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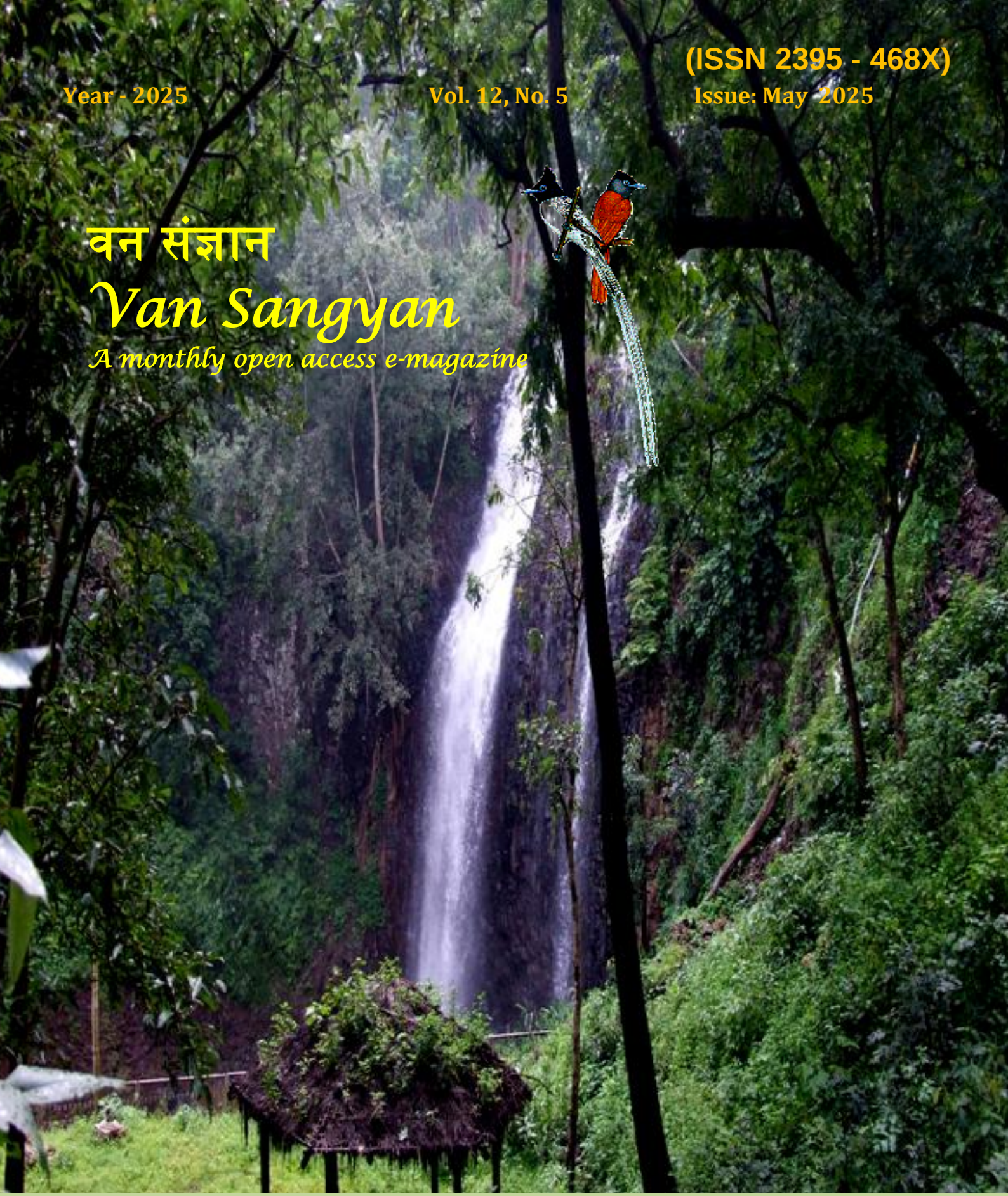

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Van Sangyan

Note to Authors:

We welcome the readers of Van Sangyan to write to us about their views and issues in forestry. Those who wish to share their knowledge and experiences can send them:

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The articles can be in English, Hindi, Marathi, Chhattisgarhi and Oriya, and should contain the writers name, designation and full postal address, including e-mail id and contact number. TFRI, Jabalpur houses experts from all fields of forestry who would be happy to answer reader's queries on various scientific issues. Your queries may be sent to The Editor, and the expert's reply to the same will be published in the next issue of Van Sangyan.

