

# Economics of *Santalum album* L. Cultivation Under Semiarid Tropics of Karnataka, India

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## Abstract

Sandalwood (*Santalum album* L., Family: Santalaceae) is one of the most important economic tree species harvested mainly for its heartwood and oil. Sandalwood referred to as “Chandana” in Sanskrit and is commercially known as “East Indian Sandalwood” and its essential oil known as “East Indian Sandalwood Oil”. The oil extracted from the sandalwood trees are considered to be unique and is preferred over other regions for the preparations of perfumes, formulations, flavors, cosmetics, toiletries, beauty aids and medicines. Despite the policy amendments and government support to cultivate sandalwood on farm lands, there is lot of skepticism on the economic aspect of sandalwood cultivation especially due to long gestation period in accruing returns and high investment required for protection. Study on economic viability of sandalwood cultivation would be extremely useful to different stakeholders like farmers to know the relative profitability of sandalwood cultivation. Also, for financial institutions involved in advancing farm loans to sandalwood cultivators, the economics of cultivation at discounted rates is an essential aspect. For calculation of cost of raising sandalwood plantation, information on various inputs and resources at different stages of cultivation, harvesting, processing, transportation and marketing was collected from cultivators. Data related to recent price of sandalwood heartwood and sapwood was collected from Karnataka Soaps and Detergent Limited (KSDL). For financial analysis indicator like Net Present Value (NPV), Benefit-cost ratio (B/C ratio), Internal Rate of Return (IRR), Equivalent Annual Income (EAI) and Land Expectation Value (LEV) were used. Sandalwood cultivated in combination with red-gram showed B/C ratio of 1.93 and IRR of 29%, compared to growing sandalwood alone with B/C ratio and IRR values of 2.58 and 26% respectively. Though the inter-cultivation (sandalwood+tur dal) have slightly lower NPV, B/C ratio and LEV, but higher EAI (annual NPV) when compared to pure sandalwood plantations however, the possibility of yielding Pigeon pea/Tur dal/Red gram (*Cajanus cajan* (L.) Millsp.) in inter-cultivation makes farmers comparatively more attractive as it gives some income every year.

**Keywords:** *Santalum album*; Benefit/cost (B/C) ratio; Internal rate of returns; Net present value; Equivalent annual income; Land expectation value

## Introduction

*Santalum album* L., commonly known as Indian sandalwood, is a small tropical tree, widely accepted as most precious and commercial timber species with an estimated market volume of more than \$1 billion [1]. The species is naturally distributed from 30°N to 40°S; from Indonesia in the east to Juan Fernandez Island (Chile) in the west and from Hawaiian Archipelago in the north to New Zealand in the south. It is believed that sandalwood was introduced into India from Timor, Indonesia [2]. More than 90% of the sandalwood is distributed in the state of Karnataka and Tamil Nadu covering around 9,000 km<sup>2</sup> [3] of which more than 70% occurs in Karnataka [4]. The species is mostly found in dry deciduous and scrub forests. In Karnataka, *Santalum album* is estimated to be spread over an area of 5245 km<sup>2</sup> [5].

Sandalwood tree is mainly exploited for its heartwood which yields the renowned East Indian Sandalwood oil, rated very high for its sweet fragrant, persistent, spicy, warm, woody note, tenacious aroma and fixative property. The aromatic oil, which is contained in the heartwood, is only produced when the trees reaches a certain maturity. Sandalwood is used for various purposes like medicinal purposes, perfumes, agarbathis, handicraft, carvings, religious purposes etc.

The value of a sandalwood tree is largely determined by the weight of its heartwood and the concentration and composition of the oil contained within it [6]. Determining the rate of heartwood development in sandalwood tree is important, since it will largely determine the length of its commercial rotation. The weight of the heartwood is invariably dependent on the size of the tree. Very little

information has been published regarding the growth rate of *S. album*. It is reported that heartwood and oil formation in sandalwood are yet to be studied in detail [7].

