

(REVIEW ARTICLE)



Growth performance of *Santalum album* its income potentiality: A study from Pyuthan District, Nepal

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Abstract

The *Santalum album* is becoming a popular income generating tree species in Nepal but its growth performance has not been assessed so far yet. Thus, this study was objectively conducted to assess mean annual increment, income from *Santalum album* and value chain analysis. The Private plantation of Pyuthan district was selected for the study site. The diameter and height of 450 plants were measured and their age was recorded. Total fifteen key informant interviews, forty five farmers' interviews and one focused group discussion were conducted to collect primary data. The collected data were analyzed using descriptive and inferential statistics. Mean annual increment, price of *Santalum album* and contribution of *Santalum album* in total income were analyzed. The result showed that the highest mean annual diameter increment was 51.94 cm and lowest mean annual diameter increment was 28.25cm, the highest mean height increment was 6.39 m and the lowest mean annual height increment was 4.47m and the highest mean volume increment was 0.678 m³ but the lowest mean annual volume increment was 0.134 m³. The estimated maximum range of annual income from *Santalum album* was US\$ 221-530 which was 10-15% contribution in farmers annual income while minimum range of this was US\$ 194-265 and it contributes <10%. The difference of the price of *Santalum album* between the farmers and users in Kathmandu was 2200 times more.

Keywords: *Santalum album*; Growth; Plantation; Private

1. Introduction

Globally, the total area of the forest is about 3.999 million ha of land (30.6 %). Out of this, approximately 299 million ha (7%) area is planted forest that has grown by 105 million ha since 1990 [1]. Annually, the plantation areas have been increasing in different countries. The key examples are the large scale of plantation done in China, United States, Russian Federation, India and Japan. These countries contribute about 65% of total plantation areas in the world [2].

East Asia, Australia and South Asia including India, Nepal and Sri Lanka [3, 4, 5]. This species is exotic to Nepal but the importance of this species has been increasing because of high price. This species has high religious and social value and hence economic importance. The Chandan (mark on forehead) as symbol of god. This wood is generally used to worship god Shiva [6, 7]. It is also believed that goddess Lakshmi lives in the sandalwood tree. In this context, there is no research work related to this species in Nepal. According to the report of forest resource assessment [8], forest occupies a 5.96 million ha in Nepal, it is about 40.36% of the total area of the country. In addition, the other wooded land covers 0.65 million ha which is about 4.38%. Forest area of Nepal is increasing because of community forest management. The community plantation in hilly area is one of the important reasons. The hill community forest programme was the main base of massive plantation forest in 1980 to 2000 [9]. The plantation activities were continued

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in Terai (plain) areas as well to increase the forest areas and improve the quality of degraded forest. Private plantation forest is one of the achievement of Hill community forest and Terai community forestry programme [10].

The main purpose of private plantation in Nepal is to meet the demand of forest product. The timber, firewood, grass and non-timber forest products are the major forest product in private forests. The local farmers have been generating a good income from private forests. Pyuthan district is one of the hilly district in Nepal and recognized as the plantation of *Santalum album* [11, 12, 13]. This species is fast growing tree species and many farmers have been generating a good income from this species [14, 15] but there is no any research work related to this. Thus, this research was objectively conducted to assess the growth of *Santalum album* and its income potential and evaluate the value chain market of *Santalum album*.

2. Material and methods

2.1. Study Area

The study was conducted in Pyuthan district. The district covers an area of 1,309 km² with population of 226,796 in 2011 [16]. Khalanga is the district's administrative center. Pyuthan is situated 250 km west from Kathmandu in Province No. 5 in Midwestern Nepal. Pyuthan district lies in latitude of 28.1017° N and longitude 82.8533° E. Altitude of this district ranges from 305m to 3659m.

