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RESEARCH PAPER

An empirical investigation of determinants of practicing sandalwood cultivation in Karnataka

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Abstract: *Santalum album* is a culturally and commercially important plant species. Due to the robust depletion of this resource in its natural habitat and consistent demand, caused huge demand-supply gap for sandalwood globally. The domestication of sandalwood on the farm fields through various silvicultural practices can increase the supply of sandalwood. Sandalwood being a high value crop, its cultivation requires a deep understanding of farmers' perceptions and the various socio-economic and psychological factors that influence their decision to practice sandalwood farming. Hence, the study was conducted in the Karnataka state using the snowball sampling method and the primary data was collected from 200 sample farmers. The multiple linear regression analysis was employed to analyze the determinants for practicing sandalwood cultivation in the study area. This study aims to offer empirical evidence highlighting the significant impact of these factors on the cultivation of sandalwood along with the socio-economic characteristics of sandalwood farmers. The study highlights the importance of influential factors like landholding size, farmer's age, family income, government support and market demand. By addressing these factors, the area under sandalwood can be enhanced so that India can revitalize its position in the global sandalwood industry.

Key words: Determinants, Psychological factors, Sandalwood cultivation, Socio-economic characteristics

Introduction

Santalum album commonly called East Indian Sandalwood or Indian Sandalwood has high commercial value and is known as the 'Queen of Sandalwood' among the species of genus *Santalum*, due to its high-quality oil (4-9%) and good texture of the wood (Ananthapadmanabha and Gowda, 2011). The geographical occurrence of the *Santalum album* is found in India, Indonesia and Australia. Especially, it has been an integral part of India's cultural and historical heritage. Its versatile applications pervade various dimensions of human existence as it is required from cradle to cremation in Indian culture. Sandalwood not only holds its significance within the realms of history, mythology and culture, but it also has ecological and economic importance.

In India, sandalwood was naturally distributed on the Deccan Plateau. The total extent of its distribution was around 9,034 sq. km, of which 8,285 sq. km was in the states of Karnataka and Tamil Nadu (Rai, 1990). India alone constituted 85 per cent of the total global production followed by Indonesia (10%) (Ananthapadmanabha, 2000). However, later many researchers worked to figure out the area and production of sandalwood and it is to be noted that the natural habitation of sandalwood in India has almost declined. At present, the Maryoor forest of Kerala is the only place where sandal trees grow naturally (Kumar *et al.,* 2012). The production of sandalwood in India dropped from 4,000 tonnes of heartwood per year in the 1950s to a mere 500 tonnes in 2007 (Gairola *et al*., 2007).

Karnataka, historically known as the *'Gandhada Gudi*' (Temple of Sandalwood), has a rich heritage of sandalwood. Karnataka had the highest area (5,245 sq. km) under natural habitat in India. During the 1920s, the Mysuru province had the highest number of sandalwood tracts and it alone produced approximately 2,000 tonnes of sandalwood heartwood annually (Rai and Sarma, 1990). However, in the year 2021-22, the officially recorded sandalwood harvest in Karnataka was reduced to a mere 3.22 MT (Anonymous, 2022), which indicates evidence of its robust depletion over time.

Due to its robust depletion in its natural habitats, the *Santalum album* was categorized as a 'Vulnerable' species by the International Union for Conservation of Nature in 1998 (Arunkumar *et al.,* 2019). The major causes include mortality due to spike disease, forest fires, wildlife grazing, monopoly of the government, extraction of trees in an unorganized manner through smuggling, inadequate seed-bearing tree populations and lack of established plantations. The excessive exploitation of this valuable resource, without adequate replenishment, has significantly depleted the sandalwood industry, resulting in global scarcity and a sharp rise in market prices also creating huge demand-supply gap for sandalwood.

To rectify pitfalls in policy and to encourage the private domestication of sandalwood, the Government of Karnataka came up with an amendment to the Karnataka Forest Act in 2001 and gave landowners the legal right to have sandalwood trees on their land. This was followed by the Tamil Nadu Forest (Amendment) Act of 1998 in 2002. As a result, a large number of private plantations of sandalwood along with the government plantations started all over India even in non-conventional areas.

Sandalwood is well suited to cultivation under an agroforestry system since it needs a host plant for its growth and development. It parasitizes neighbouring plant roots *via* a haustorium adaptation. More than 300 species are identified as

the hosts of sandalwood and it can parasitize from grass to other sandalwood trees under gregarious conditions (Rai, 1990). Hence, it paves the way for increasing farmer's income by adopting sandalwood based agroforestry models.

