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Overview of the Rubber plantations in Kanyakumari district with special reference to rubberwood industry

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Abstract

Kanyakumari district of Tamil Nadu is a significant producer of natural rubber in India. However, rubber cultivation is slowly becoming less profitable for the growers. Scientific research greatly aids in understanding the threats and opportunities to the development of any industry. The present study reviews the research carried out on the rubber plantations of the district. The low research interest and the research lacuna in rubber plantations of the district are identified. There is no previous research on the properties, utilization, or potential applications of rubberwood in the district. Underutilization of rubberwood can be considered a primary reason for the gradual decline of interest in rubber plantations of the district. Despite its uniqueness and good structural properties, people still view rubberwood as a waste or by-product. It has been mainly used as firewood or in single-use applications which require low or no value addition. Theoretical quantitative assessment of the district's rubberwood was done due to the absence of data. The present value of rubberwood in the district is understood from levels of value addition. This study serves as a base for further research by providing an overview of the rubber plantations in the district with detailed insight into rubberwood utilization.

Keywords : Kanyakumari, resource development, rubber industry, rubber tree, rubberwood, Wood industry.

Introduction

In India, the Kanyakumari district of Tamil Nadu occupies about 3% of the nation's rubber plantation area. However, rubber plantations in the district are presently witnessing signs of decline and discontent. Multiple issues like low return on investment, wage conflict, labor issues, fluctuating rubber prices, pest attacks, and low rubberwood price force growers to look at more financially rewarding cash crops like palm trees.

It is well observed that scientific research on the problems, opportunities, feasibility in implementing practices, and advancements followed elsewhere in the world play a vital role in the growth and development of any industry. The rubber industry is no exception. Data compiled from google scholar shows low research interest in the rubber plantations of the district, with an average of 2 research articles per year. 37% of the published articles encompass the social, economic, and marketing facets of rubber plantations in the district.

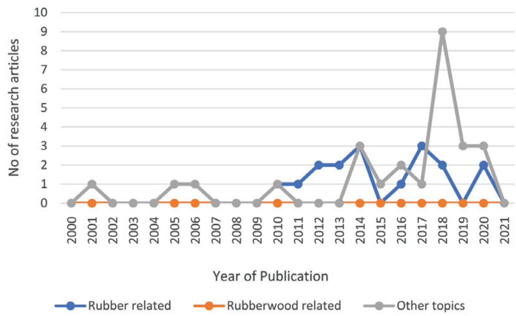

Figure 1. Research article publications related to the rubber plantations in the Kanyakumari district.

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Fig. 1 shows an increase in research publications after 2010. Some studies are redundant, and the lack of information forces some authors to rely on outdated data for analysis, resulting in significant errors. Other research areas include the health, psychological, and labor aspects of plantation workers, geospatial mapping, and environmental impact. The authors have failed to find evidence of any investigation into rubberwood or its value addition in the Kanyakumari district to date.

This paper aims to identify the current research areas, present statistically relevant data to nurture future research and emphasize the importance of rubberwood in making rubber plantations more financially rewarding through value addition, highlighting the threats and opportunities.

1. Social, Economic and Geospatial studies in rubber plantations of Kanyakumari district

An assessment of the socio-economic condition of the rubber plantation workers was carried out on a sample size of 326 laborers. The critical findings of the study indicate that the earnings of 72.1% of respondents are between ₹ 300-500 per day. 46.9% of respondents' annual income is below one lakh per annum. 50.9% of respondents have only one earning member in the family. 71.2% of the respondents are landless (Binitha et al., 2018).

A pilot study conducted on randomly selected 200 respondents from regions of the traditional belt, including Kanyakumari district, showed an inclination rate of 75% towards growing banana as an intercrop during the initial three years. The cultivation of banana as an intercrop is favored because of the availability of water, suitability of climatic conditions, and assured market for the yield. In addition, Intercropping reduces weed growth and acts as an alternative source of income (Siju et al., 2015).

A study on 150 rubber growers in the district was done to understand the general adoption rate of improved cropping practices for higher yield. Results shown in Fig. 2 highlight the need for better awareness to improve the overall percentage of adoption and increase productivity (Jerginand Somasundaram, 2018).

Dengue is endemic in the Kanyakumari district. *Aedes albopictus* is the most common agent transmitting the virus. 300 houses and 772 containers were checked for positive cases of *Aedes* breeding in Kalkulam taluk of Kanyakumari. The positivity rate was 30% and 10.75% for houses and

