhunga
Sindhuli
Bara
Khotang
Bhojpur
Terhathum
Panchthar
Sarlahi
Madesh
Dhankuta
Rautahat
Mahottari
Udayapur
Ilam
Dhanusha
Siraha
Sunsari
Morang
Saptari
Japa

Legend

Density (clumps/hectare)

- 1-5
- 6-10
- 11-15
- 16-20
- >20

0 50 100 200 km

Density Map of *Bambusa tulda* (Jhapta Bans)

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

Humla
Darchula
Bajhang
Baitadi
Bajura
Mugu
Sudurpashchim
Dadeldhura
Doti
Achham
Kalikot
Jumla
Dolpa
Karnali
Kanchanpur
Kailali
Surkhet
Dailekh
Jajarkot
Rukum west
Rukum_e
Mustang
Manang
Myagdi
Gandaki
Bardiya
Salyan
Rolpa
Baglung
Kaski
Parbat
Lamjung
Gorkha
Pyuthan
Gulmi
Banke
Dang
Lumbini
Syangja
Tanahu
Arghakhanchi
Palpa
Rasuwa
Bagmati
Dhading
Nuwakot
Sindhupalchok
Kathmandu
Dolakha
Bhaktapur
Nawalparasi_e
Kapilbastu
Rupandehi
Nawalparasi_w
Chitawan
Makawanpur
Lalitpur
Kabhrepalanchok
Ramechhap
Solukhumbu
Sankhuwasabha
Taplejung
Koshi
Okhaldhunga
Parsa
Bara
Sarlahi
Sindhuli
Khotang
Bhojpur
Terhathum
Panchthar
Madesh
Rautahat
Mahottari
Udayapur
Dhankuta
Ilam
Dhanusha
Siraha
Saptari
Sunsari
Morang
Japa

Legend

Density (clumps/hectare)

- 1-5
- 6-10
- 11-15
- 16-20
- >20

0 50 100 200 km

Density Map of *Dendrocalamus hamiltonii* (Tama Bans)

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

Humla
Darchula
Bajhang
Baitadi
Bajura
Mugu
Sudurpashchim
Dadeldhura
Doti
Achham
Kalikot
Jumla
Dolpa
Karnali
Mustang
Kanchanpur
Kailali
Dailekh
Jajarkot
Rukum west
Rukum_e
Surkhet
Manang
Myagdi
Gandaki
Bardiya
Salyan
Rolpa
Baglung
Parbat
Kaski
Lamjung
Gorkha
Pyuthan
Gulmi
Syangja
Tanahu
Rasuwa
Banke
Dang
Lumbini
Arghakhanchi
Palpa
Bagmati
Dhading
Nuwakot
Kathmandu
Bhaktapur
Sindhupalchok
Dolakha
Solukhumbu
Kapilbastu
Rupandehi
Nawalparasi_w
Nawalparasi_e
Chitawan
Makawanpur
Lalitpur
Kabhrepalanchok
Ramechhap
Sankhuwasabha
Taplejung
Koshi
Okhaldhunga
Sindhuli
Khotang
Bhojpur
Terhathum
Panchthar
Parsa
Bara
Sarlahi
Madesh
Rautahat
Mahottari
Dhankuta
Ilam
Udayapur
Dhanusha
Siraha
Saptari
Sunsari
Morang
Japa

Legend

Density (clumps/hectare)

- 1-5
- 6-10
- 11-15
- 16-20
- >20

0 50 100 200 km

Density Map of *Dendrocalamus hookerii* (Kalo Bans)

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

Humla
Darchula
Bajhang
Baitadi
Bajura
Mugu
Sudurpashchim
Dadeldhura
Doti
Achham
Kalikot
Jumla
Dolpa
Karnali
Kanchanpur
Kailali
Surkhet
Dailekh
Jajarkot
Rukum west
Rukum_e
Mustang
Manang
Myagdi
Gandaki
Bardiya
Salyan
Rolpa
Baglung
Kaski
Parbat
Lamjung
Gorkha
Banke
Pyuthan
Gulmi
Dang
Lumbini
Arghakhanchi
Palpa
Syangja
Tanahu
Kapilbastu
Rupandehi
Nawalparasi_w
Nawalparasi_e
Chitawan
Rasuwa
Bagmati
Dhading
Nuwakot
Kathmandu
Bhaktapur
Sindhupalchok
Dolakha
Makawanpur
Lalitpur
Kabhrepalanchok
Ramechhap
Solukhumbu
Sankhuwasabha
Taplejung
Koshi
Okhaldhunga
Khotang
Bhojpur
Terhathum
Panchthar
Ilam
Dhankuta
Udayapur
Parsa
Bara
Sarlahi
Sindhuli
Madesh
Rautahat
Mahottari
Dhanusha
Siraha
Saptari
Sunsari
Morang
Japa