Cover Photo: Panoramic view of Achanakmar-Amarkantak Biosphere Reserve

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From the Editor's desk

Telangana Ku Haritha Haram (TKHH), launched in 2015, stands as one of India's most ambitious afforestation initiatives, striving to boost Telangana's green cover from 24% to 33%. As this program approaches its ten-year mark, it's essential to look beyond the impressive planting figures and critically evaluate its true impact. While over 2 billion saplings have transformed both urban and rural landscapes, and satellite imagery indicates a notable increase in forest cover and density across several districts, challenges remain. Urban green spaces have indeed expanded, and degraded forest lands in rural areas show signs of revival. Moving forward, the focus must shift from mere numbers to tangible ecological outcomes, including enhanced biodiversity, improved groundwater recharge, and strengthened community involvement. Ultimately, while TKHH is a commendable stride towards climate resilience and ecological restoration, prioritizing quality over quantity will secure its lasting legacy.

In line with this crucial assessment, this issue of Van Sangyan features an in-depth article evaluating the impact of Telangana Ku Haritha Haram. Beyond this, we've curated a diverse collection of insightful pieces for our readers. Explore a "Case Study: Wooden handicraft clusters/industries of southernmost part of Kerala," offering perspectives on products, problems, and potential solutions. Discover the timeless wisdom of "Tulsi: queen of medicinal herbs through the ages" and the versatile benefits of "Bamboo: Nature's green fuel." We also delve into the economic potential of "Taur: a source of economy", "Role of weather forecasting in agricultural management", "Natural fibres and their composites: Opportunities, challenges and a pathway to a green and sustainable future. Further, explore "Computational approaches for assessing genetic diversity," and " Declining Population of Syzygium jambos (Rose Apple) in Chhattisgarh: A Call for Conservation". We hope you find this issue both informative and inspiring!

Looking forward to meet you all through forthcoming issues

Dr. Naseer Mohammad

Chief Editor

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Contents **Page**

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Assessing the impact of Telangana Ku Haritha Haram: A massive afforestation programme of Telangana, India

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Abstract

This study evaluates the effectiveness of "Telangana Ku Haritha Haram", A massive afforestation and social forestry initiative launched on July 3, 2025. The program aims to increase the forest and tree cover from 24% to 33% of the state's geographical area, which is aligning with India's National Forest Policy, 1988 and other international commitments. Our methodology includes comprehensive review of data from India's State Forest Reports, Government documents, published papers etc. Results revealed a positive trajectory in overall forest and tree cover, increasing from 23,088 km^2 in 2017 to 24,697 km^2 in 2023. While forest cover showed variable patterns across density classifications (Very Dense Forest, Moderately Dense Forest and Open Forest), tree cover demonstrated consistent growth, with particularly significant increase in 2021 (966 km^2) and 2023 (636 km^2) when compared to the previous report. The success of program contributed to recognition of the title "Tree City of the World" to Hyderabad city for two consecutive years (2020-2021). To ensure sustained impact, we recommend implanting robust monitoring systems for seedling survival, prioritizing indigenous species over potentially problematic exotic varieties like *Conocarpus erectus*, leveraging GIS and remote sensing technologies to foster local ownership. These measures will help Telangana to achieve continuous progress toward its afforestation goals while contributing to climate change mitigation and biodiversity conservation.