Sandalwood being a high value crop, its cultivation requires a deep understanding of farmers' perceptions and the various socio-economic and psychological factors that influence their decision to practice sandalwood farming. This study aims to offer empirical evidence highlighting the significant impact of these factors on the cultivation of sandalwood along with the socio-economic characteristics of sandalwood farmers.

Materials and methods

Karnataka state was purposively selected for the study as it has the richest heritage of sandalwood. An exponential non-discriminative snowball sampling method was employed for the selection of sandalwood farmers because of their diverse and scattered nature. This chain of sampling sequence continued until the number of farmers reached the required sample size of 200. The primary data related to the socio-economic characteristics of the sample farmers and the determinants for practicing sandalwood cultivation were collected with the help of pre-tested and well-structured interview schedules. The collected data were compiled and tabulated by working out descriptive statistics like averages, percentages and frequencies to analyze the socio-economic characteristics of sample farmers.

Multiple linear regression analysis

The multiple linear regression analysis was used for the estimation of determinants of practicing sandalwood cultivation by the farmers. The equation is given below.

$Y = f(X_1, X_2, X_3, \ldots\ldots\ldots\ldots, X_{n-1}, X_n)$

$Y = a + b_1X_1 + b_2X_2 + \ldots\ldots\ldots\ldots + b_nX_n + U$

$Y = a + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + b_6X_6 + b_7X_7 + b_8X_8 + u$

Where,

Y = Estimate of the area under sandalwood (ha)

X_1 = Landholding size of the sample farmer (ha)

X_2 = Age of the farmer (Years)

X_3 = Education of the farmer (No. of years)

X_4 = Family size of the sample farmer (No.)

X_5 = Family income of the sample farmers (₹ /annum)

X_6 = Government support and subsidies (0 = No government support and subsidies;

1 = Presence of government support and subsidies)

X_7 = Peer influence (0 = Influence by the government officials; 1 = Peer influence)

X_8 = Huge market demand (0 = Personal interest; 1 = Huge market demand)

$b_1, b_2, b_3, b_4, b_5, b_6, b_7, b_8$ = Regression coefficients

a = Intercept term

u = Error term

Breusch Pagan Test

The Breush Pagan test is a statistical test used to detect the presence of heteroscedasticity in a linear regression model. The test involves regressing the squared residuals of the original regression model on the predictor variables and testing the significance of the resulting coefficients. If coefficients are significantly different from zero, it indicates the presence of heteroscedasticity.

Weighted least square method

The weighted least squares (WLS) method was used due to the presence of heteroscedasticity. In WLS, the estimated equation minimizes *"*$w_i e_i^2$ where w_i is a weight given to the i^{th} observation. The objective was to minimize the sum of the squares of the random factors of the estimated residuals. If the variance of the i^{th} observation is $ó_i^2$, then weights $w_i = 1/ ó_i^2$ give the theoretically correct results for standard errors of coefficients and different significance tests.

Results and discussion

Socio-economic characteristics of the sample farmers

Table 1 provides a comprehensive overview of the socio-economic characteristics of the sample farmers. The average age of the sample farmers was 53.25 years and the majority of the farmers belonged to the middle age group (57.50%), followed by the old age group (40.50%). A significant proportion of these sample farmers, upon retiring from their respective professions, embraced agriculture as a passion, especially sandalwood cultivation due to its cultural and commercial importance. Many individuals in these age groups had achieved a level of financial stability through years of work and savings which enabled them to have higher risk-taking abilities. However, there were only a small number of young farmers (2.00%) in the sample.

The majority of the farmers had secondary education (36.50%) and there was also a significant percentage of farmers with graduation (31.00%) and 20.50 per cent received pre-university education. It was also observed that no sample farmer was illiterate signifying the role of education in sandalwood cultivation. The majority of the farmers were from joint families (59.00%) and there was also a significant percentage of farmers from nuclear families (41.00%). The average family size was 6.85 members. The average number of males and females in a family was 2.50 and 2.51, respectively and the average number of children in a family was 1.84.

Most of the farmers were actively involved in social participation. The most common form of social participation was through sandalwood farmers associations (54.50%), followed by sandalwood-related trainings (30.00%). However, 1.50 per cent of the farmers actively participated in both of these. Since sandalwood cultivation gained prominence in recent decades after the liberalization of the policies and only a limited number of farmers had prior experience with successful harvests, many farmers faced uncertainties regarding cultivation practices. This prompted their inclination to seek association with like-minded individuals to address the challenges arising during cultivation.