Although *S. album* is grown in small quantities, India has a virtual monopoly over sandalwood production. Over 90 per cent of India's sandalwood is grown in Karnataka and Tamil Nadu. The present Government policy pertaining to the management of sandalwood goes back to King Tipu Sultan, erstwhile ruler of Mysore. King Tipu Sultan declared sandalwood a royal tree and monopolized the sandalwood trade in 1792. Till 2002, state governments, especially Karnataka and Tamil Nadu have had monopoly control over all the sandalwood resources including those in private lands. According to the prevailing rules in the southern States, except Kerala, sandalwood continues to be a royal tree and trade in the wood is the monopoly of the state. In Kerala, however, there is no restriction on storage and transportation. This has given rise to widespread smuggling and illegal trade especially between Karnataka and Kerala. Places such as Karnataka-Kerala-Tamil Nadu border have become havens for illegal trade in sandalwood. Due

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to extensive illegal cutting of native Sandalwood trees, this species has become vulnerable to extinction.

In Karnataka, sandalwood populations are sparse and devoid of larger girth classes; matured trees have been nearly vanished. Despite favorable conditions for its growth and natural regeneration in many forests of Karnataka and Tamil Nadu, both production and export of sandalwood and its products have shown a steep decline. Sandalwood genetic resources in the country are threatened by a variety of factors, because of its high economic value both inside the country as well as in the International market [8]. Sandalwood production in the country has fallen from about 4,000 tonnes per annum in the 1960s to less than 1,000 tonnes during the 1990s [9]. Sandalwood oil has virtually disappeared from the international market and its place has been taken over by synthetics. With sandalwood bio-resources depleting at a rapid pace due to various reasons, the gap between demand and production has widened tremendously.

During 2001 and 2002, Karnataka and Tamil Nadu governments have relaxed the existing rules and regulations related to sandalwood in an effort to boost production through encouraging private domestication of sandalwood. Despite the policy amendments favoring private growing of sandalwood and the advantages of sandalwood as an agro forestry species, there prevail considerable skepticism on the economic prospects of sandalwood cultivation due to the time lag in accruing returns from the tree and the high investments required for its protection. Against this backdrop the present study assesses the viability of sandal cultivation practices in southern India through a Benefit Cost (BCA) analysis using financial indicators like; Net Present Value (NPV), Benefit-cost ratio (B/C ratio), Internal Rate of Return (IRR), Equivalent Annual Income (EAI) and Land Expectation Value (LEV).

## Materials and Methods

Raising of sandalwood plantation on farm land offers a feasible alternative to augment supplies especially since the species is quite hardy and can thrive in stress conditions making it an ideal tree species even in dry and degraded lands. In our study a modest attempt is made to find out the economic viability of sandalwood cultivation as a sole crop and along with the combination of Pigeon pea/Tur dal/Red gram (*Cajanus cajan* (L.) Mill sp.) under semi-arid conditions of Karnataka. The economics of cultivation of sandalwood compares input cause and anticipated returns of 3 scenarios; an annual cropping system and 2 plantations of sandalwood regimes over a 15 year period is considered. The economic analysis compares 3 management regimes;

1. Growing only tur/red gram cropping system: using a continuous red gram rotation for simplicity.
2. Sandalwood plantation with generation of revenue from timber harvest only.
3. Sandalwood plantation with red gram, generation of revenue from sale of sandalwood plus annual red gram harvest for 15 years.

Since, the financial returns from sandalwood cultivation are delayed, the feasibility of this practice is judged through financial indicators like Net Present Value (NPV), Benefit-cost ratio (B/C ratio), Internal Rate of Return (IRR), Equivalent Annual Income (EAI) and Land Expectation Value (LEV).