Legend

Density (clumps/hectare)

- 1-5
- 6-10
- 11-15
- 16-20
- >20

0 50 100 200 km

Density Map of *Dendrocalamus strictus* (Katha Bans)

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

Humla
Darchula
Bajhang
Baitadi
Bajura
Mugu
Sudurpashchim
Dadeldhura
Doti
Achham
Kalikot
Jumla
Dolpa
Karnali
Mustang
Kanchanpur
Dailekh
Jajarkot
Kailali
Rukum west
Rukum_e
Surkhet
Manang
Myagdi
Gandaki
Baglung
Kaski
Gorkha
Bardiya
Salyan
Rolpa
Parbat
Lamjung
Rasuwa
Pyuthan
Gulmi
Banke
Syangja
Tanahu
Bagmati
Dang
Lumbini
Arghakhanchi
Dhading
Nuwakot
Sindhupalchok
Palpa
Kathmandu
Dolakha
Nawalparasi_e
Bhaktapur
Solukhumbu
Kapilbastu
Chitawan
Kabhrepalanchok
Sankhuwasabha
Taplejung
Rupandehi
Nawalparasi_w
Makawanpur
Lalitpur
Ramechhap
Koshi
Okhaldhunga
Parsa
Sindhuli
Khotang
Bhojpur
Terhathum
Panchthar
Bara
Sarlahi
Madesh
Dhankuta
Rautahat
Mahottari
Udayapur
Ilam
Dhanusha
Siraha
Sunsari
Morang
Saptari
Japa

Legend

Density (clumps/hectare)

- 1-5
- 6-10
- 11-15
- 16-20
- >20

0 50 100 200 km

Density Map of *Dendrocalamus species* (Dhungre Bans)

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

Humla
Darchula
Bajhang
Baitadi
Bajura
Mugu
Sudurpashchim
Dadeldhura
Doti
Achham
Kalikot
Jumla
Dolpa
Karnali
Kanchanpur
Kailali
Dailekh
Jajarkot
Rukum west
Rukum_e
Surkhet
Mustang
Manang
Myagdi
Gandaki
Bardiya
Salyan
Rolpa
Baglung
Kaski
Lamjung
Gorkha
Parbat
Pyuthan
Gulmi
Syangja
Tanahu
Banke
Dang
Lumbini
Arghakhanchi
Palpa
Nawalparasi_e
Kapilbastu
Rupandehi
Nawalparasi_w
Chitawan
Rasuwa
Bagmati
Dhading
Nuwakot
Sindhupalchok
Kathmandu
Dolakha
Bhaktapur
Solukhumbu
Sankhuwasabha
Taplejung
Kabhrepalanchok
Makawanpur
Lalitpur
Ramechhap
Koshi
Okhaldhunga
Parsa
Sindhuli
Khotang
Bhojpur
Terhathum
Panchthar
Bara
Sarlahi
Madesh
Dhankuta
Rautahat
Mahottari
Udayapur
Ilam
Dhanusha
Siraha
Saptari
Sunsari
Morang
Japa

