

# Distribution and availability of raw materials for production of Nepali handmade paper from *Daphne* species in Darchula district, Nepal

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The study, conducted in 2005 in Darchula district of the far western region of Nepal, aimed at assessing the distribution of Lokta plants (*Daphne* species) and the sustainable availability of their bark as a raw material for Nepali handmade paper. Stratified random sampling design was adopted for collecting primary data from 340 circular shaped sample plots. The study revealed asymmetric distribution and production of Lokta in different Range post areas of Darchula district. While the tree diameter at 30 cm from base ( $D_{30}$ ) varied from 1 to 18 cm, the maximum tree height varied from 2.1 to 6 m. On the basis of diameter class, about 87 % of the bark weight was found to be of exploitable category. For the entire district of Darchula, the annual yield of Lokta bark for six years rotation amounted only to about two-third of the four years rotation. The study concludes that the stock of Lokta bark that prevails in the district can sustain promotion of Nepali paper production enterprises.

**Key words:** Annual yield, Non Timber Forest Product, rotation, Range post, sustainable production

Non Timber Forest Products (NTFPs) have a pivotal role in the rural as well as national economic development of Nepal (MPFS, 1989; MoFSC, 2004; NPC, 2010). In the country, approximately 10.13 thousand tons of NTFPs was extracted contributing to revenue of NRs. 67.38 million in the Fiscal Year 2002/03 alone (DoF, 2004). Lokta (*Daphne bholua* and *D. papyracea*) constitute one of the principal species among the limited NTFPs identified and traded in Nepal. The species has also been identified by the Master Plan for the Forestry Sector (MPFS) as one of the seven minor forest products available in the country (MPFS, 1989).

The distribution of *Daphne bholua* extends from Uttar Pradesh in India, through Nepal, southern Tibet, northern Assam, Bengal, Sikkim and Bhutan to south-west China. It occurs between 1800 to 3600 m, and occasionally extends up to 4000 m. Similarly, the distribution of *D. papyracea* which extends from Pakistan to central Nepal occurs between 1600 m and 2500 m, and occasionally extends up to 3000 m (Jackson, 1987). In Nepal, Lokta is mainly used on a cottage industry scale

for manufacturing handmade papers. Harvesting of Lokta bark and manufacturing of local paper both provide opportunities for creating local employment, thereby, providing potentials for generating income to sustain livelihoods of the local people. Realizing these facts, both the government and non-government sectors in Nepal have long been pursuing to promote the sustainable management of Lokta resources in the country.

Resource assessment is one of the important components of all sustainable management endeavours (FAO, 2010). The assessment provides clues for careful management of natural resources which is highly needed for preventing the resources being exhausted from over-exploitation. Haphazard practices of using resources without carrying out proper resource inventory only lead to exhaustion of such resources. This has happened with the Lokta resources of Nepal, which have been exploited heavily without carrying out any resource inventories in the past. Without assessing the growing stock, growth and yield patterns,

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Lokta plants, were exploited heavily only to find latter that no more raw materials are available for sustainable operation of paper factories. In Nepal, many paper factories had to be closed due to the scarcity of Lokta barks which are primarily used as raw materials for the paper factories (ANSAB, 2004).

At present, only a few literatures on Lokta resource assessment and management are available (Pokharel, 1989; FRD, 1991; Jeanrenaud and Thompson, 1986). Moreover, most of such literatures remain case specific, focusing only on the matters of resource assessment and the methodologies.

Lokta resources exist in 24 of the total 41 Village Development Committees (VDCs) of Darchula district. The Lokta containing 24 VDCs (including community forests) lie in the northern and eastern parts of the district. Despite their great potential for generating income and employment, no resource assessment work has yet been carried out for Lokta resources in Darchula district. A study on distribution and availability of Lokta plant (*Daphne* spp.) in the district has thus become an imperative.