For calculating the cost of cultivation and economic returns the following assumptions were considered:

1. Discounted rate 15% (annual percentage deletion in value of today's money)
2. Rotation of sandal is worked out for fifteen years.
3. All figures are calculated on per ha basis.
4. Land expectation value was considered in calculation.
5. Land owner's time not included in the costing.
6. Cost of security includes cost of labour charges as and when required for miscellaneous activities like fertilizer application, irrigation, pruning etc.
7. Soil/site quality is optimum for this regime
8. Carbon values and comparisons have not been included.

Note: Citrus is grown as secondary host both in combination and pure sandalwood cultivation. However the citrus crop is maintained only for 6 years only. Hence cost and income is neutralized.

To workout cost of raising sandalwood plantations, information regarding labour, material and management cost at different stages of cultivation, harvesting, processing, transportation and marketing was collected from sandalwood cultivating farmers in semiarid tropics of Karnataka. Among the ten agro-climatic zones of Karnataka, sandalwood growing farmers of Eastern Dry Zone (Bangalore Rural, Bangalore Urban, Kolar, Tumkur districts), Southern Dry Zone (Mysore, Mandya, Tumkur, Hassan districts) and Southern Transition Zone (Hassan, Shimoga districts) were visited to collect information on cultivation costs. Some of the data related to price of sandalwood i.e., heartwood and sapwood were collected from Karnataka Soaps and Detergent Limited (KSDL), Government of Karnataka, Bangalore.

## Details of cost of cultivation

### First plantation year cost data (sandal wood):

1. Site preparation (JCB@ 800 Rs/hr for 10 hr)  
=800 × 10=**8000**
2. Cost of 400 seedlings/ha (Spacing 5 × 5 m) @ 30 Rs. per seedling  
=400 × 30=**12000**
3. One labor can dig 20 pits per day therefore 20 labors can dig 400 pits in one day.  
Cost of digging the pits; Rate per labour – 350 rupees =20 × 350=**7000**  
Cost of Tur seed 1 Kg seeds @ Rs 250 =**250**  
Cost of sowing primary host (Tur) =4 × 350=**1400**
4. Fertilizer:  
2 Kg FYM per plant; cost of 1 Kg FYM is Rs 5  
The required fertilizer for 400 plants is 800 kg.  
Cost of 800 kg FYM @ Rs. 5/Kg =5 × 800=**4000**  
Labour charges for FYM application (four labour) =4 × 350=**1400**
5. Fencing:  
Cost of barbed wire fencing per running kilometer is 650000 rupees  
For 1 ha, 400-meter fencing is required (including labour)  
=(650000 × 400)/1000=**260000**
6. Watering:

Cost of bore well, pipe line, transformer, pump set - 5 HP motor, drip system=**350000**

**For next 14-year costs:**

1. Fertilizer:

250 gm per plant; 1 kg for 4 plants; cost of 1 kg fertilizer is 15 rupees

Required fertilizer for 400 plants is 100 kg.