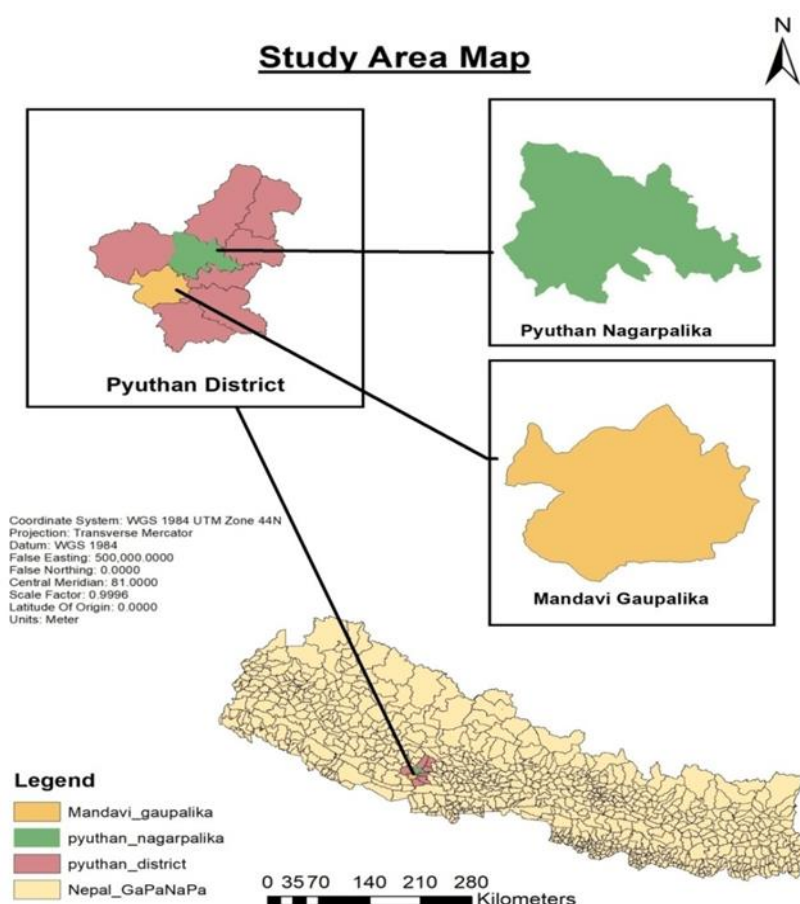


Figure 1 Study area

Sandalwood has been planting over 20 years in this district and there are large number of this tree in this district. Therefore, Pyuthan district was selected as the study site. Within the district, the study area was selected by considering availability of Sandalwood in Private plantation. Three sites were selected as the study area, particularly site 1 as Kwadi, and site 2 Bijaya Nagar in Pyuthan Municipality and site 3 Ramdi in Mandavi Rural Municipality (figure 1).

2.2. Data collection

The primary and secondary data were collected from the field. Stratified sampling was applied to collect the primary data. The diameter at breast height and heights of plants were measured using D tape, Range finder and simple tape. All together 450 plants were measured using stratified random sampling. Specifically, 45 household having 10 plants in each plot were measured in private plantation. The secondary information was gathered from available records from Division Forest Office, Pyuthan and forest owner. The secondary information included the plantation time, seed sources and previous measurements. In addition, the literature review, various publications of Ministry of Forest and Environment, Department of Forests and Soil conservation, Department of Research and Survey and other related literature (published and unpublished) was consulted during this study.

2.3. Data analysis

The data includes the estimation of mean annual increment and coefficient of variance.

Basal Area was calculated using following formula:

$$(BA) = \pi d^2 / 4$$

Where, BA = Basal area and d = diameter in cm

Volume of tree was calculated using volume calculation formula mentioned in Inventory Guide line, 2061. The Volume Calculation Formula is as following:

$$Volume(V) = \left(\frac{\pi d^2}{4} * Height * form factor\right) / 10000$$

Where, V = Volume in m³ and d = diameter in cm

Mean diameter and Mean annual diameter increment was calculated using following formula:

$$MD = \frac{\text{Sum of total diameter}}{\text{total number of measured tree}}$$

$$MADI = \frac{MD}{\text{Age of tree}}$$

Mean height and Mean annual height increment was calculated using following formula:

$$MD = \frac{\text{Sum of total hight}}{\text{total number of measured tree}}$$

$$MAHI = \frac{MH}{\text{Age of tree}}$$

Mean basal area and Mean annual Basal area increment was calculated using following formula:

$$MBa = \frac{\text{Sum of total Ba}}{\text{total number of measured tree}}$$

$$MABaI = \frac{MBa}{\text{Age of tree}}$$

Mean Volume and Mean annual Volume increment was calculated using following formula:

$$MV = \frac{\text{Sum of total Volume}}{\text{total number of measured tree}}$$

$$MAVI = \frac{MV}{\text{Age of tree}}$$

$$\text{Coefficient of variance (CV)} = \frac{\text{Standard deviation}}{\text{Mean}} \quad [17, 18]$$

3. Results and discussion

3.1. Mean Annual Growth of *Santalum album* at site 1(Kwadi)

The result showed that the estimated highest mean annual diameter increment was 47.84±1.720 cm at 16 years while it was the lowest at the age of 9 years i.e. 28.25±0.391cm. More ever, the estimated highest mean annual height increment was 6.312±0.07 at the age of 15 years while it was the lowest at the age of 9 years i.e. 4.575±0.064. Instinctively, the estimated highest mean annual volume increment was 0.573±0.018 m³at the age of 16 years while it was the lowest at the age of 9 years i.e. 0.144±0.005 m³. The growth of the plant according to soil quality and environment [19, 20, 21]

Table 1 Mean Annual Growth of *Santalum album* at site 1(Kwadi)

| Age | Diameter increment (cm) | | | | Height Increment(m) | | | | Volume Increment(m ³) | | | |
|-----|-------------------------|-----|-----|------|---------------------|-----|-----|------|-----------------------------------|------|-------|-------|
| | MADI±SE | Max | Min | SD | MAHI±SE | Max | Min | SD | MAVI±SE | Max | Min | SD |
| 9 | 28.25±0.391 | 30 | 26 | 1.36 | 4.575±0.064 | 5 | 4.3 | 0.22 | 0.144±0.005 | 0.18 | 0.114 | 0.019 |
| 10 | 31.07±0.649 | 38 | 26 | 3.31 | 8.042±5.563 | 7.2 | 4.4 | 13.1 | 0.285±0.072 | 2.06 | 0.128 | 0.367 |
| 11 | 30.994±0.773 | 38 | 27 | 3.28 | 5.111±0.101 | 6 | 4.5 | 0.43 | 0.196±0.012 | 0.32 | 0.134 | 0.054 |
| 12 | 34.12±0.779 | 38 | 26 | 3.12 | 5.443±0.129 | 6.6 | 4.6 | 0.52 | 0.252±0.014 | 0.34 | 0.121 | 0.056 |
| 13 | 37.33±0.701 | 43 | 32 | 2.72 | 6.06±0.156 | 7 | 4.9 | 0.6 | 0.454±0.045 | 1.02 | 0.247 | 0.182 |
| 14 | 42.25±1.778 | 60 | 30 | 7.11 | 6.293±0.14 | 7.2 | 5.5 | 0.56 | 0.455±0.046 | 1 | 0.25 | 0.183 |
| 15 | 45.9±0.836 | 54 | 32 | 4.8 | 6.312±0.07 | 7 | 5.1 | 0.45 | 0.527±0.018 | 0.47 | 0.261 | 0.108 |
| 16 | 47.84±1.720 | 54 | 36 | 6.2 | 6.289±0.169 | 7 | 4.9 | 0.61 | 0.573±0.018 | 0.74 | 0.227 | 0.04 |

(Source: Field survey, 2019)

3.2. Mean Annual Growth of *Santalum album* at site 2 (Bijaya Nagar)

The result showed that, the estimated highest mean annual diameter increment was 51.94±0.73 cm at 16 years while it was the lowest at the age of 9 years i.e. 28.25±0.391 cm.

