Growth Performances and Growing Stock of Rattan in the Community Managed Forests of Nepal

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ABSTRACT

Calamus tenuis Roxb, the economically potential rattan species, has been increasing in the community managed forests. Quantitative and qualitative information was collected in 2016 and 2017. The research was carried out in 20 Community Forest User Groups of Kailali and Bardiya district. Growing stock was measured using stratified random sampling in the community forests, followed by socio-economic information through semi-structured questionnaire to 526 respondentsincluding focus group discussions with executive member of community forest user groups. The study found that average growth of *Calamus tenuis* in the community forests was 0.85 cms per year, the maximum growth attained up to 2.5 meter per year if they get associated trees to climb on. It' is a clumpy palm, producing 3-7 rhizomes in one year and reaches up to 25 rhizomes in 3-4 years period. There are 15 to 25percent immature culms in a clump with estimate the number of clumps per hectare in managed rattan forest are 200 to 500. Growing stock is estimated from 38,860 to 39,560 per hectare in the community forest comprising about 57 percent large size, 19 percent medium size and 24percent regeneration. The mean length was measured 5.80 meter and mean diameter 9.29 mm. Weight difference of rattan with and without leaf sheath is 25 percent, reduction in oven dry weight is 75.9 percent, and air dry weight is 32 percent. More than 20 CFUGs have produced natural rattan in the community forests of Kailali and Bardiya districts. By the number of CFUGs, Bardiya district has more than 19 CFUGs and Kailali district has one CFUG managing natural rattan. Total estimated production of rattan in both districts is over 250 metric ton. Harvesting is restricted due to limitation of provision of Initial Environment Examination (IEE). According to these conditions, CFUGs should have get approval the detail IEE. None of the CFUGS have prepared the IEE. In such a condition, CFUGs can only harvest less than five quintal (5000 kg) rattan as per approved FOP. The study concludes that despite site quality remains constant, the associated tree species to climb them are encouraging factor. Detail growing stock needs to be incorporated in the rattan management plan / forest operational plan to mainstream in the process.

KEYWORDS

INTRODUCTION

Calamus tenuis Roxb is economically potential Non-Timber Forest Products (NTFPs) in Nepal, distributed in tropical forest an altitudinal range from 75 to 500 meter. It belongs to *Lepidocaryoidae*, a large group of the palm family. *Calamus tenuis Roxb, has* protected mostly in community forests (Chowdhary & Paudel, 2008). About 90 percent of the production of cane comes from natural forests and the rest from plantations being raised by most of the major producing countries (Iqbal, 1993; Manokaran, 1990; Pabuayon, 2000; Sastry, 2002). Despite its immense commercial significance, rattan faces difficulties and uncertainties inherent in ascertaining sustainable extraction level and impacts associated with harvesting (Siebert, 2002).

Rattan is collected almost exclusively from wild population and market demand for rattan cane is strong (Dransfield & Manokaran, 1993) and the majority is gathered from forests in which management has been largely absent or ineffective Barry *et al* (2003).*Calamus tenuis* including other NTFPs are planted for commercial purposes (K.Sengdala & Evans, 2002). The study carried out in Bangladesh shows that the maximum stem length of *Calamus tenuis*was recorded 21.15m (Islam S. A., Miah, Habib, & Rasul, 2015). According to research studies and observation carried out in the Philippines the cane grows at the average rate of 0.70 meter per year (IIRR, 1992). A similar study carried out in China by Yang et al (ND) also showed that some medium-diameter species, such as *Daemonorops margarita* and *Calamus simplicifolius*, growing fast with annual increment of 1.0-1.5 m and continue to keep these vigorous trends for 2 to 3 years or more after reaching technical maturation. Sunderland and Drandfield (2000)reported that rattans are vigorous climbers with relatively high growth rate. Sukla (2015)also concluded that growth of *Calamus tenuis* in Meerut areas was 1.95m.

*Calamus tenuis*is a clumpy palm. It produces 3-7 rhizomes in one year and increase up to 25 rhizomes in 3-4 years period. There are 15 to 25percent immature culms in a clump with estimate the number of clumps per hectare in managed rattan forest are 200 to 500. Growing stock was estimated from 38,860 to 39,560 per hectare in the community managed forest comprising about 57 percent large size, 19percent medium size and about 24 percent regeneration. The mean length was measured 5.80 meter and mean diameter 9.29 mm.