Cost of fertilizer per year  $15 \times 100=1500$  Rs

Cost of fertilizer for 5 years  $=5 \times 1500=7500$

Labour charges for fertilizer application (four labour)  $=4 \times 350=1400$

2. Security:

2-3 years  $5000 \times 24$  months=**120000** Rs

Cost of one security guard per month  $=5000$  Rs

4-9 years

Cost of one security guard per month  $=5000$  Rs

For two security guards=**10000** Rs

Cost of security guards for one year-  $10000 \times 12 =120000$

Cost of security for next 6 year  $=120000 \times 6=720000$

10-15 years

Cost of one security guard per month  $=5000$  Rs

For four security guards  $=20000$  Rs

Four security guards are required for rest 6 years

For four security guards **240000** Rs/year required

Cost for security for rest 6 years  $=240000 \times 6=1440000$

**Cost of agriculture crop (Tur cultivation)**

Site preparation (JCB @ 800 Rs/hr for 10 hr)  $=8000$  Rs

Disc ploughing @ Rs 8000/ ha  $=8000$  Rs

Cost of tur seeds 12.5 Kg /ha @ Rs 250/Kg  $=250 \times 12.5=3125$

Sowing @ 12.5 Kg /ha 10 MD @ Rs 350/MD  $=350 \times 10=3500$

Cultivator @ Rs 3750 /ha  $=3750$

Fertilizer (25-30 kg N, 50-75 kg  $P_2O_5$ )  
**=10000**

FYM 5 tractors/ha @ Rs 3500/tractor  $=3500 \times 5=17500$

Pesticide expenses (Endosulfan 35 EC or Nuvacrone 40 EC) **=10000**

Harvesting Processing (2500 Kg/ha)  $=10000$

Security  $=60000$

**Income from sandalwood plantation:** Out of 400 trees planted, 10% of trees died during the period of 15 year, therefore 360 trees survived healthily.

One trees gives 15 kg heart wood; 360 trees gives  $360 \times 15=5400$  kg heartwood, 1 kg heartwood cost 6000 rupees.

Cost of 5400 kg heart wood

$=5400 \times 6000=Rs$  **3,24,00,000**

For one tree 30 Kg of white/sap wood is produced, for 360 trees  $=360 \times 30$  Kg=**10800** Kg

White/sap wood sold @ Rs. 70/Kg  $=10800 \times 70=7,56,000$  Rupees

The income earned from sandalwood (heart wood+sap wood)  $=(3,24,00,000+7,56,000)=Rs.$  **3,31,56,000**

After deduction of 10% as processing and transportation final income from sandalwood/ha=**Rs 2,98,40,400**

**Income from Pigeon pea/Tur dal/Red gram (*Cajanus cajan* (L.) Millsp.)**

Tur dal production @ 2500 Kg/year in sole crop @ Rs 100/Kg= $2500 \times 100 =Rs$  **2,50,000**

Tur dal production @ 2000 Kg/year in intercrop @ Rs 100/Kg= $2500 \times 100 =Rs$  **2,00,000**

As the financial returns from sandalwood cultivation are delayed, the viability of the practice is judged through a Benefit-Cost Analysis (BCA), taking the time value of money into account following. The various financial analysis models associated with each of the models of costs and benefits were identified initially for the specific rotation periods. Costs and benefits were valued at retail prices and discounted at 15% based on prevailing interest rates (9%). Discounting is necessary to find the present value of future stream of returns or future returns, at a specified interest rate. In order to bring on par the returns realized in different periods of time, Discounted net benefits were added up to calculate NPV [10].

$$\text{Net Present Value(NPV)} = \sum_{t=0}^T \frac{B_t - C_t}{(1-r)^t}$$

where, B is the benefits in year t, C is the costs in the year t and r is the selected discounted rate, following Nair [10].

Net Present Value (NPV): It is the difference between sum of the PV of benefits and sum of the PV of costs and denotes the net worth of the project. Project with positive NPV is worth considering and ranking the projects based on magnitude of NPV is made in the case of capital rationing.

Benefit cost ratio: BCR is the ratio of sum of present value of benefits to sum of present value of costs. It is precisely called as discounted BCR. A project is viable and worth taking up when the Discounted BC ratio is more than 1. The Benefit Cost Ratio was worked out using the formulae:

$$\text{Benefir Costs Ration} = \frac{\text{Total discounted benefits}}{\text{Total discounted costs}}$$

Internal Rate of Returns (IRR) indicates the rate of net return realizable for every Rs. 100 of investment made at any point in time in any enterprise.

Equivalent Annual Income (EAI): EAI is the cost per year of owning and operating an asset over its entire lifespan. The Equivalent Annual Income was calculated using the formulae:

$$EAI = NPV \frac{r(1+r)^t}{(1+r)^t - 1}$$

Where, r is the selected discount rate and t is the selected time period.