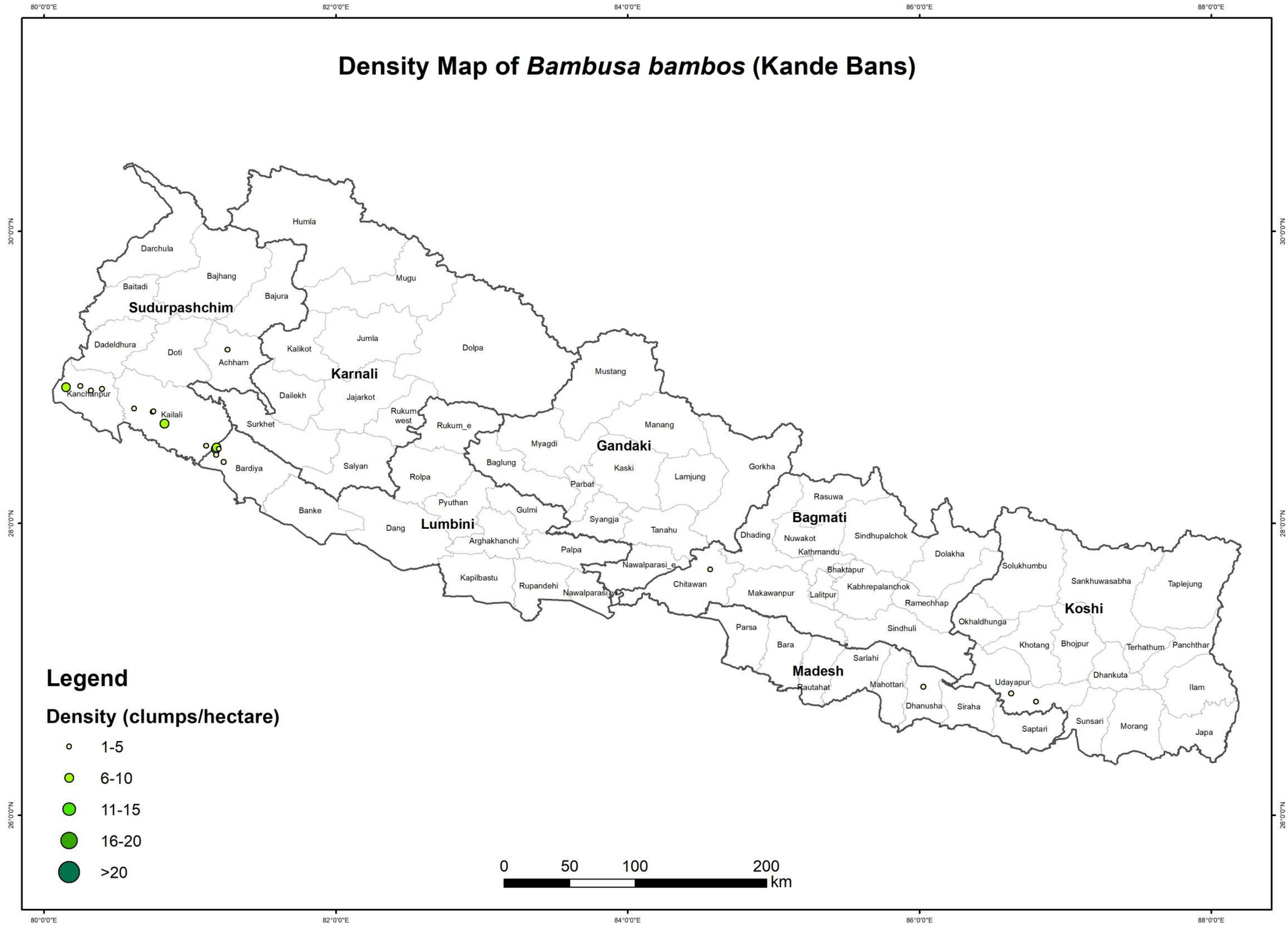
Legend

Density (clumps/hectare)

- 1-5
- 6-10
- 11-15
- 16-20
- >20

0 50 100 200 km

Density Map of *Bambusa bambos* (Kande Bans)



Density Map of *Bambusa alamii* (Nigale Bans)

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

Humla
Darchula
Bajhang
Baitadi
Bajura
Mugu
Sudurpashchim
Dadeldhura
Doti
Achham
Kalikot
Jumla
Dolpa
Karnali
Kanchanpur
Kailali
Dailekh
Jajarkot
Rukum west
Rukum_e
Surkhet
Mustang
Manang
Myagdi
Gandaki
Bardiya
Salyan
Rolpa
Baglung
Kaski
Lamjung
Gorkha
Parbat
Pyuthan
Gulmi
Syangja
Banke
Dang
Lumbini
Arghakhanchi
Palpa
Tanahu
Rasuwa
Bagmati
Dhading
Nuwakot
Sindhupalchok
Kathmandu
Dolakha
Bhaktapur
Solukhumbu
Kapilbastu
Rupandehi
Nawalparasi_e
Nawalparasi_w
Chitawan
Kabhrepalanchok
Sankhuwasabha
Taplejung
Makawanpur
Lalitpur
Ramechhap
Koshi
Okhaldhunga
Parsa
Sindhuli
Bara
Khotang
Bhojpur
Terhathum
Panchthar
Sarlahi
Madesh
Dhankuta
Rautahat
Mahottari
Udayapur
Ilam
Dhanusha
Siraha
Saptari
Sunsari
Morang
Japa

Legend

Density (clumps/hectare)

- 1-5
- 6-10
- 11-15
- 16-20
- >20

0 50 100 200 km

Density Map of *Himalayacalamus hookerianus* (Paryang Bans)

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

Humla
Darchula
Bajhang
Mugu
Bajura
Baitadi
Sudurpashchim
Karnali
Jumla
Dadeldhura
Doti
Kalikot
Dolpa
Achham
Mustang
Kanchanpur
Dailekh
Jajarkot
Rukum west
Kailali
Surkhet
Rukum_e
Manang
Gandaki
Myagdi
Bardiya
Salyan
Lumbini
Baglung
Kaski
Gorkha
Rolpa
Lamjung
Parbat
Rasuwa
Banke
Pyuthan
Gulmi
Syangja
Tanahu
Bagmati
Sindhupalchok
Dang
Dhading
Nuwakot
Arghakhanchi
Palpa
Dolakha
Kathmandu
Solukhumbu
Nawalparasi_e
Bhaktapur
Kapilbastu
Rupandehi
Chitawan
Kabhrepalanchok
Sankhuwasabha
Taplejung
Makawanpur
Lalitpur
Ramechhap
Nawalparasi_w
Okhaldhunga
Parsa
Sindhuli
Khotang
Bhojpur
Terhathum
Panchthar
Madesh
Bara
Sarlahi
Dhankuta
Udayapur
Ilam
Rautahat
Koshi
Mahottari
Dhanusha
Siraha
Sunsari
Morang
Saptari
Japa