The study primarily aimed at assessing the distribution of *Daphne* species in Darchula district and sustainable availability of their bark as a raw material for Nepali handmade paper. Since the Range posts are the basic unit of forest management and administration, the study was focused in assessing the resources existed within the Range post boundaries. It is anticipated that the study will provide meaningful guidance for sustainable and wise use of Lokta resources for production of Nepali handmade paper enterprises in the district. This will help enhance local as well as the national economy of the country through creation of increasing income generation opportunities for the local population.

## Materials and methods

### Study site

Darchula district is located in the far western development region of Nepal. It covers an area of 2329.6 km<sup>2</sup> with wide range of altitudinal variation ranging from 357 to 7132 masl (MPRC, 2011). The

district headquarter is situated in North 29° 51' latitude and East 80° 34' longitude. The district enjoys subtropical climate in the south to alpine and tundra in the northern belt. The topographic conditions vary from Mid mountain in the south and middle part and to High Himalayas in the north. Of the total forest cover of 79,538 ha of the district, 20,064 ha have already been handed over to 226 Community Forest User Groups (CFUGs) (DFO Darchula, 2005). The district comprises eight Range posts. However the study area encompasses only six of them: Dethala, Joljibi, Khalanga, Khandeshwari, Khar and Rapla.

### Sampling design

Stratified random sampling technique was used to collect information on distribution of Lokta plant as well as on availability of bark materials for Nepali handmade paper in the district. Qualitative categories of Lokta plants were considered as strata for the resources survey. Based on area proportion, the total numbers of sample plots were distributed in each stratum of the Lokta forest. Using participatory process, high density, medium density and low density strata of Lokta distribution areas were traced out in the topographic map of the district.

Like in Baglung Lokta Inventory (Mathema, 1990), circular plots of 25 m<sup>2</sup> of 2.82 m radius were taken as sample plots for the measurement purposes. The first plot was laid out where the Lokta plant first appeared. The subsequent plots were established at 180° south at an interval of 100 m in each stratum. Isolated patches and blocks of Lokta plant were considered while allocating the sample plots. Altogether, 340 sample plots were laid out in all study area and allocated them in different strata based on proportion to area principle.

### Plot measurement

The measurement was carried out in 2005. Lokta plants smaller than 30 cm in height were considered as seedlings and as such, were only counted, without measuring. However, Lokta plants greater than 1 m in height were measured at diameter: 30 cm from the base ( $d_{30}$ ); for bark biomass estimation. The height of the plants and  $D_{30}$  were measured to precisions of  $\pm 0.1$  m and to  $\pm 0.1$  cm respectively. Randomly selected 20

plots were measured for bark biomass estimation. Out of 6 Range posts; 2 plots from Dethala, 1 from Joljibi, 6 from Khalanga, 3 from Khar and 8 from Rapla were taken for bark biomass assessment. The number of stems and bark weight per plot were estimated at first, and later, average figures were derived at per hectare level. Lokta plants greater than 3 cm  $D_{30}$  were included for the harvestable Lokta biomass estimation. Green weight of the bark was used to estimate the Lokta biomass.

#### Data analysis

At first, the compiled data were analyzed at plot level using the MS Excel software. Later on, per hectare figures were estimated using appropriate conversion.

### Results and discussion

#### Stem distribution and density of Lokta plant

Although, the participatory resource mapping phase had identified 7 Range posts and 24 VDCs as Lokta distribution areas, the sample survey during the field work could cover the data from 6 Range posts and 16 VDCs only. Stem distribution of Lokta in the studied Range posts is presented in table 1. The average number of stems per hectare was higher in Khar Range post and lower in Dethala. However, the total number of stems was found highest in Khandeswari Range post and lowest in Joljibi.

Stem density of Lokta by Range post was found to be significantly different at 5 % significance level ( $p = 2.13^{-06}$ ;  $df = 5$ ). The total number of stems in the studied areas was more than 12 million.