Land Expectation Value (LEV): LEV is the value for the bare land for growing successive rotations of ever-aged timber. It can also be defined as the present revenue value for the bare land with all future

costs and income generated by the productive asset. This is calculated using the formulae:

$$LEV = NPV \frac{(1+r)t}{(1+r)t-1}$$

where, r is the selected discount rate and t is the selected time period.

## Results

The details of expenditure incurred in cultivation of sandalwood as a sole crop, tur dal as sole crop and intercrop cultivation of sandalwood and tur dal on per hectare basis are presented in Tables 1-3. The profitability of sandalwood cultivation was assessed in the present

Particulars (only sandalwood)	0 year	1 Year	2 Year	3 Year	4 Year	5 Year	6 Year	7 Year	8 Year	9 Year	10 Year	11 Year	12 Year	13 Year	14 Year	15 Year
Site preparation (JCB @ 800 Rs/hr for 10 hr)	8000															
Cost of 400 seedlings/ha (Spacing 5 × 5 m) @ 30 Rs. per seedling		12000														
Cost of digging the pits; @ 350 Rs/labour; for 20 labours	7000															
Cost of Tur seed 1 Kg seeds @ Rs 250		250														
Cost of sowing primary host (Tur)		1400														
Cost of 800 kg FYM @ Rs. 5/Kg	4000															
Labour charges for FYM/ fertilizer application	1400	1400														
Cost of fertilizer		1500	1500	1500	1500	1500										
Cost of barbed wire fencing per running kilometer is 650000 rupees. For 1ha, 400 meter fencing is required (including labour)		260000														
Cost of bore well, pipe line, transformer, pump set 5HP motor, Drip irrigation		350000														
Security for sandalwood			60000	60000	120000	120000	120000	120000	120000	120000	240000	240000	240000	240000	240000	240000
Actual cost	20400	626550	61500	61500	121500	121500	120000	120000	120000	120000	240000	240000	240000	240000	240000	240000
Interest @ 9 %	2826	58226	61925	11070	16470	21870	21735	21600	21600	21600	32400	43200	43200	43200	43200	43200
<b>Cost of sandalwood cultivation</b>	<b>23226</b>	<b>684776</b>	<b>123425</b>	<b>72570</b>	<b>137970</b>	<b>143370</b>	<b>141735</b>	<b>141600</b>	<b>141600</b>	<b>141600</b>	<b>272400</b>	<b>283200</b>	<b>283200</b>	<b>283200</b>	<b>283200</b>	<b>283200</b>

Table 1: Raising cost of Sandalwood (*Santalum album*) plantation on per hectare basis.

Particulars (only Tur dal)	0 year	1 Year	2 Year	3 Year	4 Year	5 Year	6 Year	7 Year	8 Year	9 Year	10 Year	11 Year	12 Year	13 Year	14 Year	15 Year
Site preparation (JCB @ 800 Rs/hr for 10 hr)	8000															
Disc ploughing @ 8000/ ha		8000	8000	8000	8000	8000	8000	8000	8000	8000	8000	8000	8000	8000	8000	8000
Cost of tur seeds 12.5 Kg / ha @ Rs 250/Kg		3125	3125	3125	3125	3125	3125	3125	3125	3125	3125	3125	3125	3125	3125	3125
Sowing @ 12.5 Kg /ha 10 MD @ Rs 350/MD		3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500	3500
Cultivator @ Rs 3750 /ha		3750	3750	3750	3750	3750	3750	3750	3750	3750	3750	3750	3750	3750	3750	3750
Fertilizer (25-30 kg N, 50-75 kg P2O5)		10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000
FYM 5 tractors/ha @ Rs 3500/tractor		17500	17500	17500	17500	17500	17500	17500	17500	17500	17500	17500	17500	17500	17500	17500
Pesticide expenses (Endosulfan 35 EC or Nuvacrone 40 EC)		10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000
Harvesting Processing (2500 Kg/ha)		10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000	10000
Security		60000	60000	60000	60000	60000	60000	60000	60000	60000	60000	60000	60000	60000	60000	60000
Actual cost	8000	125875	125875	125875	125875	125875	125875	125875	125875	125875	125875	125875	125875	125875	125875	125875
Interest @ 9 %	19329	22658	22658	22658	22658	22658	22658	22658	22658	22658	22658	22658	22658	22658	22658	22658
<b>Cost of Tur dal cultivation</b>	<b>27329</b>	<b>148533</b>	<b>148533</b>	<b>148533</b>	<b>148533</b>	<b>148533</b>	<b>148533</b>	<b>148533</b>	<b>148533</b>	<b>148533</b>	<b>148533</b>	<b>148533</b>	<b>148533</b>	<b>148533</b>	<b>148533</b>	<b>148533</b>

