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Economic appraisal of adoption of the grow-own-fuel initiative in FCV tobacco curing: Empirical evidence from Mysuru and Hassan districts of Karnataka

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Abstract
The study examines fuelwood usage patterns, traceability, and sustainability initiatives in FCV tobacco curing in the Mysuru and Hassan districts of Karnataka, with emphasis on the Grow Own Fuel (GOF) initiative. Primary data from 391 FCV tobacco growers were analyzed to assess curing energy sources, fuelwood procurement methods, and the economic implications of GOF adoption, highlighting its role in enhancing energy efficiency and production sustainability. Fuelwood continues to be the primary energy source for FCV tobacco curing, with 91.8 percent of farmers relying on it, while adoption of alternative fuels remains limited. Nearly half of the farmers sourced fuelwood from Grower-Owned Forests (GOF), reducing dependence on commercial vendors and associated price risks. Eucalyptus emerged as the most preferred GOF species due to its fast growth and fuel efficiency. Economic analysis showed that GOF adopters incurred lower cultivation costs (₹92,009 per acre) than non-adopters (₹1,07,722 per acre), mainly due to reduced fuelwood expenditure. Fuelwood accounted for only 2.35 percent of total costs among adopters compared to 15.83 percent among non-adopters. GOF adopters also achieved higher gross returns (₹1,67,048 per acre), net returns (₹75,039 per acre), and better returns per rupee of expenditure (1.82). The study highlights that GOF adoption enhances economic efficiency, reduces external fuelwood dependence, and supports sustainable FCV tobacco production, underscoring the need for strengthened policy and technical support to promote wider adoption.

Keywords: Traceability, sustainability, grow own fuel, gross returns, net returns, economic efficiency

Introduction

Tobacco (*Nicotiana tabacum* L.) cultivation remains a significant contributor to India's agrarian economy, supporting rural livelihoods, employment generation, and foreign exchange earnings. India is one of the world's leading producers and exporters of unmanufactured tobacco, exporting approximately 315.50 million kilograms during 2023-24 and earning a record ₹12,005.89 Crore. This growth, representing an increase of over 87 percent compared to 2019-20, has positioned India as the second-largest producer and exporter of unmanufactured tobacco globally. Beyond export revenues, the tobacco sector supports the livelihoods of nearly 45.70 million people across cultivation, curing, marketing, and allied activities, underscoring its socio-economic importance.

A distinctive feature of Indian tobacco cultivation is the diversity of tobacco types grown across varied agro-climatic regions. Among these, Flue-Cured Virginia (FCV) tobacco occupies a prominent position due to its export orientation and superior leaf quality. FCV tobacco is predominantly cultivated in Andhra Pradesh and Karnataka, with Karnataka producing the KLS variety mainly in the Mysuru and Hassan districts. The production and marketing of FCV tobacco in India are regulated by the Tobacco Board under the Ministry of Commerce and Industry, which oversees licensing, crop size determination, and marketing through electronic auction platforms. In 2023-24, FCV tobacco farmers realized favorable prices, reflecting improved market conditions and quality standards. However, rising production costs, climate variability, and energy-related constraints continue to pose challenges to the sustainability of FCV tobacco farming.

Curing is a critical and energy-intensive stage in FCV tobacco production, as it determines the color, texture, and overall quality of the cured leaf. The curing process involves controlled heating of harvested tobacco leaves in specially designed barns over a period of five to six days. In Karnataka alone, more than 51,000 registered curing barns are operational, primarily in the Mysuru and Hassan districts. Fuel wood is the principal source of energy for curing, making its availability, cost, and sustainability central to the economic viability of FCV tobacco cultivation.

An estimated 300,000-350,000 tonnes of fuel wood are consumed annually for tobacco curing in Karnataka. While a substantial portion of this fuel wood is sourced from trees outside forests, such as farm forestry and agroforestry systems, the sector remains largely unorganized, leading to challenges related to traceability, quality consistency, price volatility, and long-term sustainability. Increasing dependence on externally sourced fuel wood has further heightened production costs for farmers, raising concerns about the environmental footprint and economic resilience of FCV tobacco systems.

In response to these challenges, sustainability-oriented initiatives promoting efficient and traceable fuel wood sourcing have gained importance. One such initiative is the "Grow Own Fuel" (GOF) concept, which encourages tobacco farmers to raise fast-growing tree species such as eucalyptus, silver oak, and *melia dubia* on their own lands or nearby plots to meet curing fuel requirements. The GOF approach aims to reduce dependence on market-purchased fuel wood, stabilize energy costs, enhance traceability, and alleviate pressure on natural forests. Complementary measures, including fuel-efficient curing technologies and the use of alternative biomass sources, further support sustainable energy management in tobacco curing.