Legend

Density (clumps/hectare)

- 1-5
- 6-10
- 11-15
- 16-20
- >20

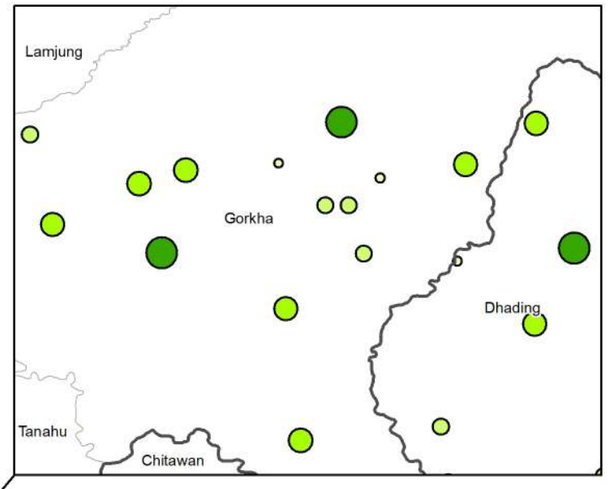
0 50 100 200 km

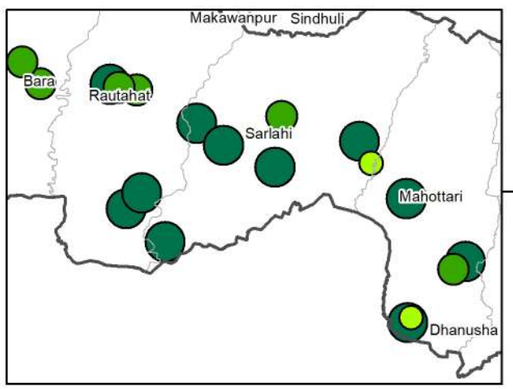
Density Map of *Bambusa balcooa* (Dhanu Bans)

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

Humla
Darchula
Bajhang
Baitadi
Bajura
Mugu
Sudurpashchim
Dadeldhura
Doti
Achham
Kalikot
Jumla
Dolpa
Karnali
Kanchanpur
Kailali
Dailekh
Jajarkot
Rukum west
Rukum_e
Surkhet
Mustang
Manang
Myagdi
Gandaki
Bardiya
Salyan
Baglung
Kaski
Gorkha
Lamjung
Rolpa
Pyuthan
Banke
Dang
Lumbini
Gulmi
Arghakhanchi
Palpa
Syangja
Tanahu
Rasuwa
Dhading
Nuwakot
Kathmandu
Bagmati
Sindhupalchok
Dolakha
Solukhumbu
Nawalparasi_e
Bhaktapur
Kapilbastu
Rupandehi
Nawalparasi_w
Chitawan
Makawanpur
Lalitpur
Kabhrepalanchok
Ramechhap
Sankhuwasabha
Taplejung
Koshi
Okhaldhunga
Parsa
Sindhuli
Bara
Sarlahi
Madesh
Rautahat
Mahottari
Dhanusha
Khotang
Bhojpur
Terhathum
Panchthar
Udayapur
Dhankuta
Ilam
Siraha
Saptari
Sunsari
Morang
Japa





Legend

Density(culms/hectare)

- 0-50
- 50-100
- 100-200
- 200-400
- > 400

0 50 100 200 km

Density Map of *Bambusa nepalensis* (Khasre Bans)

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

Humla
Darchula
Bajhang
Baitadi
Bajura
Mugu
Sudurpashchim
Dadeldhura
Doti
Achham
Kalikot
Jumla
Dolpa
Karnali
Mustang
Kanchanpur
Dailekh
Jajarkot
Kailali
Rukum west
Rukum_e
Surkhet
Manang
Myagdi
Gandaki
Bardiya
Salyan
Baglung
Kaski
Gorkha
Rolpa
Parbat
Lamjung
Pyuthan
Gulmi
Rasuwa
Banke
Syangja
Bagmati
Dang
Lumbini
Tanahu
Dhading
Nuwakot
Sindhupalchok
Arghakhanchi
Palpa
Dolakha
Nawalparasi_e
Solukhumbu
Kapilbastu
Chitawan
Sankhuwasabha
Taplejung
Rupandehi
Nawalparasi_w
Makawanpur
Lalitpur
Kabhrepalanchok
Ramechhap
Koshi
Parsa
Okhaldhunga
Sindhuli
Khotang
Bhojpur
Terhathum
Panchthar
Bara
Sarlahi
Madesh
Dhankuta
Ilam
Rautahat
Mahottari
Udayapur
Dhanusha
Siraha
Sunsari
Morang
Saptari
Japa