Table 2: Cultivation cost of Tur dal (*Cajanus cajan*) on per hectare basis.

Particulars (sandalwood+tur)	0 year	1 Year	2 Year	3 Year	4 Year	5 Year	6 Year	7 Year	8 Year	9 Year	10 Year	11 Year	12 Year	13 Year	14 Year	15 Year
Site preparation (JCB @ 800 Rs/hr for 10 hr)	8000															
Cost of 400 seedlings/ha (Spacing 5×5 m) @ 30 Rs. per seedling		12000														
Cost of digging the pits; @ 350 Rs/labour; for 20 labours	7000															
Cost of Tur seed 1 Kg seeds @ Rs 250		250														
Cost of sowing primary host (Tur)		1400														
Cost of 800 kg FYM @ Rs. 5/Kg	4000															
Labour charges for FYM/ fertilizer application	1400	1400														
Cost of fertilizer		1500	1500	1500	1500	1500										
Cost of barbed wire fencing per running kilometer is 650000 rupees. For 1ha, 400 meter fencing is required (including labour)		260000														
Cost of bore well, pipe line, transformer, pump set 5HP motor, Drip irrigation		350000														
Security for sandalwood			60000	60000	120000	120000	120000	120000	120000	120000	240000	240000	240000	240000	240000	240000
Cost of Agriculture crop (Tur dal cultivation )		65875	65875	65875	65875	65875	65875	65875	65875	65875	65875	65875	65875	65875	65875	65875
Actual cost	20400	692425	127375	127375	187375	187375	185875	185875	185875	185875	305875	305875	305875	305875	305875	305875
Interest	2826	64154	73782	22928	28328	33728	33593	33458	33458	33458	44258	55058	55058	55058	55058	55058
<b>Cost of intercropping sandalwood + tur dal</b>	<b>23226</b>	<b>756579</b>	<b>201157</b>	<b>150303</b>	<b>215703</b>	<b>221103</b>	<b>219468</b>	<b>219333</b>	<b>219333</b>	<b>219333</b>	<b>350133</b>	<b>360933</b>	<b>360933</b>	<b>360933</b>	<b>360933</b>	<b>360933</b>

Table 3: Intercropping cultivation cost of Sandalwood (*Santalum album*) in combination with Tur dal (*Cajanus cajan*) on per hectare basis.

	Sandalwood sole crop	Tur dal / Red gram sole crop	Sandalwood+Tur dal intercropping	Remarks
Net Present Value	2584914	677644	2436994	Intercropping of tur dal with sandalwood is considered for initial five years. Later the shade effects of sandalwood inhibit the cultivation of tur dal.
(NPV in Rs)				
	2.58	1.68	1.93	
Benefit – Cost ratio (B/C ratio)				
Internal Rate of Return (IRR)	26%	-	29%	
Equivalent Annual Income (EAI)	43586	108423	389919	
Land Expectation Value (LEV)	2778782	728467	2619768	

Table 4: Financial analysis of sandalwood cultivation per hectare.

study through B-CA using indicators like NPV, B/C ratio, IRR, EAI and LEV. The results of three different sandalwood cultivation regimes (tur dal plantations, sandalwood plantation and sandalwood+tur dal) considered, showed financially viable as all of them have NPV greater than Zero and B/C ratios higher than one (Table 4).