Growth performance of *Calamus tenuis* in community forests of Sati Community Forest of Kailali, Shiva Community Forest and Sarswoti Community Forest of Bardiya districts are 1.28 meter, 0.63 meter and 0.65 meter, respectively. Average growth of *Calamus tenuis* in community forests was 0.85 meter per year, the maximum growth attained up to 2.5 meter per year if they get associated trees to climb on. Weight of rattan varied with leaf sheath, oven dry weight, and air dry weight. Total estimated production of rattan in both districts is over 250 metric ton. However, more CFUGs are waiting for Initial Environment Examination (IEE) report to overcome this restriction.

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METHODOLOGY

The study was carried out in the community forests of Kailali and Bardiya districts. Sampling size was determined from the total availability of rattan in community forests. Sampling design was ascertained based on certain criterions such as community forestry user groups leading to manage rattan, handed over community forest, harvested rattan in the previous years, and approved Forest Operational Plan (FOP). By number of forest, out of 20 community forests having rattan available, 10 community forests were sampled. The study was based on the study conducted in community forest user groups (CFUG) of Kailali and Bardiya districts which are located in the far and mid-west Terai of Nepal, there was 10 to 15 number of sampling plots selected for pilot sampling. The questionnaire survey was conducted to 526 respondents in 10 Community Forest User Group members to access socio-economic and management information. Sampling size were selected using Yamane formula (for finite population), the confidence level for this purpose is 95% at p =0.05. Quantitative data of the growing stock was collected using stratified random sampling in 10 m x10 m sampling plot, oven dry weight was measured in laboratory of Department of Forest Research and Survey, air dry weight was measured in the field. Current Annual Increment (CAI) and Mean Annual Increment (MAI) was estimated referring growth of stem in a periodic time interval and MAI with the average mean annual increment using (Chapman, 1921). MAI was calculated using (Husch, Miller, & Beers, 1982). The length and diameter of stems was taken above 15.24 cm from the ground level. The quantitative data was analyzed using SPSS 20 and Microsoft Excel analysis software tools. Qualitative data was analyzed using descriptive method and narratives were presented in relevant to contents.
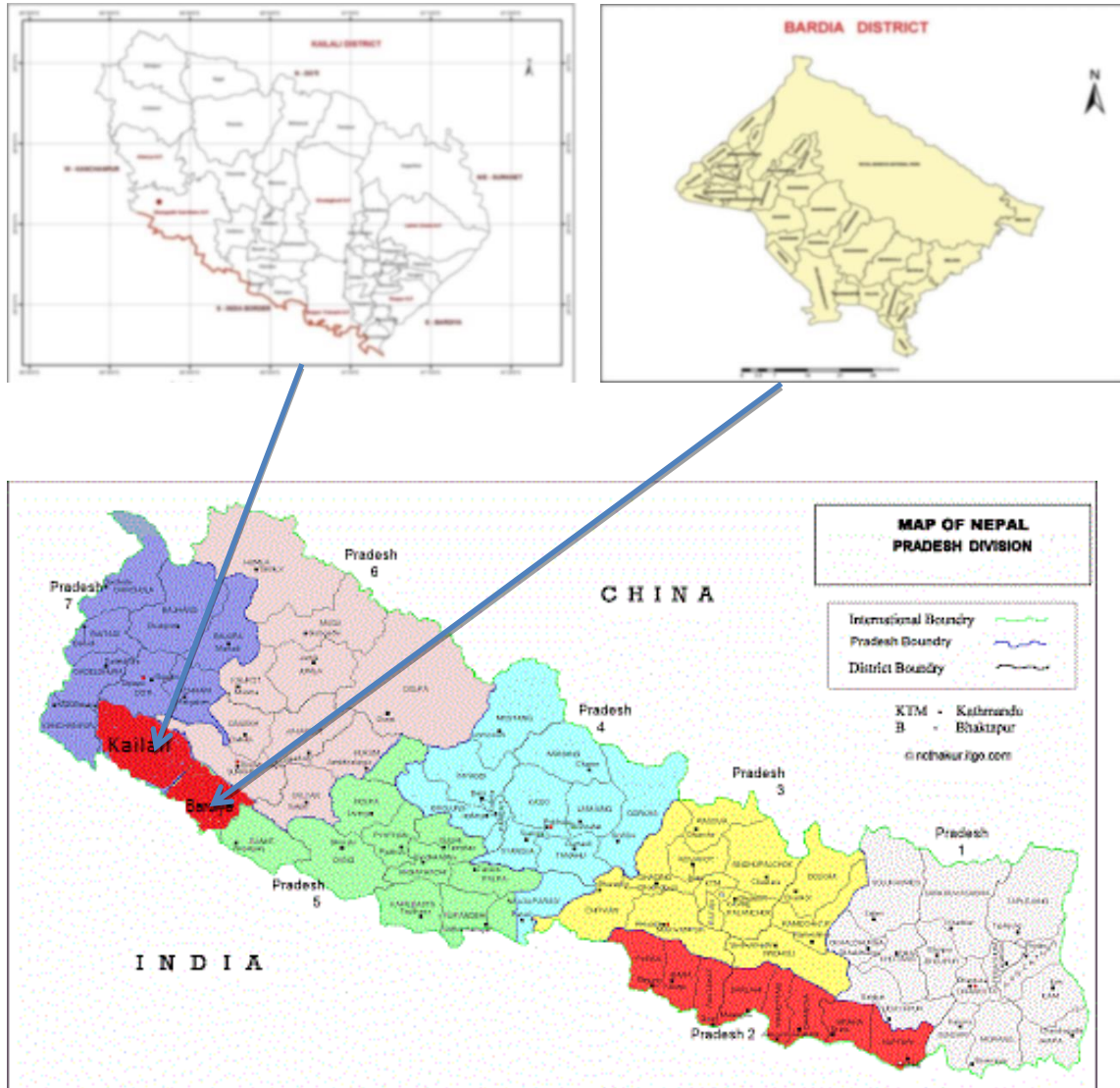
Figure 1: Map of study area- Kailali and Bardiya district