Rasuwa
Nuwakot
Sindhupalchok
Dhading
Kathmandu
Bhaktapur
Kabhrepalanchok
Lalitpur
Ramechhap

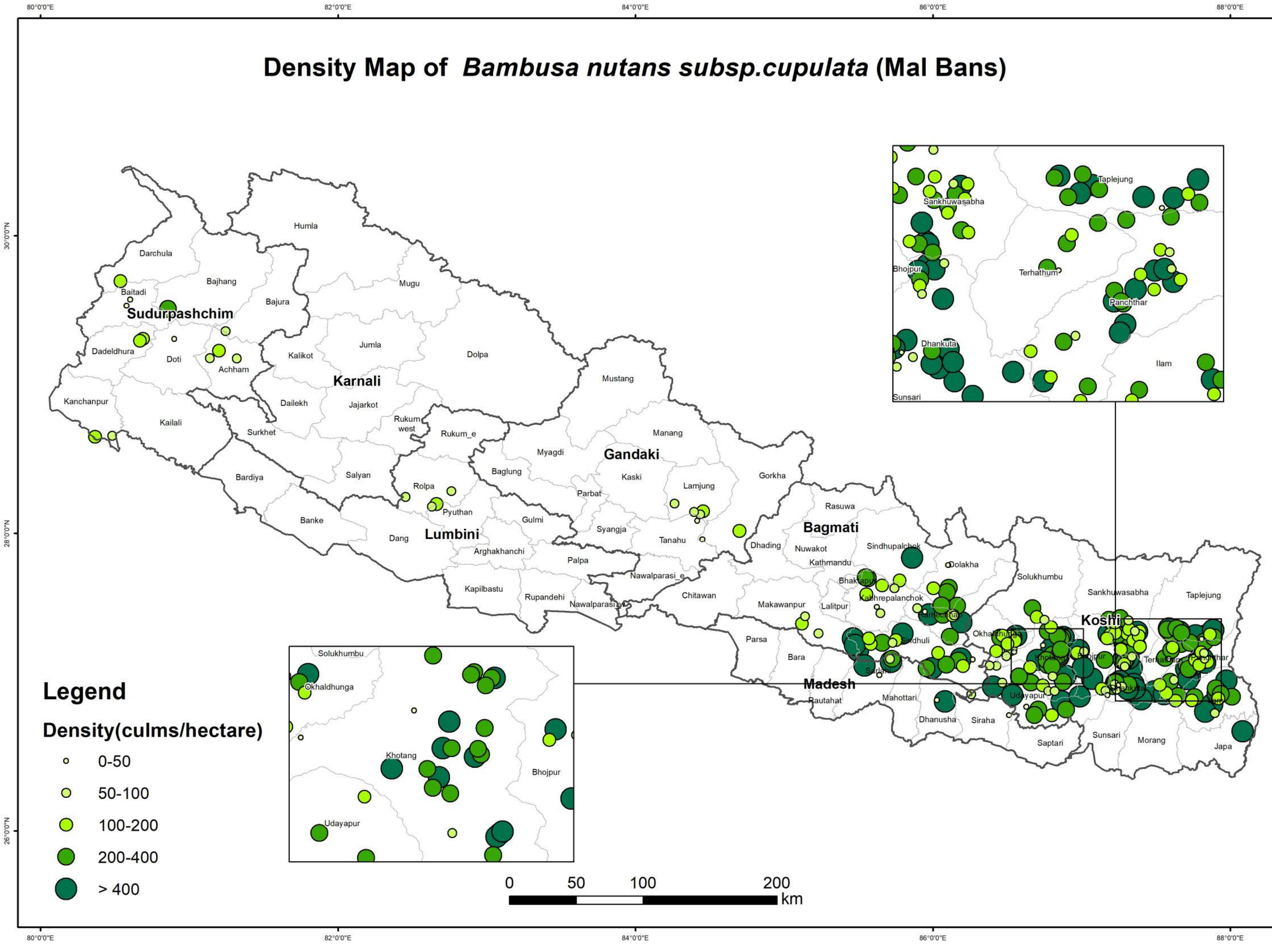
Legend

Density(culms/hectare)

- 0-50
- 50-100
- 100-200
- 200-400
- > 400

0 50 100 200 km

Density Map of *Bambusa nutans subsp.cupulata* (Mal Bans)