Table 2 Mean Annual Growth of *Santalum album* at site 2 (Bijaya Nagar)

| Age | Diameter increment(cm) | | | | Height Increment(m) | | | | Volume Increment(m ³) | | | |
|-----|------------------------|-----|-----|-------|---------------------|-----|-----|-------|------------------------------------|-------|-------|-------|
| | MADI±SE | Max | Min | SD | MAHI±SE | Max | Min | SD | MAVI±SE | Max | Min | SD |
| 9 | 27.6±0.349 | 30 | 26 | 1.352 | 4.5±0.043 | 4.8 | 4.2 | 0.169 | 0.134±0.003 | 0.159 | 0.114 | 0.014 |
| 10 | 30.7±0.597 | 36 | 26 | 2.67 | 5.16±0.08 | 6 | 4.5 | 0.386 | 0.194±0.009 | 0.29 | 0.12 | 0.041 |
| 11 | 30.7±0.59 | 36 | 26 | 2.7 | 6±0.090 | 5.7 | 4 | 0.413 | 0.188±0.009 | 0.29 | 0.114 | 0.044 |
| 12 | 36.04±0.52 | 39 | 31 | 2.49 | 5.57±0.086 | 6.5 | 4.9 | 0.415 | 0.287±0.011 | 0.388 | 0.184 | 0.054 |
| 13 | 39.07±1.07 | 46 | 33 | 4.001 | 5.96±0.126 | 7 | 5.3 | 0.472 | 0.361±0.021 | 0.484 | 0.246 | 0.079 |
| 14 | 41.54±0.531 | 49 | 37 | 2.6 | 5.97±0.101 | 6.9 | 5 | 0.496 | 0.407±0.013 | 0.584 | 0.283 | 0.067 |
| 15 | 50.53±1.347 | 56 | 40 | 4.85 | 6.39±0.089 | 6.9 | 5.9 | 0.32 | 0.640±0.033 | 0.8 | 0.376 | 0.119 |
| 16 | 51.94±0.73 | 60 | 47 | 3.2 | 6.37±0.07 | 6.7 | 5.6 | 0.3 | 0.678±0.021 | 0.876 | 0.549 | 0.093 |

(Source: Field survey, 2019)

More ever, the estimated highest mean annual height increment was $6.39\pm 0.089\text{m}$ at the age of 15 years while it was the lowest at the age of 9 years i.e. $4.5\pm 0.043\text{m}$. Instinctively, the estimated highest mean annual volume increment was $0.678\pm 0.021\text{ m}^3$ at the age of 16 years while it was the lowest at the age of 9 years i.e. $0.134\pm 0.003\text{ m}^3$.

3.3. Mean Annual Growth of *Santalum album* at site 3 (Ramdi)

The result showed that, the estimated highest mean annual diameter increment was $50.64\pm 0.69\text{ cm}$ at 16 years while it was the lowest at the age of 9 years i.e. $28.53\pm 0.94\text{ cm}$. More ever, the estimated highest mean annual height increment was $6.5\pm 0.09\text{ m}$ at the age of 15 years while it was the lowest at the age of 9 years i.e. $4.47\pm 0.053\text{ m}$. Instinctively, the estimated highest mean annual volume increment was $0.647\pm 0.028\text{ m}^3$ at the age of 16 years while it was the lowest at the age of 9 years i.e. $0.145\pm 0.011\text{ m}^3$.

Table 3 Mean Annual Growth of *Santalum album* at site 3 (Ramdi)