#### Stem distribution by diameter classes in Range post

In the study area, the diameter of the Lokta plants ranged from 1 cm to 18 cm with about 5.1 cm mean value. Distribution of Lokta plant was divided into four diameter classes: < 2 cm, 2 - 4 cm, 4 - 6 cm and > 6 cm. Stem densities greatly varied in different diameter classes. Stem density of < 2 cm diameter was found as less as only about 10 % of the total stems density. Whereas, stem density of diameter classes between 2 - 4 and 4 - 6 cm were found almost equal representing about 31 % of the total density by each one. Table 2 depicts the stem density distribution by Range post and different diameter classes in the study area.

Table 2 clearly indicates that the Lokta distribution was highly dominated by bigger size diameter plants. There is a significant difference in the average density of Lokta by diameter classes ( $\alpha = 0.05$ ,  $p = 2.6^{-11}$ ). Table 3 presents stem distribution of Lokta plant on the basis of exploitable and non-exploitable diameter sizes.

**Table 1: Stem distribution by Range posts**

Range post	Lokta distribution area (ha)	No. of Sample plot	Average stems/ha	Total stems in 000 unit
Dethala	862.5	34	376	325
Joljibi	325.0	12	933	303
Khalanga	3475.0	85	767	2666
Khandeswori	5087.5	36	978	4974
Khar	2575.0	99	1026	2643
Rapla	2300.0	74	741	1703
Total/average	14625.0	340	826	12614

Table 2: Stem distribution of Lokta plant by Range post and diameter classes

Range post	Per hectare stem density by diameter classes				Average
	< 2 cm	2-4 cm	4 - 6 cm	6 cm	
Dethala	12	176	165	24	376
Joljibi	0	400	367	167	933
Khalanga	339	395	33	0	767
Khandeswori	0	0	78	900	978
Khar	8	327	493	198	1026
Rapla	0	157	319	265	741
Average/ total	88	260	259	219	826

Table 3: Stem distribution by exploitable and non-exploitable diameter classes

Range posts	Distribution per ha		Distribution in range post in 000 unit	
	< = 3 cm	> 3 cm	< = 3 cm	> 3 cm
Dethala	47	329	41	284
Joljibi	133	800	43	260
Khalanga	635	132	2208	458
Khandeswari	0	978	0	4974
Khar	105	921	271	2372
Rapla	38	703	87	1616
Total/average	207	619	2649	9965

Acknowledging Mathema (1990), who has advised not to harvest Lokta plant with diameter of < 3 cm at  $D_{30}$ , this study considered  $D_{30} > 3$  cm as exploitable size for Lokta. Per hectare stem distribution and total number of stem distribution in all the range posts covered by the study are presented in Table 3. It is evident from Table 3 that per hectare wise, Khandeswari Range post contained highest number of stems > 3 cm. Similarly, Khalanga Range post contained lowest number of stems with such sizes. Stems of exploitable size were found in maximum number in Khandeswari Range post and in minimum number in Joljibi Range post. Density wise, large sized Lokta stems (exploitable size) is highest in Khandeswari and smaller size Lokta plants are highest in Khalanga. Table 3 also shows that more than three-fourth (about 79 %) of the total stems bear exploitable sizes.

#### Stem distribution by height classes

In the past, it was a tradition to consider all stems > 2 m in height as exploitable size. However, this study has considered two categories of height: small (< 1.5 m) and tall (> 2 m). The reason for this is based on the flowering height and the age. Lokta plants flower when it reaches about a height of 1.5 m in about 7 years of time (NCFP, 1994). The height category wise number of stems per hectare as well as the number of stems present in Range posts covered by the study is given in table 4. Per hectare wise, the Khar Range post has the largest and Khalanga Range post, the lowest number of taller stems. Altogether, 7.7 million taller category stems, with highest number in Khandeswari and lowest number in Joljibi Range were found in all Range posts covered by the study.