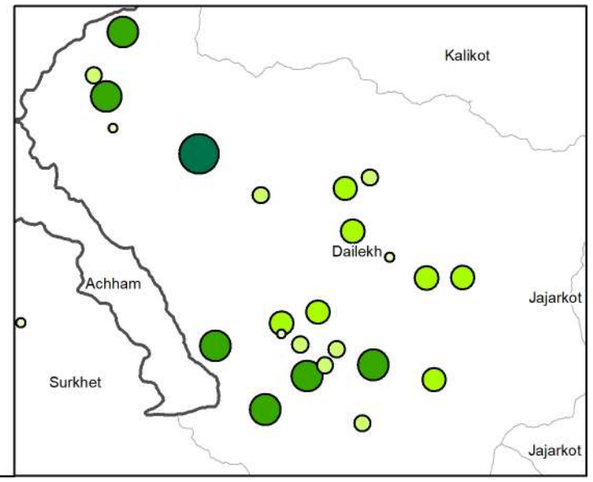


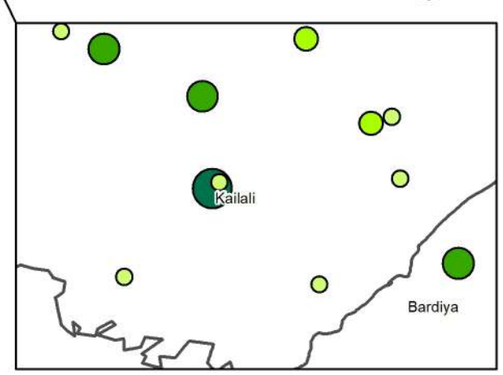
Density Map of *Bambusa nutans subsp.nutans* (Taru Bans)

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

Humla
Darchula
Bajhang
Baitadi
Bajura
Mugu
Sudurpashchim
Dadeldhura
Doti
Kalikot
Jumla
Dolpa
Achham
Karnali
Mustang
Kanchanpur
Kailali
Surkhet
Jajarkot
Rukum west
Rukum_e
Manang
Myagdi
Gandaki
Salyan
Baglung
Kaski
Gorkha
Bardiya
Rolpa
Parbat
Lamjung
Rasuwa
Pyuthan
Banke
Gulmi
Syangja
Tanahu
Lumbini
Bagmati
Arghakhanchi
Palpa
Nawalparasi_e
Sindhupalchok
Dolakha
Kapilbastu
Rupandehi
Nawalparasi_w
Chitawan
Makawanpur
Lalitpur
Kabhrepalanchok
Ramechhap
Solukhumbu
Sankhuwasabha
Taplejung
Koshi
Okhaldhunga
Parsa
Bara
Sarlahi
Sindhuli
Khotang
Bhojpur
Terhathum
Panchthar
Madesh
Rautahat
Mahottari
Udayapur
Dhankuta
Ilam
Dhanusha
Siraha
Saptari
Sunsari
Morang
Japa





Legend

Density(culms/hectare)

- 0-50
- 50-100
- 100-200
- 200-400
- > 400

0 50 100 200 km

Density Map of *Bambusa tulda* (Jhapta Bans)

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

Humla
Darchula
Bajhang
Baitadi
Bajura
Mugu
Sudurpashchim
Dadeldhura
Doti
Achham
Kalikot
Jumla
Dolpa
Karnali
Kanchanpur
Kailali
Surkhet
Dailekh
Jajarkot
Rukum west
Rukum_e
Mustang
Manang
Myagdi
Gandaki
Bardiya
Salyan
Rolpa
Baglung
Kaski
Lamjung
Gorkha
Parbat
Pyuthan
Gulmi
Banke
Dang
Lumbini
Syangja
Tanahu
Arghakhanchi
Palpa
Nawalparasi_e
Kapilbastu
Rupandehi
Nawalparasi_w
Chitawan
Rasuwa
Bagmati
Dhading
Nuwakot
Sindhupalchok
Kathmandu
Dolakha
Bhaktapur
Solukhumbu
Kabhrepalanchok
Makawanpur
Lalitpur
Ramechhap
Sankhuwasabha
Taplejung
Koshi
Okhaldhunga
Parsa
Sindhuli
Khotang
Bhojpur
Terhathum
Panchthar
Bara
Sarlahi
Madesh
Rautahat
Mahottari
Udayapur
Dhankuta
Ilam
Dhanusha
Siraha
Saptari
Sunsari
Morang
Japa

Legend

Density(culms/hectare)

- 0-50
- 50-100
- 100-200
- 200-400
- > 400

0 50 100 200 km

Density Map of *Dendrocalamus hamiltonii* (Tama Bans)