| Age | Diameter increment(cm) | | | | Height Increment (m) | | | | Volume Increment(m ³) | | | |
|-----|------------------------|-----|-----|------|----------------------|-----|-----|------|------------------------------------|------|------|-------|
| | MADI±SE | Max | Min | SD | MAHI±SE | Max | Min | SD | MAVI±SE | Max | Min | SD |
| 9 | 28.53±0.94 | 39 | 26 | 3.41 | 4.47±0.053 | 4.8 | 4.2 | 0.19 | 0.145±0.01 | 0.28 | 0.11 | 0.04 |
| 10 | 28.5±0.510 | 32 | 26 | 1.91 | 4.80±0.090 | 5.6 | 4.5 | 0.33 | 0.154±0.07 | 0.2 | 0.11 | 0.02 |
| 11 | 32.96±0.55 | 42 | 29 | 2.76 | 5.14±0.06 | 5.9 | 4.5 | 0.34 | 0.222±0.01 | 0.4 | 0.16 | 0.05 |
| 12 | 36.94±0.50 | 39 | 31 | 2.12 | 5.65±0.09 | 6.5 | 4.9 | 0.42 | 0.305±0.01 | 0.38 | 0.18 | 0.04 |
| 13 | 41.36±1.04 | 49 | 38 | 3.47 | 5.94±0.13 | 6.5 | 5.3 | 0.44 | 0.402±0.02 | 0.57 | 0.3 | 0.07 |
| 14 | 42.33±0.55 | 49 | 37 | 3.19 | 6.10±0.07 | 6.8 | 5 | 0.4 | 0.431±0.01 | 0.58 | 0.28 | 0.06 |
| 15 | 50.18±1.12 | 56 | 45 | 3.73 | 6.5±0.09 | 7 | 5.9 | 0.32 | 0.645±0.02 | 0.77 | 0.47 | 0.008 |
| 16 | 50.64±0.69 | 55 | 41 | 3.46 | 6.40±0.11 | 7 | 4.5 | 0.56 | 0.647±0.02 | 0.79 | 0.43 | 0.099 |

(Source: Field survey, 2019)

Similar studies were done [19, 20, 21] to find the Assessment of Growth Performance of *Tectona grandis* and *Acacia catechu*. The mean annual volume increment (MAVI) before thinning was found to be highest in Block D i.e. 0.0015 m^3 and lowest in Block B i.e. 0.0011 m^3 . The mean annual volume increment in 2018 was found to be highest in Block D i.e. 0.0031 m^3 and lowest in Block A i.e. 0.0022 m^3 . The mean annual volume increment is quite similar to our research.

3.4. Percentage contribution of *Santalum album* total income

Table below showed that the contribution of Income from *Santalum album* can be categorized into four main types these are <10%, 10-15%, 15-20% and >20%. The highest annual income from *Santalum album* was recorded US \$ 221-530 at site 3 which was 10-15% contribution in farmers annual income while it was the lowest US \$ 194-265 at site 3 which contribute <10%.

Table 4 Percentage contribution of *Santalum album* of total income

| % contribution of <i>Santalum album</i> (total income) | Site 1(Kwadi) | | Site 2(Bijaya Nagar) | | Site 3(Ramdi) | |
|--|---|---------------------|---|---------------------|---|---------------------|
| | Income from <i>Santalum album</i> US \$ | Annual income US \$ | Income from <i>Santalum album</i> US \$ | Annual income US \$ | Income from <i>Santalum album</i> US \$ | Annual income US \$ |
| <10% | - | - | 226-353 | 3398-3716 | 194-265 | 1911-2654 |
| 10-15% | 265-442 | 1699-3292 | 198-318 | 1911-2442 | 221-530 | 1911-3610 |
| 15-20% | 212-353 | 1061-2123 | 415- | 2761- | 318-371 | 1699-2336 |
| >20% | 194-336 | 1061-1061 | 292- | 1274- | - | - |

3.5. Consistency of income generation form *Santalum album*

The result showed that there was consistent in income generation from *Santalum album* at site 1(Kwadi) because the coefficient of variance was 24.54. The value of coefficient of variance was at site 1, this showed that there was high consistency in income from *Santalum album* ($CV1 < CV2 < CV3$) i.e. ($24.54 < 31.1 < 34.69$).

3.6. Layer of value chain market of *Santalum album*

The layer starts from farmers to middle man. Farmers from Pyuthan district grow/produces *Santalum album* and Middle men purchase at very first and sells to the local market or Pyuthan Road head. After arriving on the Road head market the product is brought by the wholesaler of Kathmandu Boudha. Before selling to shopkeeper it is packed in different sizes and shapes with different prices.