Corporate and institutional interventions have played a significant role in advancing sustainable fuel wood practices. Notably, ITC Limited, through its Social Investment Programme (SIP) on Sustainable Tobacco Cultivation, has facilitated large-scale agroforestry and energy plantation development in Karnataka. Over the past decade, such initiatives have contributed to the expansion of sustainable fuel wood plantations in major tobacco-growing regions, improving fuel security while promoting environmental conservation and climate resilience. Despite the growing emphasis on sustainability, empirical evidence on fuel wood usage patterns, species composition, sourcing mechanisms, and the economic impact of GOF adoption at the farm level remains limited. Understanding these aspects is crucial for designing policies and interventions that enhance both profitability and sustainability in FCV tobacco production systems.

Against this backdrop, the present study undertakes a comprehensive assessment of fuel wood usage, species composition, traceability, and sustainability initiatives in FCV tobacco curing in the Mysuru and Hassan districts of Karnataka. Specifically, the study evaluates the type of fuel wood used for curing and quantifies the economic impact of the Grow Own Fuel (GOF) initiative on the cost of production of cured tobacco. The findings are expected to provide valuable insights for policymakers, farmers, and stakeholders to promote sustainable, cost-effective, and resilient fuel wood management strategies in the FCV tobacco sector.

Methodology

Study Area: The study was conducted in Mysuru and Hassan districts of Southern Karnataka, selected for their prominence in Flue-Cured Virginia (FCV) tobacco cultivation and concentration of curing barns. To understand regional fuelwood dynamics, supplementary information was collected from Mandya, Ramanagar, and Kodagu districts.

Sampling and Data Collection: A multistage purposive-random sampling approach was employed. Ten Tobacco Auction Platforms (TAPs) were selected across the two districts, and 391 FCV tobacco farmers were drawn using Population Proportionate to Size Random Sampling (PPSRS) from a total population of 16,779 registered farmers.

The sample size was determined using Raosoft's sample size calculation method by considering:

$n = Z^2 * P(1-P)/e^2$

Where,

n= Sample size

Z= Confidence coefficient

P= Population proportion

e= margin of error

The Sample farmers are drawn using Population Proportionate Simple Random Sampling (PPSRS) method as below:

TAP	No. of farmers in TAP (N)	Sample respondents (n)
1	1048	25
2	1394	32
3	1808	42
4	1680	38
5	1993	45
6	2966	70
7	845	20
62	3223	73
63	930	25
64	892	21
Total	16779	391

Additionally, 30 fuelwood vendors were surveyed. Primary data were collected through structured face-to-face interviews conducted during July 2025, covering socio-economic characteristics, tobacco cultivation and curing practices, fuelwood types and sources, costs, GOF adoption, and energy-efficient practices. Qualitative insights were obtained via Focus Group Discussions (FGDs) with farmers and vendors. Secondary data were sourced from Tobacco Board of India reports, ITC sustainability documents, and Forest Department records.

Analytical Tools: Descriptive statistics, including means, percentages, and tabular analysis, were used to summarize socio-economic characteristics, fuelwood usage, and sourcing patterns. Garrett's ranking technique was applied to identify factors influencing GOF adoption. As per the Garrett's ranking technique, the percentage positions were calculated by the following formula:

$$\text{Percent position} = \sum_{j=1}^{n} [(Rij - 0.5) / Nj] * 100$$

Where,

R_{ij}= Rank given for the i^{th} item by the j^{th} individual, and

N_j= Number of items ranked by the j^{th} individual

Economic Analysis: The impact of GOF adoption on costs and returns was evaluated using standard cost-return analysis. Costs were categorized into fixed (including depreciation and interest on curing barns) and variable (labour, inputs, fuelwood, and interest on working capital) components. Depreciation was estimated using the straight-line method over a 20-year lifespan. Gross returns were calculated based on cured tobacco output and market prices, while net returns and returns per rupee of expenditure were used to assess economic efficiency.

Results and Discussion

This section presents a comprehensive analysis of fuelwood usage, sourcing patterns, species composition, motivational factors for adoption of Grow Own Fuel (GOF), and the economic implications of GOF adoption in Flue-Cured Virginia (FCV) tobacco cultivation in Mysuru and Hassan districts. The discussion integrates quantitative and qualitative insights to highlight patterns, farmer strategies, and implications for sustainable tobacco production.