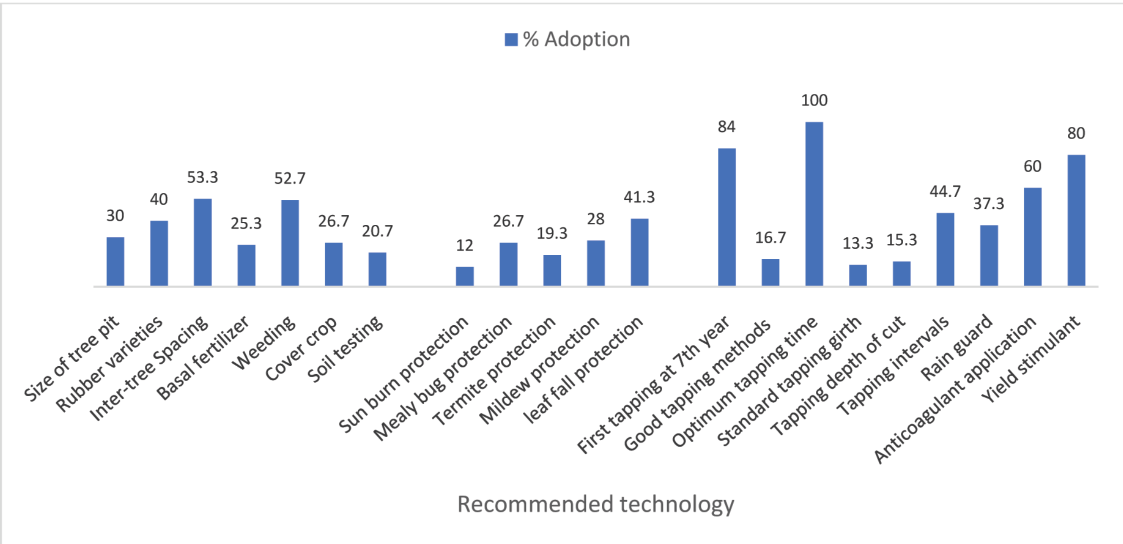

Figure 2. Percentage adoption of recommended technology by rubber growers in Kannyakumari district.

containers, respectively. Results show the presence of rubber plantations as the primary reason for the high incidence of *Aedes* breeding and dengue cases. It breeds in the coconut or plastic shells used to collect the latex. It also breeds in the innumerous discarded and unused latex collection containers, leaf axils, ground foliage, tree cavities, and pits found in rubber plantations (Marin et al., 2020).

Geospatial studies are conducted on rubber plantations in the district to understand factors contributing to rubber yield. The study classifies the landform of the district under khondalite, with laterite being the other primary rock type observed. 70% and 80% of the rubber plantation area are under low elevation (0-100m) and below 5-10% slope. Rainfall is uniformly distributed with an annual value of 1228.1mm. 70% of the rubber trees in the district have a girth of more than 60cm with a mean value of 63.4cm (Meti et al., 2014).

Rubber Board presently follows the ground survey method of assessing the natural rubber cultivation area. It is time and resource-consuming. Geographic Information System (GIS) and remote sensing uses satellite imagery to create cost-effective maps of land cover to understand the natural rubber area distribution. It can be correlated with sample analysis to provide reliable results. The GIS results can be further analyzed to generate soil and topological information helpful to growers, researchers, and policymakers (Meti et al., 2016). A study is done to identify soil organic carbon-rich rubber plantations using satellite-based plantation maps. They can be eliminated from fertilizer application. It results in many advantages like fertilizer cost savings, eliminating excessive fertilizer use, and saving waterbodies from algal bloom and contamination. ₹ 39 million can be saved annually in Kanyakumari by implementing this concept of GIS (Balan et al., 2019).

Rubber tree growth and properties are greatly affected by various factors, including soil nutrient content, slope, elevation, climate, rainfall, cropping practices, and planting density. Rubber tree properties have shown variation among countries and even among districts in the same state (Shukla, and Lal, 1985; Sanyal and Dangwal, 1983). Google Scholar search results returned no similar studies in the Kanyakumari district.

Present position of rubber plantations in the Kanyakumari district

Para rubber (*Hevea brasiliensis*) is a deciduous tree commercially grown in India as a plantation crop. It is preferred for natural rubber production over other members of the genus *Hevea* due to its high latex and low impurity content. Rubber plantation is traditionally concentrated in the southern states of Kerala, Tamil Nadu, and Karnataka. The rubber tree is grown to extract latex from the tree. The tree attains a height of 10-30m and a girth of 0.5-2m. The stem is generally straight and provides a branched, leafy canopy at the top. It has a lactation period of 25-30 years, during which latex is extracted from its bark. After latex extraction, the trees are cut down and replanted. Latex finds application in the manufacture of a wide range of rubber products. The felled trees are considered waste/by-product/residue and are traditionally used mainly as firewood.

Rubber tree statistics

In 2017, Natural rubber tree was grown in 11.74 million ha worldwide, and India stood sixth globally behind Indonesia, Thailand, Malaysia, China, and Vietnam (Hang, 2020). As of 2020, the worldwide rubber plantation area increased to 14.1 million ha, with India contributing a global share of 5.83% (Gitz et al., 2020), as shown in Fig. 3.

In India, rubber plantation (and consequently, rubber latex and rubberwood production) is predominant in the southern states because of its favorable climatic conditions and soil profile. Kerala's domination of the domestic rubberwood sector continues with a plantation area of 548225 ha in 2017-18, which translates into a share of 66.7%. It shows a decline from 90% in the 1980s. Tripura

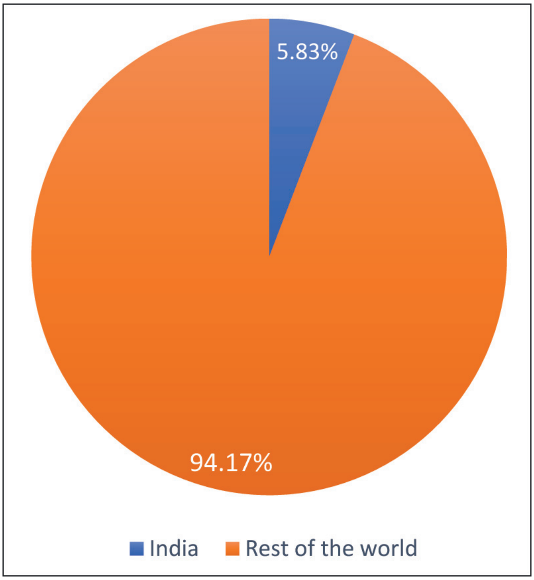

Figure 3. India's share in the global rubber plantation area.

comes second with an area of 85,038 ha under plantation (Adikari and Sharma, 2018; Chakraborty, 2020). Tamil Nadu enjoyed being the second-largest rubber cultivator before Tripura, Assam, and Karnataka surpassed it. Rubber holdings in Tamil Nadu are clustered in Kanyakumari, encompassing more than 90% of the total rubber output of the state, with a plantation area of 28358 ha as of 2020. It can be seen from Table 1 that the contribution of the district remains more or less stagnant at around 3%.