The actual cost in cultivation of sandalwood per hectare is Rs. 34.40 lakhs (including interest at 9% rate), whereas when sandalwood is grown with tur dal as intercrop, cost of cultivation is Rs. 46 lakhs. The B/C ratio with 2.58, 1.68 and 1.93 was recorded for sole sandalwood, pure tur dal and combination respectively. However, combination of growing tur dal and sandalwood resulted in higher NPV of Rs. 24.37

lakhs and IRR of 29%. IRR represents the intrinsic rate of return that is expected to be derived from an investment considering the amount and timing of the associated cash flows. Though the inter-cultivation (sandalwood+tur dal) have slightly lower NPV and B/C ratio compared to pure sandalwood plantations, the possibility of yielding tur dal in inter-cultivation makes farmers comparatively more attractive as it gives some income every year. Added to this, an IRR of 29% in combination of sandalwood and tur dal suggests that the proposed investment will generate an average annual rate of return equal to 29% over the life of the project taking into consideration the amount and timing of the expected cash inflows and outflows are specific to the investments.



The NPV were expressed in terms of Equivalent Annual Income (EAI) and Land Expectation Value (LEV) to compare the annual NPV and annual returns from the particular NPV for pure sandalwood cultivation, pure tur dal cultivation and inter-cultivation of Sandalwood and tur dal; keeping in view the rotation period of sandalwood is 15 years. EAI values were high with Rs. 3.89 lakhs for inter-cultivation of Sandalwood and tur dal followed by Rs. 1.08 lakhs from pure tur dal cultivation. However, the LEV values showed higher returns for pure sandalwood cultivation and inter-cultivation of sandalwood and tur dal with Rs. 27.78 lakhs and Rs. 26.19 lakhs respectively.

## Discussion

Similar types of results were found during analysis of financial viability of sandalwood based agroforestry practices in southern India [1]. The returns that can be expected from sandalwood will depend on the yield which can influence by soil type, rainfall and management practices. This analysis does not take into account the environmental benefits that are derived from the establishment of sandalwood plantations such as providing habitat and ground water and erosion control.

The reason behind selection of tur dal in combination with Sandalwood as tur dal is an important legume crop, which helps in nitrogen fixation through symbiosis to enrich soil fertility naturally. In addition to it, they are short lived, fast growing shrub and suitable to dry climatic and poor soil conditions (drought-resistant as preferred by Sandalwood). Considering the morphology, they are shorter, less shady and significantly smaller plants making it appropriate as primary host for sandalwood beginning from nursery stages. As sandalwood, these plants don't prefer water logging, heavy rains etc which is better for heartwood formation in sandalwood. The cultivation of this highly valued gram (nutritive value) helps to earn additional profit in comparison with pure cultivation. Added to this, intercropping with and without tur dal which in turn will be an example for farmers cultivating only tur dal, so has to enhance their income by intercropping with sandalwood.

Under natural conditions, sandalwood tree at 27-30 yrs would yield 25/30 Kg of heartwood. But, under managed plantation conditions, rotation period of sandalwood is considered as 15 years because with scientific approach like initial watering at seedling stage, periodical pruning and fertilizer application, sandalwood trees easily yield at least 15 kgs of heartwood at the age of 15 yrs with the dbh of approx.15 cms (Mishra et al.). According to recent studies, heartwood initiates at the age of 6 to 8 yrs and sizable heartwood is formed at 15 years which is worth harvesting. As per Viswanath et al. [1], comparison of overall financial indicators at 15 and 20 years proved that a rotation period of 15 years is more economically viable than 20 years for all the sandalwood cultivation models under study. Added to this, beyond the age of 15 years, cost of security/protection (theft issues) increases considerably with added marginal increase in heartwood yield ending in less profit. In the international market the prices for the heartwood and sandalwood oil are quite high.