Fuel types used for tobacco curing

The study revealed that fuelwood remains the predominant energy source for curing FCV tobacco, with 91.81 percent of the sample farmers relying on it (Table 1). Although the unit price of fuelwood (₹4,783 per tonne) was marginally higher than that of alternative fuels such as coffee husk (₹3,700 per tonne), farmers continued to prefer fuelwood due to its higher calorific value, ease of handling, and ability to provide sustained and uniform heat essential for consistent leaf curing. Similar dominance of fuelwood in FCV tobacco curing has been widely reported in earlier studies, which emphasize its superior combustion characteristics and reliability compared to agricultural residues (Shankar *et al.,* 2017) [13].

Table 1: Fuel types used for tobacco curing by sample farmers in the study area

Type of Fuel	Number	Percent (%)	Price (Rs./tonne)
Fuel wood	359	91.81	4783
Coffee husk	3	0.76	3700
Coffee root	8	2.04	4212
Mixed fuel	21	5.37	4072
Total	391	100	

Only a small proportion of respondents reported using alternative fuels, with 2.04 percent using coffee roots, 0.76 percent using coffee husk, and 5.37 percent using mixed fuels. Mixed fuels typically comprised combinations of fuelwood, coffee residues, or coconut fronds, used primarily to reduce costs or modify combustion behaviour. However, the limited adoption of these alternatives suggests that technical suitability and consistency of heat output are prioritized over marginal cost savings. Previous studies have similarly noted that agricultural residues often suffer from lower energy density, higher moisture content, and inconsistent combustion, which can adversely affect curing efficiency and leaf quality (Reddy and Prakash, 2021) [12].

The minimal use of coffee residues and mixed fuels further reflects logistical challenges associated with collection, storage, and handling, as well as concerns over smoke generation and uneven heat distribution during curing. Kumar *et al.,* (2020) [5] reported that such fuels may lead to fluctuations in barn temperature and potential deterioration in cured leaf quality, discouraging their widespread adoption. Overall, the findings underscore farmers' strong preference for proven, high-energy fuelwood sources to maintain curing efficiency, product quality, and operational reliability, consistent with earlier research on energy use patterns in FCV tobacco curing systems.

Fuelwood supply sources

Fuelwood supply patterns in the study area indicate a gradual shift towards self-sufficiency through Grow Own Fuel (GOF) initiatives. Nearly half of the surveyed farmers (48.85 percent) sourced fuelwood from their own plantations, while 42.20 percent depended on commercial vendors and 8.95 percent obtained fuelwood from neighbouring or fellow farmers (Table 2). This distribution suggests that although market dependence remains substantial, an increasing proportion of farmers are adopting on-farm fuelwood production to reduce exposure to supply constraints and escalating fuelwood prices.

Table 2: Fuel wood supply sources for tobacco curing in the study area

Fuel wood sources	Number	Percent (%)
Grow Own Fuel	191	48.85
From neighbouring/ fellow farmers	35	8.95
Fuel wood vendors	165	42.20
Total	391	100.00

The growing reliance on GOF reflects not only economic considerations but also a deliberate risk-management strategy. Farmers producing their own fuelwood are better insulated from uncertainties associated with commercial suppliers, such as price volatility, inconsistent quality, and delayed availability during peak curing periods. Similar shifts towards self-reliant fuelwood systems have been reported in FCV tobacco-growing regions of Karnataka and Andhra Pradesh, where on-farm fuelwood plantations were found to significantly reduce dependence on external markets and enhance energy security (Shankar *et al.,* 2017) [13].

The relatively low dependence on neighbouring farmers for fuelwood suggests a declining role of informal sharing arrangements, likely due to increasing fuel demand and the prioritization of self-produced resources. This observation is consistent with findings by Singh and Kumar (2020) [5], who noted that as fuelwood scarcity intensifies, farmers tend to retain on-farm biomass for their own use rather than sharing or selling it locally. Overall, the observed fuelwood sourcing pattern highlights a strategic balance between self-reliance and market dependence, reinforcing the role of GOF as a viable approach for improving energy security and stabilizing production costs in FCV tobacco cultivation. These results are in conformity with earlier studies emphasizing the importance of grower-managed fuelwood systems in reducing vulnerability to fuelwood market fluctuations and ensuring sustainable curing operations (Kumar *et al.,* 2020) [5].