The geographical extent of Kanyakumari is 167200 ha, in which plantation crops grow in an area of 65804ha. Fig. 4 shows rubber as the predominant

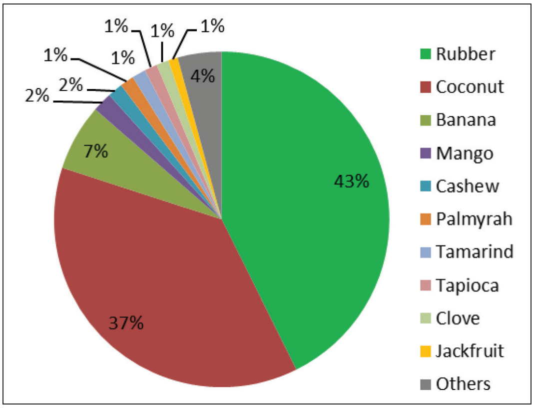

Figure 4. Distribution of plantation crops in Kanyakumari district.

Table 1:Rubber plantation area and natural rubber yield in India and Kanyakumari's share
(*Annual Trends in Area, Production, Consumption, Import, Export and Average Prices of Natural Rubber in India* , 2021; "India Rubber Production: Tamil Nadu," n.d.; *Production of Natural Rubber*, 2019; "Statewise Natural Rubber Plantation / Production," n.d.; *Statewise Production of Natural Rubber (Tonnes) – (Provisional)*, n.d.; Deputy Director of Statistics, n.d.; Janet Y. Selvia, 2012; Krishivigyan Kendra, 2019)

Year	Rubber plantation area in India (ha)	Rubber plantation area in Kanyakumari (ha)	Kanyakumari's share to total area (%)	Rubber yield in India (tonne)	Rubber yield in Kanyakumari (tonne)	Kanyakumari's share in total yield (%)
2005-06	597,610	18397	3.078	802,625	23031	2.869
2006-07	615,200	18806	3.056	852,895	23486	2.753
2007-08	635,400	18979	2.986	825,345	23291	2.821
2008-09	661,980	18994	2.869	864,500	23867	2.760
2009-10	686,515	19500	2.840	831,400	24300	2.922
2010-11	711,560	21089	2.963	861,950	25160*	2.918*
2011-12	734,780	22865	3.111	903,700	25170*	2.785*
2012-13	757,520	24324	3.211	913,700	25350*	2.774*
2013-14	778,400	25957	3.334	774,000	24502*	3.165*
2014-15	795,135	27407	3.446	645,000	24144*	3.743*
2015-16	810,800	27407	3.380	562,000	19495*	3.468*
2016-17	818,000	27245	3.330	691,000	21140*	3.059*
2017-18	820,900	27316	3.327	694,000	21110*	3.041*
2018-19	822,000	28061	3.413	651,000	21500*	3.302*
2019-20	822,300	28358	3.448	712,000	21600*	3.303*

**Value for Tamil Nadu*

Figure 5. Contribution of smallholdings and estates to rubber plantation area in Kannyakumari district

plantation crop in the district with an area of 28060 ha (Department *of Horticulture and Plantation Crops*, n.d.), contributing 42.6% to the total plantation crop area and 16.8% to the total geographical area of the district.

The Rubber Act in 2009 classified plantations having 10 ha or above as estates and the rest as small holdings. The contribution of small holdings shows an increasing trend over the years, as shown in Fig. 5, contributing 69% in 2009-10. The average size of the holdings in the district was 0.45 ha (Janet, 2012)

The utilization of rubber trees requires classification into two industries based on the raw material processed. They are the natural rubber and rubberwood industry. Fig. 6 is a graphical representation of the same.

The industries in the district involved in the processing of natural rubber and rubberwood-based products are listed in Table 2.

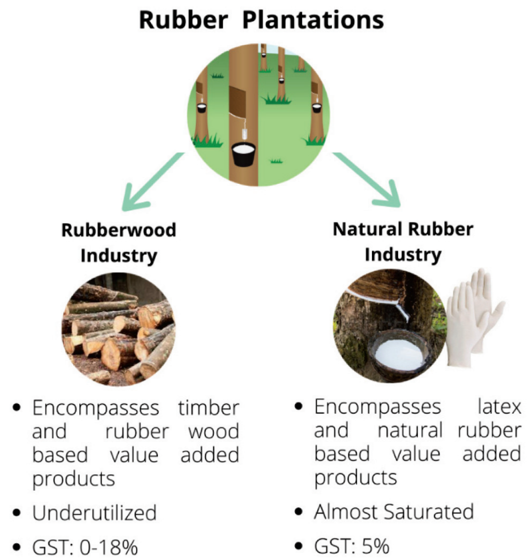

Figure 6. Categorization of products derived from the rubber tree

Natural Rubber Industry

The natural rubber industry is well developed and manufactures over 30,000 products, including tires, medical gloves, condoms, mattresses, and tubes. It has almost reached saturation concerning its range of applications. Literature on the economic significance of natural rubber is globally well documented and readily available. The Goods and Services Tax (GST) on Natural rubber products is 5%.