RESULTS

Development of seedling

A study on germination and growth of seeding was carried out in rattan. For this experiment, 100 seeds of *Calamus acanthospathus* and 48 seeds of *Calamus leptospadix* were tested in two nurseries – Sati Karnali Community Forest of Kailali (165 meter) and Salyan (1550 meter). Kailali has tropical climate whereas Salyan has sub-tropical climate. Seeds were collected from Asam India. It was sown in the nursery after 20 days of seed collection. The combined result showed the 75.7% germination (Table 1).

Table 1: Germination and growth of rattan seedling

Number of days	Number of seeds germinated	%	Average Height (cm)
75	81	54.7	3.7
91	98	66.2	4.5
107	104	70.7	5.9
123	112	75.7	8.4

Maximum germination was occurred between 60 to 80 days, and continued up to 117 days. Germination was 100 percent in *Calamus acanthospathus* and 64 percent in *Calamus leptospadix*. Similarly, survival percent was studied in the community nursery of Sati Karnali Community Forest User Group, Kailali. Seeds of *Calamus tenuis* was taken 2100, *Calamus latifolius* 150 and *Calamus acanthospathus* 350. *Calamus tenuis* was collected from local Community Forests, *Calamus latifolius* and *Calamus acanthospathus* was brought from Asam India (Table 2).

Table 2: Comparative survival of seedling (in percent)

Month	*Calamus tenuis*		*Calamuslatifolius*		*Calamus acanthospathus*	
	Numberof seedling	Survival percent	Number of seedling	Survival percent	Number of seedling	Survival percent
4	2100	84.3	150	36.8	350	58.3
5	1500	60.	135	33.1	197	32.8

The combined performance of all the three species was 30.2 percent after 60 days, whereas species wise result shows that *Calamus tenuis* 40.2 per cent, *Calamus acanthospathus* 20.4 per cent and *Calamus latifolius*30 per cent germination. Seed germination was taken place from 21 days. Survival percent of seedling was recorded in 4th and 5th month. The result shows that survival percent was higher in *Calamuss tenuis* up to 4th month in Kailali and then decreased, whereas less in *Calamus acanthospathus*.

Growth of rattan

Average growth performance of *Calamus tenuis*in community forests is 0.85 meter per year. However, specific to community forest of Sati Karnali Community Forest of Kailali, Shiva Community Forest and Sarswoti Community Forest of Bardiya districts are 1.28 meter, 0.63 meter and 0.65 meter per year, respectively, and maximum growth was recorded 2.5 meter per year particularly when they were supported by trees to climb on them.