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

Humla
Darchula
Bajhang
Baitadi
Bajura
Mugu
Sudurpashchim
Dadeldhura
Doti
Achham
Kalikot
Jumla
Dolpa
Karnali
Kanchanpur
Kailali
Dailekh
Jajarkot
Surkhet
Rukum west
Rukum_e
Mustang
Manang
Myagdi
Gandaki
Baglung
Parbat
Kaski
Lamjung
Gorkha
Bardiya
Salyan
Rolpa
Pyuthan
Banke
Gulmi
Syangja
Tanahu
Dang
Lumbini
Arghakhanchi
Palpa
Rasuwa
Bagmati
Dhading
Nuwakot
Kathmandu
Bhaktapur
Sindhupalchok
Dolakha
Solukhumbu
Sankhuwasabha
Taplejung
Nawalparasi_e
Kapilbastu
Rupandehi
Nawalparasi_w
Chitawan
Makawanpur
Lalitpur
Kabhrepalanchok
Ramechhap
Koshi
Okhaldhunga
Sindhuli
Parsa
Bara
Sarlahi
Madesh
Rautahat
Mahottari
Khotang
Bhojpur
Terhathum
Panchthar
Udayapur
Dhankuta
Ilam
Dhanusha
Siraha
Saptari
Sunsari
Morang
Japa

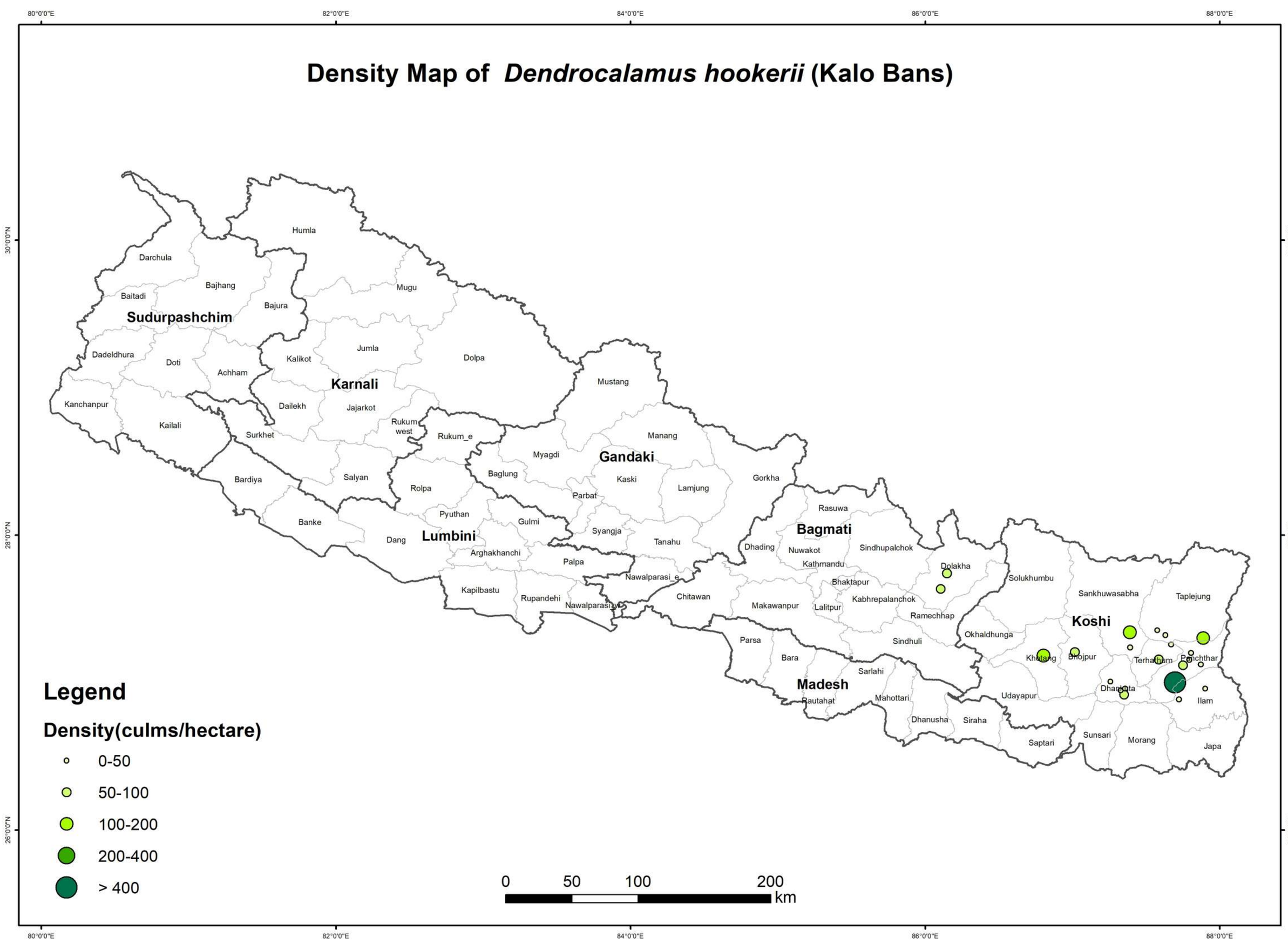
Legend

Density(culms/hectare)