Table 1. Socio-economic characteristics of sample farmers in the study area n = 200

SN	Particulars	No. of farmers	Per cent
I. Age			
1.	Young (< 35 years)	04	2.00
2.	Middle-aged (36 to 55 years)	115	57.50
3.	Old-aged (> 55 years)	81	40.50
	Total	200	100.00
	Average age (Years)	53.25	
II. Education			
1.	Primary Education	19	9.50
2.	Secondary Education	73	36.50
3.	Pre-university Education	41	20.50
4.	Graduation	62	31.00
5.	Post-graduation	05	2.50
	Total	200	100.00
	Average Education (Years)	11.86	
III. Family type			
1.	Nuclear	82	41.00
2.	Joint	118	59.00
3.	Total	200	100.00
IV. Family composition (Average No.)			
1.	Male	2.50	36.50
2.	Female	2.51	36.57
3.	Children	1.84	26.93
	Total	6.85	100.00
V. Social participation			
1.	No active social participation	18	9.00
2.	Panchayat	10	5.00
3.	Sandalwood farmers associations	109	54.50
4.	Sandalwood-based trainings	60	30.00
5.	Both Sandalwood farmers associations and Sandalwood-based trainings	03	1.50
	Total	200	100.00
VI. Occupational pattern			
1.	Agriculture and allied	123	61.50
2.	Agriculture and allied + Business	23	11.50
3.	Agriculture and allied + Service	54	27.00
	Total	200	100.00
VII. Family income			
1.	Group A (< ₹ 7,50,000 per annum)	87	44.50
2.	Group B (₹ 7,50,000 to ₹ 20,00,000 per annum)	67	33.50
3.	Group C (> ₹ 20,00,000 per annum)	44	22.00
	Total	200	100.00
4.	Average family income (₹ /annum)	24,95,500	
VIII. Income distribution of the family (₹ /annum)			
1.	Agriculture and allied activities	17,27,760	
2.	Business	5,33,550	
3.	Service	4,52,340	
IX. Landholding size			
1.	Marginal farmers (< 1 ha)	19	9.50
2.	Small farmers (1 to 2 ha)	45	22.50
3.	Semi-medium farmers (2 to 4 ha)	60	30.00
4	Medium farmers (4 to 10 ha)	51	25.50
5.	Large farmers (> 10 ha)	25	12.50
	Total	200	100.00
X. Average size of landholding (ha)			
1.	Rainfed	0.76	14.81
2.	Irrigated	4.37	85.19
	Total	5.13	100.00

About 61.50 per cent of the farmers were engaged in agriculture and allied activities. A small number of farmers were engaged in agriculture and allied activities along with service (27.00%) and business (11.50%). The majority of the farmers had a family income of less than ₹ 7,50,000 per annum (44.50%) and 33.50 per cent of the farmers had a family income of ₹ 7,50,000 to ₹ 20,00,000 per annum. Comparatively, the least number (22.00 %) of farmers had a family income of more than ₹ 20,00,000 per annum. The average family income was ₹ 24,95,500 per annum, showcasing a noteworthy level of financial stability among the farmers and indicating their capacity to undertake risks which insisted on making investments in sandalwood cultivation. In addition, the majority of the farmers belonged to the category of semi-

Table 2. Determinants of practicing sandalwood cultivation in the study area n=200

(Dependent variable = Area under sandalwood in hectare)

Variables	Regression coefficients	Standard Error	P-value
Intercept	9.949***	2.800	<0.001
Landholding size	0.604***	0.120	<0.001
Age of the farmer	0.068**	0.036	0.049
Education of the farmer	0.056	0.123	0.647
Family size	-1.072***	0.124	<0.001
Family income	0.0003*	0.687	0.092
Government support and subsidies[#]	7.098***	0.977	<0.001
Peer Influence[##]	-5.299***	0.907	<0.001
Huge market demand[###]	2.911***	0.957	0.002
R^2	0.869		
Adjusted R^2	0.868		

Note: ***, ** and * represents the level of significance at one, five and ten per cent respectively

[#] Dummy variable 1: No Government support and subsidies = 0 Government support and subsidies = 1

[##] Dummy variable 2: Influence by the Government officials = 0 Peer influence = 1 [###] Dummy variable 3: Personal Interest = 0 Huge market demand = 1

medium farmers (30.00%). Among the total sample farmers, 25.50 and 22.50 per cent were medium and small farmers, respectively. The average size of landholding was 5.13 hectares, among which 0.76 hectares (14.81%) was under rainfed and 4.37 hectares (85.19%) was under irrigated conditions.