Growing stock

Calamus tenuis is a clumpy palm. It produces 3-7 rhizomes in one year and increase up to 2 rhizomes in 3-4 years period. Clumps are heterogeneous in natural condition. Distance between clumps to clump is 0.58 m to 2.06 m. There are 15 to 25 percent immature culms in a clump. Number of clumps per hectare in the managed rattan forest has 200 to 500.

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Average number of rattan cane in Sati Karnali Community Forest of Kailali, Shiva Community Forests and Sarswoti Community Forests of Bardiya were found 4 in per square meter. Mean diameter is 9.28 mm. specifically; mean diameter of Shiva, Sati Karnali and Sarswoti community forests is 9.39 mm, 8.77 mm and 9.7 mm (Table 3). The estimation shows that there are no more differences in growing stock in per square meter in them.

Table 3: Growing stock of rattan in Sati Karnali, Shiva and Sarswoti Community Forests

Parameters	Shiva	Sati	Sarswoti
Area of plot (m^2)	1000	1000	1000
No of large cane	2200	2044	2256
No of medium cane	554	967	528
No of small cane	866	945	854
Av no/ m2	3.886	3.956	3.892
Av no/ ha	38860	39560	38920
Total length m. (100 samples)	585.15	547.00	668.00
Mean	22.19	18.6	22.71
Diameter	939	877	970
Mean	9.39	8.77	9.7

Field survey 2016

Stem length, minimum and maximum diameter and standard error

The stem length, minimum and maximum diameter and standard error of rattan in Sati Karnali Community Forest shows that average length of rattan cane in six years period was 6.4 meter, where minimum and maximum length were 3.9 meter and 8.3 meter, and average minimum and maximum diameter over leaf sheath were 3.4 cm and 4.4 cm (average diameter 3.9 cm).The measurement of length and diameter of culms in plot 1 to 8 is presented in Table 4 and 5. The community forest was divided into 8 plots for management purpose.

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Table 4: Average lengths, minimum and maximum length and standard error

Plots no	Average length (m)	Standard error	Minimum length (m)	Maximum length (m)
1	8.3	0.27	1.5	20.4
2	6.4	0.25	1.4	15.7
3	5.4	0.18	1.1	11.9
4	6.7	0.14	1.3	22.5
5	8.2	0..28	1.4	22.5
6	5.4	0.17	1.1	17.1
7	3.9	0.13	1.1	9.2
8	6.5	0.24	1.4	17.1
Plot 1-8	6.4	0.50	3.9	8.3

Source: Thapa et al, 2001, Chowdhary and Paudel 2008, updated field data in 2017)

Table 5: Average diameters, minimum and maximum diameter and standard error

Plot no.	Av. Diameter (cm)	Standard error	Minimum error (cm)	Maximum diameter (cm)
1	3.5	0.07	2	6
2	4.1	0.09	2	6
3	4.2	0.08	2	6
4	3.7	0.05	2	6
5	3.4	0.07	2	6
6	4.0	0.06	2	6
7	4.4	0.08	2	6
8	3.8	0.08	2	6
Plot 1 to 8	3.9	0.10	3.4	4.4

Thapa et al, 2001 and Chowdhary and Paudel 2008, updated field data in 2017)

Green and Dry weight of rattan cane

Green weight and dry weight of rattan cane was estimated in major three community forests of Kailali and Bardiya district. According to Paudel and Chowdhary (2005) green weight of rattan with leaf sheath is 1.24 kg per rattan cane height of 6 meter. Weight difference of rattan with and without leaf sheath is 25%. However, oven dry weight of rattan cane is 75.9% less and air dry weight is 27 to 35% less (Thapa, Paudel, & Chowdhary, 2000) and air dry weight is reported also 27.71% reduction in weight (Chowdhary & Paudel, 2008). All the Community Forest User Groups sell the dry weight rattan (Table 6).

Table 6: Green and dry weight of rattan

Name of CFUG	Total number of sampled rattan cane	Green weight (1.2 Kg /stem)	Oven dry weight (75%)	Dry weight (30% reduction) air dry
Sati	3956	4747.00	1187	2448
Sarswoti	3896	4675.00	1169	2805
Shiva	3892	4670.00	1168	2802

Source :(Thapa et al, 2001, Modified with the Field data 2017)

Yield regulation and estimation of Current Annual Increment (CAI) and Mean Annual Increment (MAI)

Current Annual Increment (CAI)

Current Annual Increment (CAI) and Mean Annual Increment (MAI) was estimated referring growth of stem in a periodic of time and MAI with the average mean annual increment. The average CAI of rattan of eight CFs is 1.54 meter per year, where minimum 1.40 meter per year and maximum 1.84 meter per year (Table 7).