- 0-50
- 50-100
- 100-200
- 200-400
- > 400

0 50 100 200 km

Density Map of *Dendrocalamus hookerii* (Kalo Bans)



Density Map of *Dendrocalamus strictus* (Katha Bans)

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

Humla
Darchula
Bajhang
Baitadi
Bajura
Mugu
Sudurpashchim
Dadeldhura
Doti
Achham
Kalikot
Jumla
Dolpa
Karnali
Kanchanpur
Kailali
Dailekh
Jajarkot
Rukum west
Rukum_e
Mustang
Surkhet
Manang
Myagdi
Gandaki
Baglung
Kaski
Gorkha
Bardiya
Salyan
Rolpa
Parbat
Lamjung
Rasuwa
Pyuthan
Gulmi
Banke
Dang
Lumbini
Syangja
Tanahu
Bagmati
Dhading
Nuwakot
Sindhupalchok
Arghakhanchi
Palpa
Kathmandu
Dolakha
Nawalparasi_e
Bhaktapur
Solukhumbu
Kapilbastu
Rupandehi
Nawalparasi_w
Chitawan
Kabhrepalanchok
Sankhuwasabha
Taplejung
Makawanpur
Lalitpur
Ramechhap
Koshi
Okhaldhunga
Parsa
Sindhuli
Bara
Khotang
Bhojpur
Terhathum
Panchthar
Sarlahi
Madesh
Dhankuta
Rautahat
Mahottari
Udayapur
Ilam
Dhanusha
Siraha
Sunsari
Morang
Saptari
Japa

Legend

Density(culms/hectare)

- 0-50
- 50-100
- 100-200
- 200-400
- > 400

0 50 100 200 km

Density Map of *Dendrocalamus* species (Dhungre Bans)

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

Humla
Darchula
Bajhang
Baitadi
Bajura
Mugu
Sudurpashchim
Dadeldhura
Doti
Achham
Kalikot
Jumla
Dolpa
Karnali
Kanchanpur
Kailali
Surkhet
Dailekh
Jajarkot
Rukum west
Rukum_e
Mustang
Manang
Myagdi
Gandaki
Bardiya
Salyan
Rolpa
Baglung
Kaski
Lamjung
Gorkha
Parbat
Pyuthan
Gulmi
Syangja
Tanahu
Banke
Dang
Lumbini
Arghakhanchi
Palpa
Nawalparasi_e
Kapilbastu
Rupandehi
Nawalparasi_w
Chitawan
Rasuwa
Bagmati
Dhading
Nuwakot
Sindhupalchok
Kathmandu
Dolakha
Bhaktapur
Kabhrepalanchok
Makawanpur
Lalitpur
Ramechhap
Solukhumbu
Sankhuwasabha
Taplejung
Koshi
Okhaldhunga
Parsa
Bara
Sarlahi
Sindhuli
Khotang
Bhojpur
Terhathum
Panchthar
Dhankuta
Ilam
Madesh
Rautahat
Mahottari
Udayapur
Dhanusha
Siraha
Saptari
Sunsari
Morang
Japa

Legend

Density(culms/hectare)

- 0-50
- 50-100
- 100-200
- 200-400
- > 400

0 50 100 200 km

Density Map of *Bambusa bambos* (Kande Bans)

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

Humla
Darchula
Bajhang
Baitadi
Bajura
Mugu
Sudurpashchim
Dadeldhura
Doti
Achham
Kalikot
Jumla
Dolpa
Karnali
Mustang
Kanchanpur
Kailali
Dailekh
Jajarkot
Rukum west
Rukum_e
Surkhet
Manang
Myagdi
Gandaki
Baglung
Kaski
Gorkha
Bardiya
Salyan
Rolpa
Parbat
Lamjung
Rasuwa
Pyuthan
Gulmi
Syangja
Tanahu
Bagmati
Banke
Dang
Lumbini
Arghakhanchi
Palpa
Dhading
Nuwakot
Sindhupalchok
Kathmandu
Dolakha
Nawalparasi_e
Bhaktapur
Solukhumbu
Kapilbastu
Rupandehi
Nawalparasi_w
Chitawan
Kabhrepalanchok
Sankhuwasabha
Taplejung
Makawanpur
Lalitpur
Ramechhap
Koshi
Okhaldhunga
Parsa
Sindhuli
Khotang
Bhojpur
Terhathum
Panchthar
Bara
Sarlahi
Madesh
Dhankuta
Rautahat
Mahottari
Udayapur
Ilam
Dhanusha
Siraha
Sunsari
Morang
Saptari
Japa

Legend

Density(culms/hectare)

- 0-50
- 50-100
- 100-200
- 200-400
- > 400

0 50 100 200 km

Density Map of *Bambusa alami* (Nigale Bans)