Determinants of practicing sandalwood cultivation

Table 2 presents the results of a multiple linear regression analysis using the weighted least square method which was aimed at identifying the determinants influencing the practice of sandalwood cultivation in Karnataka. The adjusted R^2 value of 0.868 indicated that approximately 86.80 per cent of the variation in the area under sandalwood cultivation was explained by the independent variables included in the model. These values suggest that the model fits the data well. In the model, the area under sandalwood cultivation was considered as the dependent variable. The average area under sandalwood was 1.74 hectares. The quantitative independent variables such as landholding size, age of the farmer, education of the farmer, family size and family income and three dummy variables such as government support and subsidies, peer influence and huge market demand were included in the model.

The regression coefficient for landholding size was 0.604 hectares, which was highly significant at one per cent level and implies that, for every one hectare increase in landholding size of the sample farmer, there was an associated 0.604 hectares increase in the area under sandalwood cultivation. This was because the larger landholdings offered more area for diversification and experimentation with high-value crop like sandalwood. Similarly, one year increase in the age of the farmer was associated with an increase in 0.068 hectares of area under sandalwood, which was found significant at five per cent level. Because the age-old farmers had higher risk-taking abilities as they achieved a level of financial stability. Moreover, these farmers had a sense of tradition and heritage towards sandalwood which encouraged them to cultivate sandalwood.

However, the coefficient for family size was negative (-1.072) and significant at one per cent level. This implies that for every one per cent increase in family size of the farmers, there was a 1.072 per cent decrease in the likelihood of farmers practicing sandalwood cultivation reflecting a strategic effort by farmers with larger families to mitigate potential future land conflicts. This precautionary approach arose from their concern over the possibility of land fragmentation in the future. In addition, family income had a positive impact on practicing sandalwood cultivation at ten per cent level of significance.

The value of coefficient for government support and subsidies was found to be 7.098, which was highly significant at one per cent level. The farmers who received government support and subsidies were 7.098 times more likely to had larger area under sandalwood cultivation compared to those who did not receive such support. The farmers who benefitted from government support and subsidies were more likely to have larger areas under sandalwood compared to the farmers with no such benefits. The government was providing sandalwood saplings at a subsidized rate of ₹ 3 per sapling under the Raising Seedlings for Public Distribution (RSPD) scheme. Also, the government has supported the farmers by encouraging sandalwood cultivation on their own land through liberalization policies.

The coefficient for peer influence was negative (-5.299) and found to be highly significant at one per cent level. The farmers influenced by their peers were 5.299 times less likely to had a larger area under sandalwood cultivation compared to those influenced by government officials. The involvement and endorsement of government officials, particularly those from the forest department, enhanced a strong sense of trust and confidence to cultivate sandalwood among the sample farmers. Similarly, the coefficient for huge market demand was 2.911 and highly significant at one per cent level. The farmers motivated by the opinion of significant market demand for sandalwood

were 2.911 times more likely to had larger area under sandalwood cultivation compared to those driven just by their personal interest. Nonetheless, the education of the farmer didn't have any significant influence on the area of sandalwood.

Conclusion

Santalum album, the world's second most expensive wood with significant cultural and commercial value, faces a growing supply shortage, leading to a substantial demand-supply gap. While India historically met 85 per cent of global demand, it is losing its economic advantage. To maintain its global position, India must prioritize cultivating sandalwood under controlled conditions and providing practical alternatives to boost the supply of this precious resource. The domestication of sandalwood in farm fields is influenced by farmers' socio-economic and psychological characteristics. This study emphasized that landholding size, age of the farmer, family income, government support and subsidies and huge market demand for sandalwood significantly influenced the farmers to cultivate sandalwood. The family size and peer influence had negative influence and however, education of the farmers didn't play a significant role in practicing sandalwood cultivation. It was found that young farmers participated to a lesser extent in sandalwood cultivation, but due to the long gestation period of sandalwood, cultivators have a considerable opportunity to gain greater benefits as they grow older. Encouraging their participation through specialized training programs can boost their future income. The farmers influenced by government officials, particularly forest officials allocated more land to sandalwood, due to the strong sense of trust in government support. Expanding this approach to promote sandalwood cultivation and providing technical guidance can enhance the cultivation of sandalwood in larger areas. The study also provides a vision to encourage the cultivation of sandalwood to improve the livelihood of other farmers.

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