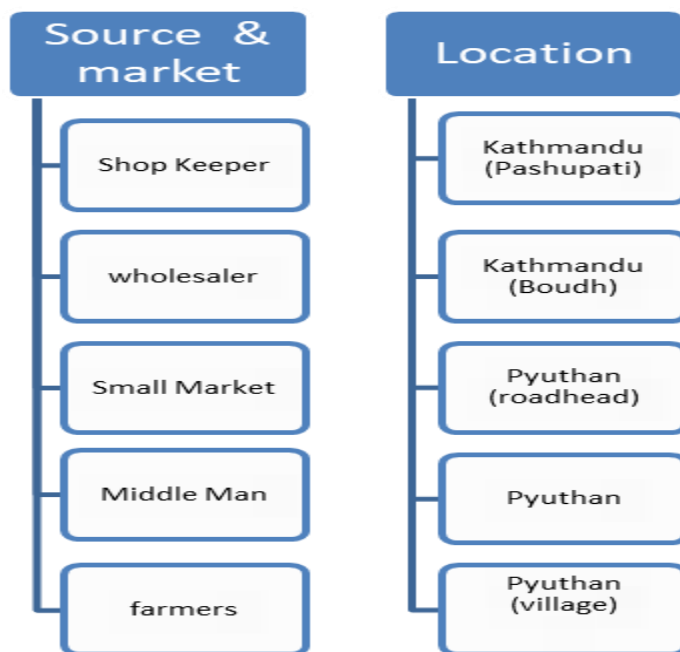


Figure 2 Layer of value chain market of *Santalum album*

3.7. Value chain of *Santalum album*: Distance & time to reach and its price

The supply chain is very long with as many as five or six marketing stages involving farmers or primary collector, Middle man, small market, wholesaler and shopkeeper or specialized suppliers.

Table 5 Value chain of *Santalum album*: Distance & time to reach and its price

| Sources and Market Level | Price US \$ / kg | Details | Distance (Km) | Time to reach | Price difference (US \$) | Price difference (%) |
|--------------------------|------------------|---------------------------|---------------|---------------|--------------------------|----------------------|
| Shopkeeper | 176.9 | Shop keeper & wholesaler | 10 | 2 hours | 106.2 | 150.21 |
| Wholesaler | 70.7 | Wholesaler & Small market | 432 | 1 - 2 days | 41.5 | 142.12 |
| Small Market | 29.2 | Small market & Middle Man | 8 | 4 hours | 12.2 | 71.76 |
| Middle Man | 17 | Middle Man & Farmers | 2 | 3 hours | 9.5 | 126.67 |
| Farmers | 7.5 | Farmers & Shopkeeper | | 1 - 2 days | 169.4 | 2258.67 |

Matured *Santalum album* which is produced by farmer takes 1 to 2 days to weight and collect from farm cost about US \$ 7.5 per kg. After the *Santalum album* is ready the middle man buys it from the farmer directly from the farm, which makes price difference of 126.67% i.e. US \$ 9.5 per kg. Small market is defined as local market in Pyuthan district where farmers takes their product on local bazaar, where price hikes about 71.76% and can reach up to US \$ 29.2 per kg. All the product which are brought from farmers, middle man or local market are collected by wholesaler in Kathmandu which is also specialized suppliers and distributor raises price from 71.76% to 142.12% i.e. US \$ 70.7 per kg. Finally after labeling and packaging the shopkeeper sells the final product as US \$ 176.9 per kg which is 2258.67% from the starting price.

3.8. Value chain of *Santalum album* from farmer to Shopkeeper

The figure described that farmers keep the profit margin of US \$7.5 per kg only. The middle man who manages relationship between farmers and local market makes around US \$17 per kg. After the product reaches from farmer to wholesaler or the specialized distributor, whole seller keeps profit margin of US \$70 per kg where transport collect and labels the product before it is ready for shopkeeper. After the final product is arrived from whole seller the shopkeeper or retailer sell them by keeping profit margin of US \$176.9 per kg (Figure 3).