Table 7: Summary of Current Annual Increment in Eight Community Forests of Kailali and Bardiya districts

District	Name of CFUG	Length of rattan cane (m.)		Current Annual Increment m/year	Standard deviation
		2 year	6 years		
Kailali	Sati Karnali	1.76	2.16	1.40	0.506
Bardiya	Sarswoti	2.06	2.77	1.84	
	Shiva	1.76	2.16	1.40	
	Lathahawa	2.06	2.77	1.47	
	Khata	1.76	2.25	1.47	
	Bhimpur	1.47	1.99	1.32	
	Tharu	2.06	2.24	1.54	
	Neulapur	1.76	2.08	1.32	
Mean				1.47	

 Source field inventory 2017

Mean Annual Increment (MAI)

The mean annual increment (MAI) refers to the average growth per year a tree or stand of trees has exhibited/experienced to a specified age. Diameter of stems was taken above 15.25 cm from the ground level. Details of rattan forest in various community forests of Kailali and Bardiya are presented in Table 8. The table illustrates that average MAI of *Calamus tenuis*is 0.150 cm per year, the MAI of Sati Karnali is 0.146 cm per year which is 11.28 percent less than Lathahawa CF.

Table 8: Summary of Mean Annual Increment in Eight Community Forests of Kailali and Bardiya districts.

District	Name of CFUG	Mean diameter (cm)	Year	Mean Annual Increment cm/year
Kailali	Sati Karnali	0.8780	6	0.1463
Bardiya	Sarswoti	0.9700	6	0.1618
	Shiva	0.9390	6	0.1565
	Lathahawa	0.9766	6	0.1628
	Khata	0.9062	6	0.1511
	Bhimpur	0.9030	6	0.1506
	Tharu	0.9682	6	0.1613
	Neulapur	0.9340	6	0.1557
Average				0.1551

From the Table 7 and 8, it is clear that both CAI and MAI are highest in Lathahawa Community Forest than Sati Karnali Community Forest and Shiva Community Forest. Rattan was not harvested in Bardiya district

Allowable cut of rattan

Availability and allowable cut of rattan was estimated as approved Forest Operational Plan (FOP) of Sati Karnali, Sarswoti, Lathahawa and Tharu community forests is presented in the Table 9. The FOP is valid for three years from BS 2071. Area of rattan forests are different 157 ha, 3 ha, 4 ha, 19.5 ha and 3.5 ha of Sati Karnali, Shiva, Tharu, Sarswoti and Lathahawa respectively. Regeneration (middle size and small size) was 35 to 38 percent. According to FOP, rattan stocking was 16500 to 25450 per ha and annual cut at the rate of 65% was 8750 in Sarswoti CF and 15000 per hector in Lathahawa CF and annual allowable cut was prescribed 40 percent in Sarswoti and 25 percent in Lathahawa that equals 3500 kg and 5750 kg in Sarswoti and Lathahawa CFs (Table 9).

Table 9: Availability and allowable cut of rattan in Community Forest

Name of Community Forest	Area of rattan (ha)	Average weight (kg/ha)	Rattan per hector	Growth rate(kg)	Allowable cut	Total annual allowable cut/ ha
Sati Karnali	157	8811	25425	8898(38%)	65%	16525
Shiva	3	3800	17280	4320 (35%)	65%	11232
Tharu	4	3700	16780	6040 (35%)	65%	10907
Sarswoti	19.5	3650	16500	4125 (25%)	75%	12375
Lathahawa	3.5	1500	15000	3750(25%)	75%	11250

DISCUSSION

The germination performance of *Calamus tenuis, Calamus acanthospathus*and *Calamus.leptospadix*) showed different result in two different nurseries experimented at tropical and sub-tropical climate. The overall germination was 75.7 per cent in subtropical whereas 30.2 per cent in tropical climate nursery. However, germination of *Calamus acanthospathus*, *Calamus leptospadix* and *Calamus tenuis* was 100 per cent, 64 percent and 42.2 per cent, respectively.Seed germination was taken place from 21 days, the maximum germination was taken between 60 to 80 days, and continued up to 117 days. The result shows that survival per cent was higher of *Calamus tenuis* up to 4th month in Kailali and then decreased, whereas Calamusacanthospathus less survival percent. Supporting to this statement, Islam, Miah &Habib(2015) concluded 36.75 per cent average survival in the plantation of *Calamus tenuis* in Bangladesh.