Species composition of fuelwood

Farmers practicing Grow Own Fuel (GOF) predominantly planted fast-growing, high-calorific-value tree species to meet the substantial energy demand associated with FCV tobacco curing (Table 3). Among the species planted, *eucalyptus* accounted for the highest share (26.58%), followed by silver oak (17.41%) and *melia dubia* (14.24%). Other species such as *pongamia*, *hercules*, *casuarina*, *tamarind*, and *neem* were planted in relatively smaller proportions, primarily serving as supplementary fuelwood sources or providing additional agro-ecological benefits.

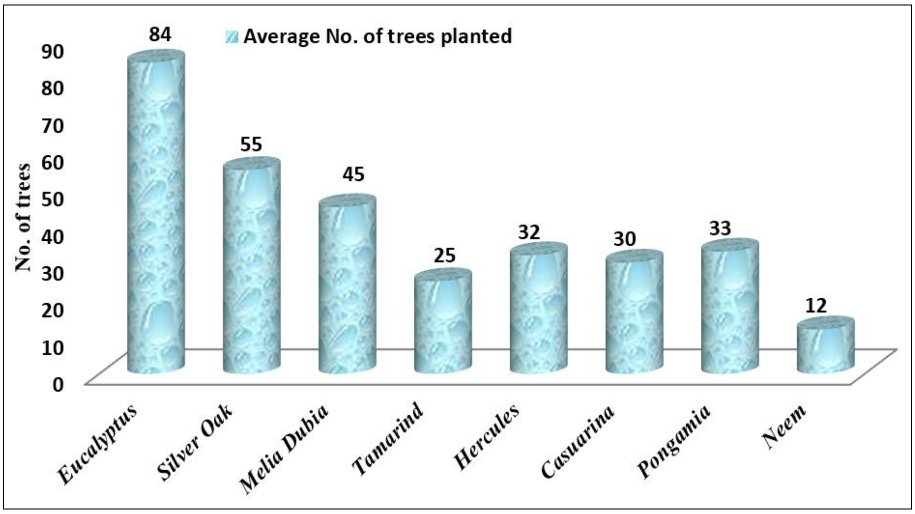

Fig 1: Species-wise distribution of fuel wood planted by sample farmers in the study area

The predominance of *eucalyptus* and *silver oak* reflects farmers' preference for species with rapid biomass accumulation, high calorific value, and consistent combustion characteristics, which are essential for maintaining uniform heat during the intensive curing process. Similar species preferences have been documented in FCV tobacco-growing regions of Southern India, where *eucalyptus* and *silver oak* were identified as the most efficient and reliable fuelwood species for curing barns (Shankar *et al.,* 2017 and Rao *et al.,* 2018) [13, 11]. The increasing adoption of *melia dubia* further aligns with findings by Kumar *et al.* (2020) [5], who highlighted its fast growth, high fuel efficiency, and adaptability to diverse agro-climatic conditions.

Table 3: Species-wise distribution of fuel wood planted by sample farmers in the study area

Type of fuel wood planted	Average No. of trees planted	Percent
Eucalyptus	84	26.58
Silver Oak	55	17.41
Melia Dubia	45	14.24
Pongamia	33	10.44
Hercules	32	10.13
Casuarina	30	9.49
Tamarind	25	7.91
Neem	12	3.80
Total	316	100.00

The inclusion of multipurpose and slower-growing species such as *pongamia*, *casuarina*, *neem*, and *tamarind* indicates a diversification strategy aimed at enhancing long-term sustainability (Fig.1). Previous studies have reported that integrating nitrogen-fixing and multipurpose tree species within agroforestry systems contributes to improved soil fertility, biodiversity conservation, and resilience of farm energy systems (Singh and Kumar, 2020) [5]. Thus, the observed species composition suggests that farmers strategically balance short-term energy requirements with long-term ecological and resource management objectives.

Overall, the species selection pattern observed in the study area demonstrates a pragmatic approach to fuelwood management, enabling farmers to ensure a reliable energy supply during peak curing periods while simultaneously addressing soil health and sustainability concerns. These findings are in conformity with earlier research emphasizing the role of species diversification in strengthening the economic and environmental performance of GOF and agroforestry-based energy systems in tobacco cultivation.