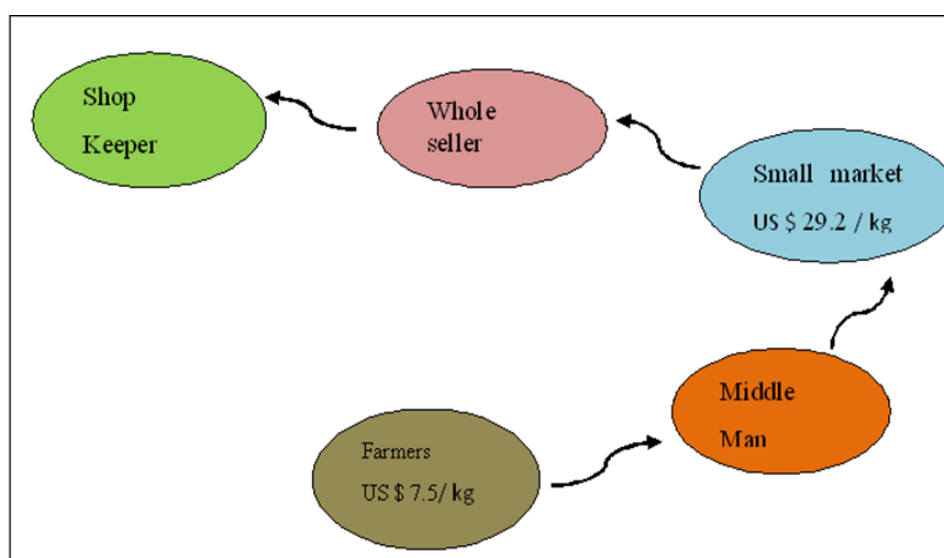


Figure 3 Value chain of *Santalum album* from farmer to Shop keeper

Value Chain Analysis of Forest Products showed that there is six layer of value chain of forest products in Koshi Hill Districts of Nepal [22]. The layer starts from farmers/collector to Village Level Traders / Middlemen. Middleman Purchase at first and sell to District level traders. After arriving at District level traders the product is brought by Regional level traders it is packed in different size and supply 90% in India and 10% in national level market. It is similar with our study which has five or six layer of value chain. Similar type of study was done by [23, 24] showed that the supply chain is often very long with as many as six or seven marketing stages involving primary collectors and producers, local contractors, regional wholesale markets, large wholesale markets and specialized suppliers which was similar with our research findings.

4. Conclusion

The growth performance of *Santalum album* with respect to height, diameter and volume was significantly differed according to site quality. The growth response of *Santalum album* of Pyuthan district has shown good performance, these sites are potential for plantation *Santalum album*. There is about one fifth contribution of *Santalum album* in total annual income. The price differences of *Santalum album* was over two thousands two hundred times between the farmers and users in Kathmandu. The high-quality growth performance of this species in these sites was the indicator of potential plantation.

Details study should be carried out to find the growth performance of this species which were planted in different region to compare within it. The value chain analysis showed large price gap between farmers to shopkeeper in Kathmandu, it needs to reduce applying appropriate policy

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest is exist.