Rubberwood Industry

The natural rubber industry has always eclipsed the domestic rubberwood industry because of its demand, marketability, and profit. Consequently, little attention is given to the domestic rubberwood

Table 2. Rubber tree-based industries in the district

Industry type	Description	Quantity
Factories	Manufacture of Wood and Products of Wood and Core, except Furniture	6
	Manufacture of Paper and Paper Products	4
	Rubber Products	23
	Manufacture & Furniture	3
	Saw Mill	6
Micro, Small, Medium Enterprises		
	Mfg. of paper & paper products	38
	Mfg. of rubber, plastic products	83
	Mfg. of furniture	294

Table 3. Present and potential rubberwood applications

Raw material used	Final product	Applications
Sawn wood	Rough Saw Kiln Dried (RSKD) Timber	Raw material for further value-added products like furniture
	Surface Four side planed timber	Raw material for further value-added products like furniture
	Plywood	Furniture, doors, false ceiling, wall cladding and interior decoration.
	H- Beam	Structural timber for scaffolding and related construction purposes.
	End jointed panel	Baseboards, wall & floor boards, door frame construction.
	Finger jointed panel	Baseboards, wall & floor boards, door frame construction.
	Flooring panel	Wood flooring
Wood waste	Particleboard	Interior cupboards, wall & floor panels, primary material in doors and furniture
	Fiberboard	Interior cupboards, wall & floor panels, primary material in doors and furniture
	Briquette	Compact biomass pellet
	Paper pulp	Raw material for processing paper
	Handicrafts	Raw material for decorative items, toys
	Fuel / Charcoal	Firewood
	Mushroom cultivation	Medium for cultivating mushroom

industry. Rubberwood is traditionally used as firewood. It also finds applications as a single-use commodity as packing crates and in the match industry as splints and matchboxes. The GST on rubberwood products is 0-18%, depending on the value addition. The possible utilization of rubberwood is shown in Table 3.

Recommended plantation density of rubber in Kanyakumari district is 420-500 trees per hectare (Rubber Board, 2012) with a useful life of 25 years. It results in a re-plantation rate of 4%. The planting density may be at variance with reality, especially in small holdings (Siju et al., 2013). Rubberwood density varies between 550-680 kg/m^3 and depends on a variety of factors.

The non-availability of data has made theoretical calculation an absolute necessity to find the quantity of the rubberwood being felled per day. The calculation is listed in Table 4. The calculated value shows a good correlation with informal reports and surveys.

The calculation shows that a significant quantity of rubberwood is felled, which can be appropriately utilized to abridge the timber supply-demand gap

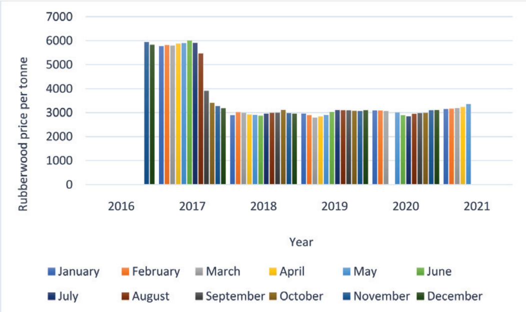

Figure 7. Variation in rubberwood price/tonne

Table 4. Theoretical calculation of rubberwood felled in Kanyakumari district

Calculation	Unit	Value
Total plantation area	ha	28358
Rotation rate	year	25
Area for felling per year	ha	1134.3
Planting density	trees/ha	500
Trees for felling per year	tree	567150
Mean density of Rubber tree	kg/m^3	600
Recoverable volume per tree (stemwood + branchwood)	m^3	1.02
Quantity of rubberwood felled per year	tonne	347096
Quantity of rubberwood felled per day	tonne	1112.5

Table 5. Theoretical calculation of rubberwood production in Kanyakumari district.

Sl No	Year	Rubberwood Production				
		Plantation area (ha)	Increase in plantation area (ha)	Total quantity of rubber wood (tonne/year)	Increase w.r.t previous year (tonne)	Increase w.r.t previous year (%)
1	2005-06	18397	-	225179	-	-
2	2008-09	18994	597	232487	7308	3.245
3	2011-12	22865	3871	279868	47381	20.380
4	2014-15	27407	4542	335462	55594	19.864
5	2017-18	27316	- 91	334348	- 1114	- 0.33
6	2019-20	28358	1042	347096	12748	3.813

of Tamil Nadu. The calculation, extrapolated to the previous years to understand the trend of rubberwood produced is in Table 5.

The trend is observed to be primarily positive and increasing over the years. The dip in 2017-18 was due to a fall in natural rubber demand.

The rubberwood price list is taken from the Department of Economics and Statistics (*Average Rubber Timber Price*, n.d.). Fig. 7 shows a steep price decline from around ₹ 6000 to ₹ 3000 per tonne in 2016-17. The prices then show minimal fluctuation and remain almost constant at ₹ 3000 per tonne. Thus, it can be observed that rubberwood production is increasing, but it fetches only a minimum average price that is equivalent to treating it as a waste product only.