Table 4: Stem distribution by Range post and height classes

Range posts	Stems/ha		Stems in Range post in 000	
	< = 1.5 m	> 1.5 m	< = 1.5 m	> 1.5 m
Dethala	82	294	71	254
Joljibi	367	567	119	184
Khalanga	659	108	2289	376
Khandeswori	278	700	1413	3561
Khar	162	865	416	2226
Rapla	249	492	572	1131
Average/ total	316	509	4881	7733

The number of tall size stems is relatively less than that of big size stems (table 3). The share of tall and small size stems is about 61 % and 39 % respectively.

#### Biomass of Lokta bark

The average weight of the Lokta bark by diameter classes is given in table 5. The bark weight of an average stem was found to be about 112 grams. Similarly, per hectare bark weight at district level was found to be equivalent to about 110 kg. A total of 1609 tons of Lokta bark has been estimated for the entire areas covered by the study.

FSRO (1984) had estimated the Lokta bark in five development regions of the country and found out less stocking in lower elevation (5000-7500 ft) and higher stocking in upper elevation (7500 – 10000 ft). The highest stocking was about 313 kg per hectare in the upper elevation of eastern development region and lowest was about 0.268 kg per hectare in lower elevation of central development region. While the growing stock of Lokta bark in the far-western development region was just about 25 kg per hectare in upper elevation and about 11 kg

in lower elevation. But the study had remarked in its finding that per hectare figure may not be applicable for small areas due to very broad nature of survey.

About half of the total bark from a randomly selected Lokta distribution area comes from > 6 cm diameter class. Around 30 % of the bark may come from 2- 4 cm diameter class followed by 4- 6 cm diameter class and < 2 cm diameter class. There is highly significant difference in the mean per hectare bark biomass of different diameter classes in the district ( $\alpha = 0.05$ ,  $p = 7.8^{-6}$ ).

#### Exploitable bark biomass

It would be convenient for managers if the total Lokta bark is separated into exploitable and non-exploitable categories. Lokta stems with more than 3 cm were considered as exploitable size in this study. In the earlier practices, the stems with more than 2 m in height were considered as exploitable size (FS, 1983). The exploitable and non-exploitable bark biomass of Lokta plant in all studied Range posts is given in table 6.

Table 5: Biomass stock of Lokta bark

Dia. Classes	Average bark biomass		Total weight in District (tons)
	Per ha (kg)	Per stem (gram)	
< = 2 cm	6.1	43.9	89.8
2 - 4 cm	31.6	65.8	461.9
4 - 6 cm	16.9	120.7	247.2
> 6 cm	55.4	251.8	810.2
<b>Average/total</b>	<b>110.0</b>	<b>112.3</b>	<b>1609.0</b>

Table 6: Bark biomass of Lokta plant by stem sizes

Range post	Area (ha)	Bark biomass (tons)		Total bark biomass (tons)
		Non exploitable size	Exploitable size	
Dethala	862.5	17.5	77.4	94.9
Joljibi	325.0	6.6	29.2	35.8
Khalanga	3475.0	70.4	311.9	382.3
Khandeswari	5087.5	103.1	456.7	559.7
Khar	2575.0	52.2	231.1	283.3
Rapla	2300.0	46.6	206.4	253.0
Grand total	14625.0	296.3	1312.7	1609.0

The per hectare average bark biomass of non-exploitable and exploitable categories were about 20 kg and 90 kg respectively, amounting to about 110 kg per hectare at district level. The total bark biomass from exploitable size of Lokta stem was found higher in Khandeswari Range post and lower in Joljibi (Table 6).