Motivational factors for GOF adoption

Economic considerations emerged as the primary drivers of GOF adoption among FCV tobacco growers (Fig. 2). Garrett's ranking analysis revealed that reduction in fuelwood costs was the most influential factor motivating adoption, with the highest Garrett Mean Score of 63.63, followed by availability of land for plantation (59.12) and subsidy support (43.21) (Table 4). Ease of access to quality saplings received the lowest score (33.03), indicating that input availability was a relatively minor constraint in comparison to economic incentives. These findings clearly suggest that farmers perceive GOF primarily as a cost-saving strategy rather than an environmentally driven intervention.

Table 4: Reasons for adoption of Grow Own Fuel by sample respondents in the study area

Reasons	Garret Mean Score	Ranking
For reducing fuel cost	63.63	1
Land available for such plantation	59.12	2
Subsidy for plantation	43.21	3
Ease of quality sapling availability	33.03	4

The dominance of fuel cost reduction as a motivating factor is consistent with earlier studies, which reported that rising energy prices and uncertainty in fuelwood supply significantly influence farmers' decisions to adopt on-farm fuelwood and agroforestry systems (Rao *et al.,* 2018 and Singh and Kumar, 2020) [11, 5]. Similarly, Patil *et al.* (2019)

[9] observed that land availability plays a crucial enabling role in the adoption of tree-based interventions in FCV tobacco systems, particularly where marginal lands and field bunds can be utilized without affecting crop area. The positive influence of subsidies on adoption aligns with findings by Kumar *et al.* (2020) [5], who emphasized that financial incentives and institutional support lower initial establishment barriers and encourage wider participation in fuelwood plantation programmes.

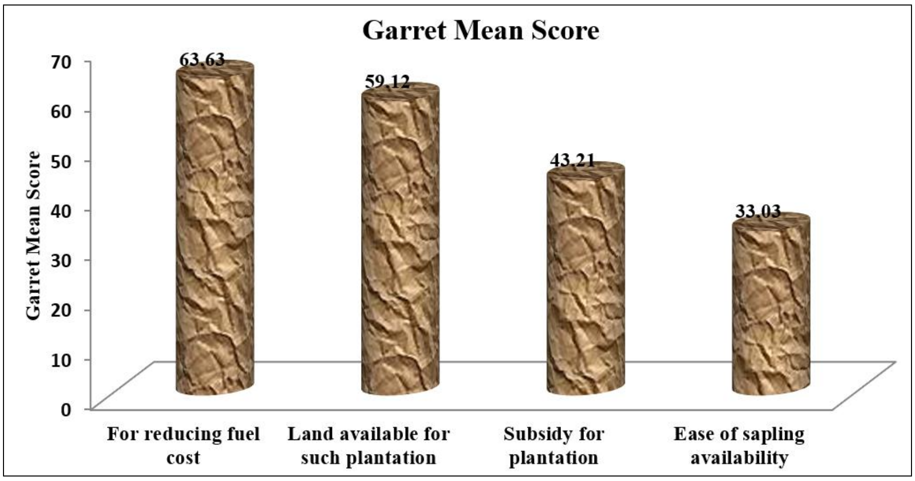

Fig 2: Reasons for adoption of Grow Own Fuel by sample respondents in the study area

Overall, the results indicate that GOF adoption is largely pragmatic in nature, driven by the objective of achieving self-reliance in fuelwood supply and reducing operational costs rather than by purely ecological considerations. Nevertheless, the facilitating role of subsidies and land availability underscores the importance of supportive policy frameworks, targeted incentives, and institutional backing in promoting wider and sustained adoption of GOF practices.

Economic performance of GOF adoption

The comparative analysis of costs and returns between GOF adopters and non-adopters reveals substantial economic advantages associated with the initiative (Table 5). The total cost of cultivation for GOF adopters was ₹ 92,009 per acre, which was considerably lower than that of non-adopters (₹1,07,722 per acre). The cost reduction of ₹ 15,713 per acre was primarily attributed to decreased dependence on purchased fuelwood, highlighting the role of on-farm fuelwood production in stabilizing input costs. Similar cost-saving effects of self-sourced fuelwood systems have been reported by earlier studies on tobacco curing and agroforestry-based energy systems (Rao *et al.*, 2018 and Singh and Kumar, 2020) [11, 5].

Fuelwood expenditure constituted only 2.35 percent of the total cultivation cost among GOF adopters, compared to 15.83 percent for non-adopters, indicating a substantial improvement in cost efficiency. Variable costs accounted for 71.14 percent of total costs for GOF adopters, which was lower than the 75.50 percent observed for non-adopters, while fixed costs were marginally higher among adopters (28.86 percent) than non-adopters (24.50 percent). The relatively higher expenditure on farmyard manure among GOF adopters reflects greater investment in soil fertility management and sustainable production practices, a trend consistent with findings reported by Patil *et al.* (2019) [9] in FCV tobacco-based farming systems.