According to Mishra et al. [11], the heartwood costs more than Rs. 2 lakhs/kg for sandalwood oil. However, the retail outlets in India, like Cauvery emporium of KSHDC, Bangalore purchase heartwood at the cost of Rs. 28,000/kg. Then again, the average auction price of sandalwood in the Salem depot of Tamil Nadu during 2013 was Rs. 6500/kg. But, recently in 2016 the average e-auction price of sandalwood in Marayoor forest of Kerala was Rs. 12,000/kg. Though the costs of heartwood are high, on procurement of sandalwood from

farmers, they paid an average price of Rs. 6400/kg from Karnataka Soaps and Detergents Ltd. (KSDL), Bangalore. So, in the present study Rs. 6000/kg of heartwood and Rs. 70/kg of sapwood was considered in the calculation.

In the present scenario of sandalwood cultivation emphasizing is more on farmlands than natural forests, hence the 18 categories of pricing followed during King Tipu Sultan period (1782-1799) is not so appropriate and there is a need to rethink on reclassifying the categorization into 4 four classes viz. stem heartwood, root heartwood, sapwood and branch heartwood. Keeping in view of the present scenario the economics of sandalwood cultivation was calculated by considering the average price paid to farmers by Karnataka Soaps and Detergents Ltd. (KSDL), Bangalore on procurement of sandalwood which is Rs. 6400/kg.

The results of the financial analysis is only applicable in liberalized policy environment with open markets, where the owner is entitled to receive the full market value of the wood on extraction. According to the prevailing rules in the southern states of Karnataka and Tamil Nadu, except Kerala, even when the tree is located on private land, it belongs to the State Government and the owner of the land is required to make a declaration on the number of trees on his land [12]. The wood can be sold only to the forest department or any public sector undertaking as notified by the government from time to time. The price is determined by forest department based on the average prices of the last two auction held in Karnataka or Tamil Nadu. But, prices are not periodically renewed by forest department based on auction prices every year. Moreover, the delay in payment due to bureaucratic red tapes will further bring down the financial indicators if the time lag in payment is also accounted for. Thus the present policy regime the financial profitability of sandalwood cultivation are varied by the restrictive policies which deny farmers the full market value for their produce and compel them to go through elaborate bureaucratic procedures to receive the benefits. Hence, revamping of legal provisions related to sandalwood is urgently needed to facilitate free trade and the markets to ensure higher and speedy returns to farmers, thereby encouraging private domestication of this priced resource.

## Significance of Research

This paper aims to highlight the role and importance of economic analysis related to investment and earnings by sandalwood cultivation under semi-arid conditions of Karnataka, India. Any tree cultivation projects require detail understanding of cost requirements keeping in view of long gestation period and associated risks factors, so as to arrive at a profit oriented bankable projects adoptable by farming community. Economic analysis of sandalwood cultivation is most useful when used early at implementation stage, for identify the economic, social and environmental benefits and risks associated with project and its components.

## Conclusions

Raising of sandalwood as a sole crop cost Rs. 34.40 lakhs per hectare (including interest at 9% rate), whereas when sandalwood is grown with tur dal as intercrop, cost of cultivation is Rs. 46 lakhs. The analysis for the economics returns of the sandalwood cultivation in combination with tur crop resulted in higher NPV of Rs. 24.37 lakhs and IRR of 29%. Though the inter-cultivation (sandalwood + tur dal) have slightly lower NPV, B/C ratio and LEV but higher annual NPV (EAI) when compared to pure sandalwood plantation, the possibility of yielding tur dal in inter-cultivation makes farmers comparatively

more attractive as it gives some income every year, as farmers prefer immediate returns.

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