Evaluation of natural rubberwood as a commercial timber

The suitability of rubberwood as commercial timber is analyzed by studying its properties, uniqueness, and shortcomings. It is imperative to understand the feasibility of providing value addition to rubberwood, eliminating its drawbacks, and making it a viable alternative to expensive commercial timbers for structural, furniture, and interior applications. Studies have shown that the structural properties of untreated rubberwood are comparable/ as good as teak on most parameters (Gnanaharan and Dhamodaran, n.d.). Table 6. gives a summary of the characteristics of rubberwood.

The high vulnerability of rubberwood to pest and microorganism attacks categorizes it as a “durability class 3” timber. It means that its mean life in ground contact is less than 60 months (Balasundaran and Gnanaharan, 1990; Code of Practice for Preservation of Timber, 1982; Vanna and Gnanaharan, 1989). Rubberwood is also easily degraded under marine conditions (Santhakumaran and Srinivasan, 1989). Therefore, despite its advantages, rubberwood cannot be classified as naturally durable.

Chemical treatment and increased scope of applications

Over the years, significant scientific research has been done on rubberwood, and commercially feasible techniques were developed to eliminate the problems associated with untreated rubberwood and add value to it. It made rubber wood as good or even better than most conventional timber as a primary material in furniture and other timber applications. These techniques include vacuum drying, pressure-induced chemical impregnation, and kiln drying. These practices followed globally are sustainable & commercially viable (Gnanaharan and Mathew, 1982; Madhavi Abeysinghe, 2011; Selamat et al., 2008; Wong et al., 1999).

Due to the above technological advancements, rubberwood can become the primary raw material for the country’s large and small wood-based product industries. Chemically treated rubberwood eliminates the defects stated in section 4.1. The manufacturing units in the district should move from minimal treatment methods like dipping, oil drying, end coating, and air drying towards more efficient

Table 6. Feasibility analysis of untreated rubberwood for value addition.

	Advantages	Drawbacks
1	Rubber tree is an agroforestry crop grown for its high yield of latex only. After its useful life, the rubber tree has no timber applications and is usually used as firewood or left to decay. Consequently, rubberwood is an agricultural residue/waste/by-product i. As a by-product/residue with no significant use, the raw material cost is less than conventional timber from forest species. The production cost/m^3 of rubberwood is only about 30% of the production cost of Meranti hardwood (Killmann and Lay Thong, 2000) ii. Rubberwood has a "green" aspect. The trees are cut down after useful life, and are replanted with fresh rubber tree saplings. There is no deforestation, unlike the case of forest timber. Rubberwood has been globally accepted as a sustainable "eco-friendly" timber. iii. The rotation rate is lower compared to other plantation crops grown for the same purpose.	Natural rubberwood has a high moisture content of 60-80%, making it economically and structurally unsuitable for timber applications.
2.	Rubberwood has good steam bending properties, making it feasible to be bent into complex shapes for various products like lacrosse sticks, violins, "Windsor" chairs.	Natural rubberwood is sweet. i.e., it has around 2% of free sugar, making it very prone to attack by fungi, termites, borers, and other pests, which may cause discoloration and make it non-durable.
3.	The characteristic light, creamy color of rubberwood is perfect for dying to imitate the texture & appearance of any conventional forest timber like teak, oak, mahogany, rosewood. In short, it has excellent staining characteristics	Natural rubberwood tends to develop seasoning defects such as cupping, twisting, bending, bowing, warping, and other distortion. Sometimes, a brown discoloration of the wood can be observed after seasoning.
4.	It has good woodworking and nail/screw holding properties.	Incorrect rubber tapping practices may cause damage to the cambium, causing stains along the growth layers and render the wood unsuitable for timber applications.
5.	It has excellent workability, i.e., it can be quickly processed and doesn't blunt the cutting tools, especially saw blades. It has very good sawing, planing, shaping, boring, and sanding properties (Zhao Youke, 2008). It also has good adhesion and preservation capacity.	The girth of natural rubberwood is less compared to conventional hardwood, limiting the dimensions and consequently the possible applications.
6.	It has an attractive grain pattern due to the favorable orientation of wood grains, especially on the tangential face.	
7.	There is abundant availability of rubberwood in the Kanyakumari district, with around 90% of the rubber plantations in Tamil Nadu present here. Therefore, transportation charges & time are low for value addition in the district. Wages are low in the Kanyakumari district, offering tremendous potential for processing and value addition in the district.	

chemical treatment like chemical impregnation, vacuum treatment, and kiln drying.

With the elimination of its shortcomings, rubberwood can be significantly value-added. The return on investment is directly proportional to the level of value addition given to rubberwood. When significant value addition increases, the profitability increases, the dependence on government subsidies drops, and wages increase. Therefore, strategies are to be developed to increase productivity and generate revenue. Timber demand of Tamil Nadu in 2008 stood at 5.133 million m^3 and was projected to reach 7.7 million m^3 by 2018 (Kumar et al., 2013). With a rotation period of 25 years, we can observe that rubberwood in the district can satisfy a significant amount of the timber demand of the state and help decrease dependency on timber imports.