Table 5: Cost and returns of FCV tobacco cultivation in the study area, (Rs./Acre)

Sl. No.	Particulars	Farmers who have adopted GOF (n=191)		Farmers who did not adopt GOF (n=200)	
		Value (Rs.)	Percent (%)	Value (Rs.)	Percent (%)
A	Cost				
	Land preparation	4105	4.46	4362	4.05
	Seeds and sowing	3244	3.53	3019	2.80
	Tray and coco peat	2601	2.83	2457	2.28
	Farm yard manure	8055	8.75	7391	6.86
	Fertilizer application	12349	13.42	12171	11.30
	Plant protection chemicals	873	0.95	932	0.87
	Weeding and intercultivation	6114	6.65	6035	5.60
	Harvesting and curing	19617	21.32	20418	18.95
	Fuel wood for curing	2164	2.35	17052	15.83
	Grading and transportation	1482	1.61	1468	1.36
	Interest on working capital @ 8%	4848	5.27	6024	5.59
I	Total variable cost (TVC)	65452	71.14	81329	75.50
	Rental value of land	14358	15.61	15127	14.04
	Land revenue and license fee	187	0.20	183	0.17
	Depreciation	9166	9.96	8255	7.66
	Interest on fixed capital @ 12%	2845	3.09	2828	2.63

II	Total fixed cost (TFC)	26556	28.86	26393	24.50
III	Total Cost (TVC + TFC)	92009	100	107722	100
B	**Returns**				
	Cured tobacco leaves produced (kg)	628		619	
	Gross returns	167048		164654	
	Net returns	75039		56932	
	Net return over total variable cost	101596		83325	
	Returns per rupee of expenditure	1.82		1.53	

Although the yield advantage of GOF adopters over non-adopters was modest (628 kg per acre versus 619 kg per acre), higher gross returns were realized by GOF adopters (₹1,67,048 per acre) compared to non-adopters (₹1,64,654 per acre). This translated into significantly higher net returns of ₹75,039 per acre for GOF adopters, as against ₹56,932 per acre for non-adopters. These findings corroborate earlier studies which observed that reductions in energy-related input costs have a more pronounced effect on profitability than marginal yield gains in FCV tobacco cultivation (Shankar *et al.,* 2017; Reddy and Prakash, 2021) [13, 12].
Furthermore, the return per rupee of expenditure was markedly higher for GOF adopters (1.82) compared to non-adopters (1.53), underscoring the superior economic efficiency and cost-effectiveness of self-sourced fuelwood systems. Overall, the results clearly indicate that GOF adoption not only reduces production costs but also enhances farm profitability, reaffirming its economic viability as a sustainable energy strategy for FCV tobacco cultivation. These findings are in conformity with earlier research emphasizing the role of grower-managed fuelwood resources in improving income stability and reducing vulnerability to market-driven energy price fluctuations (Kumar *et al*., 2020) [5].

Conclusion and policy implications

The study reveals that FCV tobacco curing in the Mysuru and Hassan districts remains highly dependent on fuelwood, sourced primarily from Grow Own Fuel (GOF) plantations, neighbouring farmers, and commercial vendors. Adoption of GOF significantly lowers fuelwood expenditure, enhances net returns, and improves the overall cost efficiency of tobacco cultivation. However, continued reliance on external fuelwood sources, limited diversification of fuelwood species, and regulatory constraints pose challenges to the long-term sustainability of the system.

To address these challenges, policy interventions should focus on strengthening GOF adoption through targeted extension services, technical guidance, and incentives that encourage on-farm cultivation of fast-growing, high-calorific fuelwood species and ensure timely availability of fuel. Promoting diversification of fuelwood species by integrating multipurpose and nitrogen-fixing trees such as *casuarina*, *albizia*, and *pongamia* on marginal lands and field bunds can enhance soil health, biodiversity, and supplementary fuel supply. Financial and land-use support in the form of subsidies or low-interest credit is essential to enable small and medium farmers to establish fuelwood plantations without compromising tobacco cultivation. Furthermore, strengthening farmer awareness and institutional support through training programmes, exposure visits, and advisory services can facilitate wider adoption of energy-efficient curing practices, sustainable fuelwood management, and cooperative resource-sharing mechanisms.

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