References

- [1] FAO. Forest Resources Assessment 1990: Tropical Countries. FAO Forestry Paper (in press). Food and Agriculture Organization of the United Nations. Rome. 1993.
- [2] McEwan A, Marchi E, Spinelli R, Brink M. Past, present and future of industrial plantation forestry and implication on future timber harvesting technology. *Journal of Forestry Research*. 2020; 31(2): 339-351.
- [3] Jaenicke H, Höschle-Zeledon I. Strategic framework for underutilized plant species research and development: With special reference to Asia and the Pacific, and to Sub-Saharan Africa. Bioversity International. 2006.
- [4] Ashton MS, Gunatilleke CV, Gunatilleke IA, Singhakumara BM, Gamage S, Shibayama T, Tomimura C. Restoration of rain forest beneath pine plantations: A relay floristic model with special application to tropical South Asia. *Forest Ecology and Management*. 2014 Oct 1; 329: 351-9.
- [5] Cederlöf G, Sivaramakrishnan K, editors. Ecological nationalisms: Nature, livelihoods, and identities in South Asia. Orient Blackswan. 2005.
- [6] Sharma UK, Gogoi J. Ethno-medico-botany of some sacred plants of Dhemaji District of Assam. *Medicinal plants traditional knowledge*, Editor Trivedi P, C, I. K international. 2006; 100-5.
- [7] Pandey HP. Socio-religious Plants of Terai Region of UP, India. *International Journal of Biological Innovations*. 2019; 1(1): 18-24.
- [8] DFRS. State of Nepal's Forests. Forest Resource Assessment (FRA) Nepal, Department of Forest Research and Survey (DFRS). Kathmandu, Nepal. 2015.
- [9] DFRS. Middle Mountains Forests of Nepal. Forest Resource Assessment (FRA) Nepal, Department of Forest Research and Survey (DFRS). Kathmandu, Nepal. 2015.
- [10] DFRS. Terai Forests of Nepal. Forest Resource Assessment (FRA) Nepal, Department of Forest Research and Survey (DFRS). Kathmandu, Nepal. 2015.
- [11] DFO, Progress report of district Forest, Pyuthan. Division Forrest Office, Pyuthan. 2018; 1-23
- [12] DOFSC. Hamro Ban, Department of Forest and Soil Conservation, Babarmahal Kathmandu Nepal. 2019; 23-34.
- [13] Narayan MK. Flipside of Hindu Symbolism: Sociological and Scientific Linkages in Hinduism. Fultus Corporation. 2007; 11-12.
- [14] Sakurai T, Rayamajhi S, Pokharel RK, Otsuka K. Efficiency of timber production in community and private forestry in Nepal. *Environment and Development Economics*. 1 Aug 2004; 5(3): 9-61.
- [15] Acharya AK, Kafle NL. degradation issues in Nepal and its management through agroforestry. *Journal of Agriculture and Environment*. 2009 Aug 12; 10 (1): 133-43.
- [16] CBA, Population Census Nepal, Central Bureau of Statistics Nepal. 2011; 123-125.
- [17] Chaturvedi AN, Khanna LS. Forest Mensuration, Z_Bio-Green. 2015; 23-34.
- [18] Kothari CR. Research methodology: Methods and techniques. New Age International. 2004; 22-27.
- [19] Pokhrel BR, Mandal RA. Assessing Growth Performance of *Tectona Grandis* in Nepal. *International Journal of Advanced Research in Botany*. 2019; 5(1): 25-33.
- [20] Adame P, Uriarte M, Brandeis T. Diameter growth performance of tree functional groups in Puerto Rican secondary tropical forests. *Forest Systems journal*. 2014; 23(1): 52-63.
- [21] Jha P, Mandal RA. Assessment of Growth Performance of *Acacia catechu*. *International Journal of Advanced Research in Botany*. 2019; 5(1): 23-30.
- [22] Pathak A. Value chain analysis of *Amomum subulatum* (Alainchi) in MSFP Lot 1 districts. *Forest Action Nepal*. 2014.

- [23] Asfaw Z. Value chain analysis of medicinal plants and the associated challenges. *medicinal plants studies*. 2016; 4(1): 45-55.
- [24] Lamichhane R, Gautam D, Miya MS, Raut Chhetri HB, Timilsina S. Role of Non-Timber Forest Products in Local Economy: A Case of Jajarkot District, Nepal. Lamichhane, R., Gautam, D., Miya, MS, Chhetri, HB and Timilsina, S.(2021). Role of Non-Timber Forest Products in National Economy: A Case of Jajarkot District, Nepal. *Grassroots Journal of Natural Resources*. 2021 Mar 25; 4(1): 94-105.