Present Value Addition

Rubber tree on an average has 0.62 m^3 of stem wood and 0.4 m^3 of branch wood (Muhamad, 2000). The branch wood is entirely used as firewood for household and industrial applications (Edwin et al., 2005). Stem wood is also used as firewood. In addition, it is also used in plywood veneers, packing cases, construction planks, matchboxes, and splints. Most applications are single-use-based and involve minimal processing and treatment. Although it may be argued that processing and value addition is carried out, it is much below the maximum possible limit in generating employment and revenue. The inefficient processing techniques and old-fashioned machinery used in most of the processing units in the district cause wastage in wood recovery, energy consumption, and waste disposal. As a result, the products do not meet global standards and fail to compete with imported products. This gross underutilization of rubberwood results in a colossal revenue loss to the government in GST, product sales, and wood processing taxes under Services Accounting Codes (SAC). Thus, there is an immediate need to provide proper value addition techniques to stem wood and branch wood, which will change the underutilized rubberwood into a money-spinner for the grower, small and medium scale manufacturing industries, and the government.

Levels of Value Addition

As shown in Table 7, the levels of value addition help understand the maximum value addition

Table 7. Levels of value addition to rubberwood

Process	Value Addition
Level 1: Primary processing	
• Utilize felled rubber trees instead of leaving them to decay. • Provide essential treatment and seasoning to provide limited protection to the wood from pest attacks and structural defects. • Convert rubberwood logs into planks and uses them for single-use applications like packing crates and matchsticks.	• Increase value addition and generate some revenue and employment.
Level 2: Secondary processing	
• Encompass advanced wood treatment & seasoning techniques like chemical impregnation, vacuum seasoning, kiln drying, and improved machining processes. • Reduce moisture content to 5-15%. • Protect from termites and pest attacks. • Eliminate structural defects like warping, cupping, twisting, bending, bowing and discoloration.	• Significantly improve structural properties of rubberwood, resulting in high product quality. • Result in significant revenue generation as GST.
Level 3: Industry friendly timber rules and regulations	
• Restrict the transport of rubberwood logs out of the state. • Allow only value-added rubberwood products to be transported out of the state.	• Create an abundance of rubberwood to be used by domestic wood processing units to create wood-based products and generate revenue. • Reduce raw material cost making it a viable alternative in commercial applications.
Level 4: Value addition & Training centre	
• Provide training for improved wood harvesting and processing techniques. • Provide skill addition to artisans and workers, making them able to create more trendy and complex designs, thereby attracting more customers. • Develop lab for product testing and quality control. • Carry out research to develop innovative wood-based products like blockboard, fiberboard, particleboard, etc.	• Result in significant revenue generation in GST and increased product cost. • Utilize branch wood and increases wood recovery by using finger & end joints to make larger panels resulting in broader applications and increased revenue. • Enforce product conformance to global and national standards, making it suitable for export to foreign markets and generate revenue.

possible to be imparted and the present status of value addition. The majority of the present value addition of rubberwood in the district is at Level 1, while the remaining lies at Level 2.

Relevant State Rules and Regulations

The intra and interstate transit of timber is governed by the Tamil Nadu Timber Transit Rules, 1968. The Act and subsequent amendments fail to recognize rubberwood as timber, and hence no permission is required for transit within or outside the district. Consequently, it is extensively transported to other states without any value addition, resulting in no revenue to Tamil Nadu under the Goods and Services Tax (GST).

The Tamil Nadu Preservation of Private Forest Act, 1949, was extended to Kanyakumari district in 1979. The Act seeks to preserve the forest cover and biodiversity of the district. The Act allows the sale, lease, purchase, and mortgage of land only with the permission of a district-level committee chaired by the collector (Suchitra, 2012).

Issues faced by the Rubber plantations in the Kanyakumari district

Low returns on investment and inadequate wages are commonly stated as plaguing domestic rubber plantations. However, the primary issues are related to the failure to understand the potential of rubberwood, under-value addition of rubberwood, and outdated timber transit rules that fail to identify the potential of rubberwood as timber and restrict its indiscriminate movement out of the state. The problems are attributed to factors like uneconomical holding size, adverse climatic conditions like heavy rain and wind, which limit the tapping days, unavailability of basic machinery like rollers, smokehouse, and lack of inclination towards improved cultivation practices. Also, plantation density ranges from 750-1000 trees/hectare over the prescribed limit of 500, leading to decreased yield and increased production cost (Janet, 2012).

A study was conducted on 326 laborers in the registered rubber plantations in the Kanyakumari district to identify the major causes of the continuing labor shortage trend in rubber plantations of the district. Low wages, low quality of work-life, lack of necessary skill set, better employment opportunities, and desire for an improved standard of life are the motivating factors for this trend (Binitha and Raj, 2018). In addition, a study in 2005-2006 with a sample of 446 participant farmers assessed the exposure of rubber plantation workers in the district to various hazards ranging from toxic fumes to intolerable noise and heat levels. The health problems faced by them are also listed (S, 2018).

Results and Discussion

Tamil Nadu is the fifth-largest rubber plantation state in India, with most of its rubber plantations concentrated in the Kanyakumari district. A share of 0.2% of the global rubber plantation area and 16.8% of the total geographical area of the district establishes rubberwood as a natural resource of the Kanyakumari district. Data from Google scholar for 2005-2021 shows the average annual research publications on rubber plantations in the district to be two, which is low for such a significant resource. The authors also failed to find evidence of prior research in the district's rubberwood properties, statistics, utilization, and value addition. The present study reviews the research on the rubber plantations of the district, predominantly the threats, social, economic, geospatial aspects. Some of the issues faced by the plantation workers are also