#### Estimation of annual production

Two types of rotations: four years and six years, have generally been recommended for Lokta bark harvesting (Mathema, 1990; FSRO, 1984; FS, 1983). A minimum of four years rotation should be maintained to provide minimum regeneration period for establishment. Six years rotation ensures more sustainable production of Lokta bark compared to four years rotation. The total production of the Lokta bark from the exploitable

Annual production is based on per hectare annual yields of Lokta bark which is about 22 kg in four years rotation period and 15 kg in six years rotation period. About 87% of the bark weight was found in exploitable category on the basis of diameter class. The annual yield of Lokta bark from six years rotation for the whole district is only about two-third of the four years rotation.

#### Conclusion

The distribution of *Daphne* spp. varies greatly by Range posts in Darchula district, both in terms of per hectare and total stems. The per hectare average bark biomass from exploitable stem category was about 90 kg at district level which is about 87 % of the total bark biomass. The annual yield of Lokta bark from six years rotation is about 15 kg per hectare for the whole district which is only about two-third of the four years rotation. Nepali handmade paper production

Table 7: Annual production of Lokta bark based on 4 and 6 years rotation

Range post	Area (ha)	Annual production (tons)	
		4 years	6 years
Dethala	862.5	19.4	12.9
Joljibi	325.0	7.3	4.9
Khalanga	3475.0	78.0	52.0
Khandeswari	5087.5	114.2	76.1
Khar	2575.0	57.8	38.5
Rapla	2300.0	51.6	34.4
Grand total	14625.0	328.2	218.8

size of the stem based on diameter classes for four years and six years rotations are presented in table 7.

enterprises can be developed in Darchula district from annual yield production based on six years rotation which might support the livelihood and income level of the rural people in the district.

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## References

- ANSAB. 2004. **Non Timber Forest Products in Newspaper (In Nepali)**. Asia Network for Sustainable Agriculture and Bioresources (ANSAB), Kathmandu, Nepal.
- DFO Darchula. 2005. District Forest Office, Darchula district, Khalanga, Nepal.
- DoF. 2004. **Hamro Ban (In Nepali)**. Department of Forests. Kathmandu, Nepal.
- FAO. 2010. **Global Forest Resource Assessment**. United Nations Food and Agricultural Organization. Rome, Italy.
- FRD, 1991. Annual Report 1990/91. Nepal-UK Forestry Research Project. Kathmandu, Nepal.
- FS. 1983. **Forest Management Plan for Sustainable Production and Utilization of Lokta Biomass in Hatia Range Post**, Baglung district, Nepal.
- FSRO, 1984. **Preliminary Survey Report of Lokta Vegetation**. Publication No. 41. Forest Survey and Research Office, Kathmandu, Nepal.
- Jackson, J. K. 1987. **Manual of Afforestation in Nepal**. 2nd edition. Forest Research and Survey Centre, Kathmandu, Nepal.
- Jeanrenaud J. P. and Thompson, I. J. 1986. *Daphne* (Lokta), bark biomass production: management implications for paper making in Nepal. *Commonwealth Forestry Review* 65 (2): 117-130.
- Mathema, P. 1990. **Baglung Lokta Inventory Report**. Forestry Research Division. Forest Research and Survey Centre, Kathmandu, Nepal.
- MoFSC. 2004. Herbs and Non Timber Forest Products Development Policy. Ministry of Forests and Soil Conservation. Government of Nepal, Kathmandu, Nepal.
- MPFS. 1989. **Master Plan for the Forestry Sector**. HMG/ ADB/ FINNIDA, Kathmandu, Nepal.
- MPRC. 2011. **District Development Profile of Nepal (2010/11): A Socio-economic database of Nepal**. Mega Publication and Research Centre, Kathmandu, Nepal.
- NCFP. 1994. **Lokta (*Daphne* Species): The Supply Situation in Basantapur Area**. Nepal-UK Community Forestry Project. Kathmandu, Nepal.
- NPC. 2010. **Three Years Plan (2010-2013)**. National Planning Commission. Government of Nepal. Kathmandu, Nepal.
- Pokharel, R. K. 1989. Production of hand-made paper from Lokta in Sankhuwasabha. *Banko Janakari* 2 (2): 145-148.