Mean growth of *Calamus tenuis* in community forests was 0.85 meter cm per year. There are various research findings to support this statement. According to research studies and observation carried out in the Philippines the rattan cane grows at the average rate of 0.70 meter per year ((IIRR, 1992). A similar studies carried out in China by Yang et al (ND) also showed that some medium-diameter species, such as *Daemonorops margarita* and *Calamus simplicifolius*, growing fast with annual increment of 1.0-1.5 m and continue to keep these vigorous trends for 2 to 3 years or more after reaching technical maturation. The research study carried out by Islam *et al*(2015) in Bangladesh on *Calamus tenuis* mentions that average growth rate is 1.78 meter per year. Chowdhary and Paudel (2008) also concluded that growth of *Calamus tenuis* is up to 2.5 meter per year if they are climbed on trees. The study carried out in Bangladesh shows that the maximum stem length was recorded 21.15m (Islam S. A., Miah, Habib, & Rasul, 2015). *Calamus tenuis* is a clumpy palm producing 3-7 rhizomes in one year and increase up to 25 rhizomes in 3-4 years period. There are 15 to 25 percent immature culms in

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a clump, and number of clumps are 200 to 500 in per hectare. Average number of rattan cane was 4 in per square meter of each community forest. Mean length and mean diameter was measured 5.47 meter9.23mm. The estimation shows that there is no more different in growing stock in per m^2 in them.

Current Annual Increment (CAI) and Mean Annual Increment (MAI) was estimated referring growth of stem in a time period and MAI with the average mean annual increment. The average CAI is 1.54 meter per year, where minimum 1.40 meter per year and maximum 1.84 meter per year. The mean annual increment (MAI) refers to the average growth per year a tree or stand of trees has exhibited/experienced to a specified age. Diameter of stems was taken above 15.25 cm from the ground level. The average MAI of *Calamus tenuis* of are 0.1514 cm per year.

Weight difference of rattan with and without leaf sheath is 25 per cent. However, oven dry weight of rattan cane is 75.9 per cent less and air dry weight is 27 to 35 per cent less (Thapa, Paudel, & Chowdhary, 2000) and air dry weight is reported also 27.71% reduction in weight (Chowdhary & Paudel, 2008).

Availability and allowable cut of rattan was estimated as approved Forest Operational Plan (FOP) of Sati Karnali, Sarswoti, Lathahawa and Tharu community. According to FOP, rattan stocking was 16,500 to 25,425 per ha and followed annual cut was 65% to 75%. Rotation year of *Calamus tenuis* has been estimated six years in Nepal that looks justified by the Dransfield (1977) that small diameter rattan can be harvested at as early six years of planting. However, Saharia and Sen (1990) recommended 12 years of rotation year of *Calamus tenuis*. Concerning to retaining of rattan stems in the harvesting blocks is not standardized yet. In East Kalimanta, only 10-20% of the stems in a cluster are harvested at a time ((Peluso, 1986).

After the implementation of Rattan Management Plan, significant improvement was noticed in all the rattan forests, those adopted it. CFUGs were sensitized to accrue benefit from other sources rather than commercial culms. They were derivatives such as leaf sheath, fruits, NTFPs and sale of seedlings produced in the nursery. For example of Sati Karnali Community Forest User Group showed that benefit increased 5 to 6 times (i.e. before RMP benefit was Rs 0.2 million which was reached up to 4 to5 million (Paudel & Chowdhary, 2005).

CONCLUSIONS

Estimation of growing stock helps to plan for the volume of products for commercial uses. Sustainable management of forest requires inventory of growing stock, quantity of annual harvesting, percent of regeneration, sapling and mature stocks, difference between green weight and dry weight, commercial length and diameter of rattan. The estimation of growing stock ensures commercial volume forest products per year. This study explored the growth pattern of rattan cane in 21 community forests of Kailali and Bardiya districts.

The measurement of growing stock was based on the sampling. Although the rattan cane was distributed in many community forests, growing stocks were still to be incorporated in the Forest Operational Plan. The growing stock was crucial for preparation of Initial Environmental

Examination and Environmental Impact Assessment reports, and growing stock needs to be incorporated in the FOP.

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