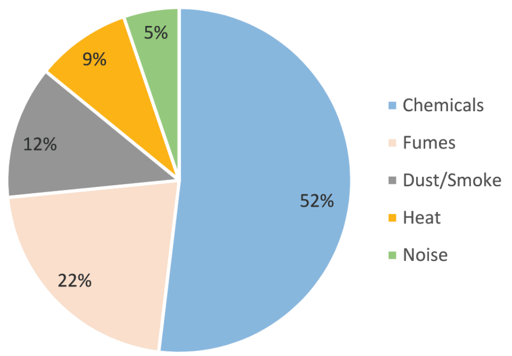

Figure 8. Exposure of workers to various health hazards

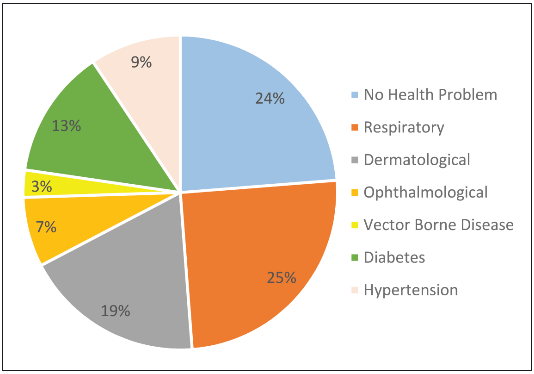

Figure 9. Health problems faced by rubber plantation workers

summarized. It is crucial to note that even though the research interest shows an increasing trend, there exists significant lacuna in current research areas and findings.

Kanyakumari district occupies 3.4% of the national rubber plantation area. Theoretical calculation estimated the availability of 347096 tonnes of rubberwood per year in the district. The average rubberwood price in 2020 is ₹ 3012 per tonne. The low cost is a motivating factor for considering rubberwood as a primary material in structural, furniture, and other commercial timber applications. Effective utilization of rubber can abridge the timber supply-demand gap of the state, reduce timber imports, and generate employment. Significant value addition can generate revenue for the government. Levels of value addition of rubberwood provide an understanding of the present standing of the domestic rubberwood industry. There is a stigma towards understanding rubberwood as timber and a potential source of significant revenue to the state. It is evident from the present value addition, which is mostly at level 1.

Some of the state rules relevant to rubber plantations are summarized. In its present form, the rules seem to hinder the development of the rubberwood industry. Kanyakumari district is a significant producer of natural rubber in India. The present study helps to understand research potential in rubberwood and wood processing industries, value addition, and feasibility in implementing new crop and wood processing practices in the district. The authors' failure to identify any research in the district's rubberwood is evident in general apathy towards the domestic rubberwood industry. Unavailability of data makes theoretical assessment an absolute necessity to provide reference values in good acceptance with unofficial trade figures. It is hinted at the potential of rubberwood in increasing profits to the growers and generating revenue for the government. This study serves as a base for further research by providing an overview of the rubber plantations of the district while providing a detailed insight into the rubberwood industry of the district.

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References

Adikari, S. B., & Sharma, A. (2018). Marketing Pattern of Rubber Plantation in Tripura. *International Journal of Current Microbiology and Applied Sciences*, *7*(06), 847–853. https://doi.org/10.20546/ijcmas.2018.706.099*Annual Trends in Area, Production, Consumption, Import, Export and Average Prices of Natural Rubber in India* . (2021). *Average Rubber Timber Price*. (n.d.). Department of Economics and Statistics.

Balan, P., Jacob, J., & Jessy, M. D. (2019). Rubber Soil Information System (RubSIS): A decision making tool for skipping fertilizer application in rubber plantations. *Rubber Science*, *32*(1), 63–67. https://www.researchgate.net/publication/342231558

Balasundaran, M., &Gnanaharan, R. (1990). Laboratory evaluation of decay resistance of rubber wood. *Journal of Indian Academy of Wood Science* ,*21*(1), 69–70.

Binitha, M., John, S., & Raj, M. (2018). *A Study on Socio-Economic Condition of Rubber Plantation Labourers in Kanyakumari District*. *20*, 35–40. https://doi.org/10.9790/487X-2003083540

Binitha, M., & Raj, S. J. M. (2018). A Study OnLabour

Shortage In Rubber Plantations Of Kanyakumari District. *UNNAYAN/ : International Bulletin of Management and Economics*, *9*.

Chakraborty, S. (2020, May). *Natural rubber output rises 9.4% to 712,000 tonnes*. Outlook - The News Scroll.

Code of practice for preservation of timber IS: 401-1982. (1982). In *Bureau of Indian Standards* (p. undefined). Bureau of Indian Standards.

Department of Horticulture and Plantation Crops. (n.d.). *Government of Tamil Nadu*. Retrieved June 13, 2021, from https://kanniyakumari.nic.in/horticulture-plantation-crops/

Deputy Director of Statistics. (n.d.). *Kanyakumari District Statistical Handbook*. Department of economics and Statistics.

Edwin, L., Thomas, S. N., &Meenakumari, B. (2005). Utilization of Rubber Wood for Fishing Canoe Construction. *Fishery Technology*, *42*(1), 47–54.

Gitz, V., Meybeck, A., Pinizzotto, S., Nair, L., Penot, E., Baral, H., & Xu, J. (2020). Sustainable development of rubber plantations in a context of climate change: Challenges and opportunities. In *Sustainable development of rubber plantations in a context of climate change: Challenges and opportunities*. Center for International Forestry Research (CIFOR). https://doi.org/10.17528/cifor/007860

Gnanaharan, R., &Dhamodaran, T. K. (n.d.). Mechanical properties of rubberwood from a 35-year-old plantation in central Kerala, India*. In *Journal of Tropical Forest Science* (Vol. 6, Issue 2).

Gnanaharan, R., & Mathew, G. (1982). *preservative treatment of rubber wood (hevea brasiliensis)*.

Hang, N.T.T. (2020). *Natural Rubber Industry Report*. www.vcbs.com.vn/vn/Services/AnalysisResearch

India Rubber Production: Tamil Nadu. (n.d.). In *CEIC*.

Janet, Y. Selvia. (2012). *A study on the impact of lpg on natural rubber and rubber based industries in kanyakumari district*.

Jergin, J. I., & Somasundaram, S. (2018). Adoption of recommended technologies by rubber growers in Kanyakumari district of Tamil Nadu. *Journal of Plantation Crops*, *46*(2), 118–123. https://doi.org/10.25081/jpc.2018.v46.i2.3724

Killmann, W., & Lay Thong, H. (2000). Rubberwood - the success of an agricultural by-product. *FAO International Journal of Forestry and Forest Industries*, *51*(201). http://www.fao.org/3/X4565E/x4565e11.htm#P0_0

Krishivigyan Kendra, K. (2019). *Annualreport (April 2018 – March 2019) Aprsummary*.

Kumar, K. S. K., Viswanathan, B., & I, Z. B. (2013). *Estimation and Forecast of wood demand and supply in Tamilandu*. https://www.mse.ac.in/wp-content/uploads/2016/09/Mono-24-.pdf

Madhavi Abeysinghe, U. (2011). *Pressure and non pressure preservation methods for rubber (Hevea brasiliensis) wood treatment by boron preservatives*. http://dr.lib.sjp.ac.lk/bitstream/handle/123456789/146/preservation-rubberwood.pdf?sequence=1&isAllowed=y

Marin, G., Vincent, S., Selvakumar, S., Arivoli, S., & Tennyson, S. (2020). Surveillance of the Asian tiger mosquito Aedes albopictus Skuse 1894 (Diptera: Culicidae) the dengue vector in rubber plantations of Kanyakumari district, Tamil Nadu, India. *International Journal of Mosquito Research*, *127*(4), 14. http://www.dipterajournal.com

Meti, S., Balan, P., Jacob, J., Shebin, S. M., & Jessy, M. D. (2016). Application of Remote Sensing and GIS for estimating area under natural rubber cultivation in India. *Rubber Science*, *29*(1), 7–19. https://www.researchgate.net/publication/303822473

Meti, S., M. Meerabai, J. Jacob, & M. Saifudeen. (2014). Geospatial variability of soil and climate on performance of rubber (Hevea brasiliensis Muell. Arg.) in traditional region of India. *Journal of Plantation Crops*, *42*(2), 175–184. https://www.researchgate.net/publication/265468817

Muhamad, B. (2000). *Timber Trade Policy and Industrialisation: Implication for Forest Harvest and Environment in Malaysia*.

Shukla, N.K.,& Lal, M. (1985). Physical and mechanical properties of Hevea brasilensis (Rubberwood) from Kerala. *Journal of the Timber Development Association (India)* ,*31*(2), 27–30.

Production of Natural Rubber. (2019, July 10). *Ministry of Commerce & Industry*.

Rubber Board. (2012). *Rubber Grower's Companion*.

S, A. J. (2018). *Problems faced by rubber plantation workers a study with reference to kanyakumari district*.

Santhakumaran, L. N., & Srinivasan, V. V. (1989). Natural durability of rubber wood (Hevea brasiliensis) under marine conditions. *Rubber Board Bulletin* ,*25*(4), 22–24.

Sanyal, S. N., &Dangwal, M. N. (1983). A short note on the physical and mechanical properties of Hevea brasiliensis in kiln-dry condition from Kottayam, Kerala. *Journal of the Timber Development Association (India)*, *29*(1), 35–38.

Selamat, S., Jantan, D., Salamah, S., & Dahlan, J. M. (2008). Vacuum-pressure treatment of rubberwood (hevea brasiliensis) using boron-based preservative. In *Journal of Tropical Forest Science* (Vol. 20, Issue 1).

Siju, T., George K, & Lakshmanan, R. (2015). *Intercropping in the Immature Phase of Natural Rubber Cultivation: Emerging Trends and Policy Challenges*. https://doi.org/https://dx.doi.org/10.2139/ssrn.2611871

Siju, T., Veeraputhran, S., Joseph, J., & George, K. T. (2013). Trends in adoption of planting density in rubber smallholdings in the traditional regions of India. *Research Article Journal of Plantation Crops*, *41*(3), 425–427. https://ssrn.com/abstract=2427214

Statewise Natural Rubber Plantation / Production. (n.d.). In *Rubber4u*.

Statewise production of natural rubber (tonnes) – (provisional). (n.d.). *The Uniter Planters Association of Southern India.* Retrieved June 13, 2021, from http://www.upasi.org/latest-statistics/

Suchitra, M. (2012, June 15). *Whose corridor is it?* DownToEarth. https://www.downtoearth.org.in/coverage/whose-corridor-is-it-38297

Vanna, R., & Gnanaharan, R. (1989). Field evaluation of preservative treated rubber wood (Hevea brasiliensis) against subterranean termites. *Material Und Orgarnsmen*,*24*(4), 287–290.

Wong, A. H. H., Dahlan, J. M., Hong, L. T., & Azlan, M. (1999). *Preservation of rubberwood*. https://www.researchgate.net/publication/291728100

Zhao Youke, E. (2008). *Promotion of Rubberwood Processing Technology in the Asia-Pacific Region*.