Key Words: Haritha Haram, Telangana, Afforestation, Social Forestry

Introduction

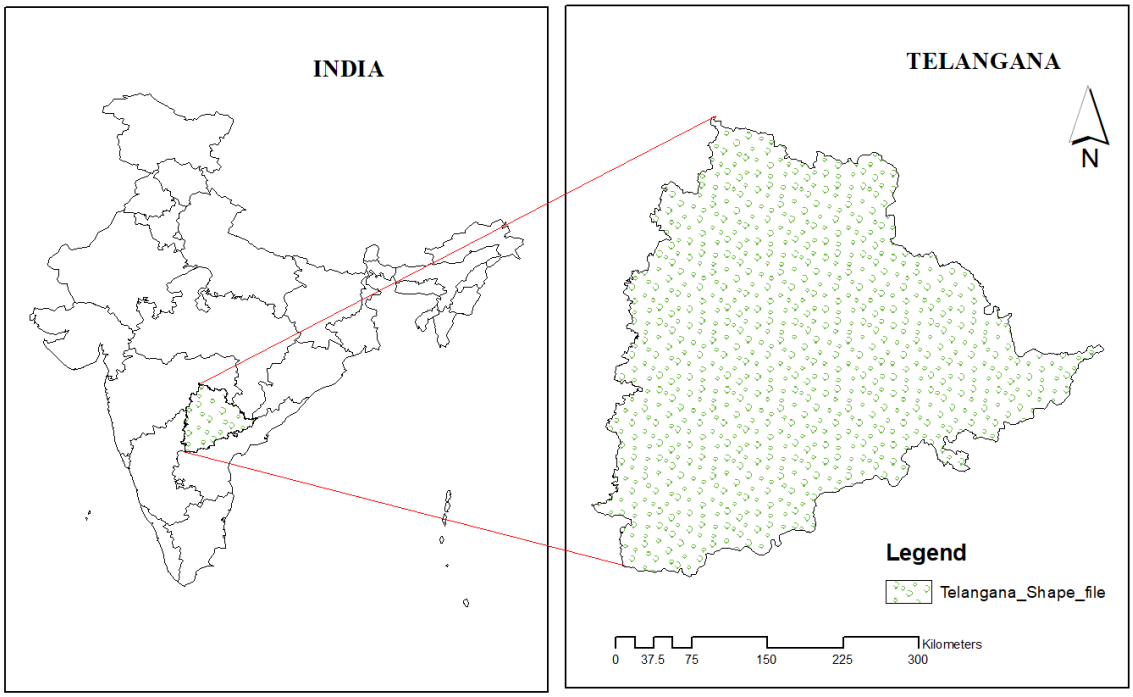
Deforestation and habitat degradation have emerged as major concerns in the 21st century, necessitating vigorous reforestation initiatives.Reforestation said to be planting of forest on land that was forest but has been out of forest cover (FAO, 2008). Given the importance ofvegetation cover, particularly tree cover and forest cover, India's National Forest Policy 1988 emphasizes the need to maintain at least 33% of the total geographical area under forest and tree cover in order to maintain the environmental stability and ecological balance, which are critical for the survival of all life-forms on land.The expansion of forest and tree cover area under the afforestation increases the storage of $C0_2$ in terrestrial vegetation (Canadell and Raupach, 2008).

Telangana the youngest State of India notified by Government of India on 2nd June of 2014 (Seshan, K.S.S, 2018). A semi-arid region covers 1,12,077 square kilometres, accounting for 3.41% of the country's total geographical area (FSI, 2023). Telangana historically faced deforestation and land degradation; to supplement these issues, First Chief Minister of Telangana launched the "Telangana Ku Haritha Haram" (TKHH) initiative on 3rd July 2015 (NITI Aayog, 2023). The name Haritha Haram means "green garland" in Telugu. It is a large-scale afforestation program planted more than 230 Crore saplings to rejuvenate degraded lands to improve forest cover.The main purpose of the programme is to increase the amount of forest cover in the Telangana State from 24 to 33% (Pujar etal., 2022). Haritha Haram programme contributed to achieve the Sustainable development goal i.e. SDG 15- Life on Land (That implies restore, protect and promote sustainable use of terrestrial ecosystems, combat desertification, sustainable management of the forests and halt biodiversity loss) (Pujar etal., 2022). TKHH initiative aligns with the goals of the Bonn Challenge. The Bonn challenge initiative aims to increase green cover, restore degraded lands, and combat deforestation (Temperton etal., 2019). Both the initiatives goals are to increase the green cover and to restore the degraded lands.The TKHH initiative is majorly focused in forest and non-forest areas, including urban landscapes, farmlands, and degraded lands of Telangana. A vast amount of plantation has been done with the support of MGNREGA, with the technical assistance of Telangana State Forest Department. Further, Vana Samrakshana Samithis, Eco-development committees, Local bodies, non-governmental agencies, Government agencies such as Panchayat Raj, Municipal Corporation, Sericulture, Hyderabad Municipal Development Authority, and Horticulture departments are highly involvedin the plantation programs. As part of the initiative village nature parks (Palle Prakruthi Vanam) are being establishedin 19,472 Gram Panchayaths using the Miyawaki model or high-density plantation known as Yadadri model, where 4,000 seedlings were planted in an area of one acre, while following a 1 m x 1 m spacing (NITI Aayog, 2023).Telangana Government has initiated a dedicated green fund called "Telangana Haritha Nidhi" contributions accepted from MLAs, MPs, MLCs, Zilla, Mandal Parishads, Municipalcorporations, Citizens and as well as government employees (Kumari, 2022). Further, the green fund has been used for the establishment of nurseries, raising of plantations, watering of plants and other investments on afforestation under TKHH. On the other hand, attempted to raise the public awareness among the people and necessity of safeguarding the forests and environment. This study aims to assess the effectiveness of the large-scale afforestation program "Haritha Haram" in increasing green cover, improving biodiversity, and mitigating climate change in Telangana.

Methodology:

Study area

The present review focuses on the mass Afforestation initiative of Telangana State, Telangana Ku Harita Haram (TKHH).



Map 1: The map showing study area (Telangana state)

Method

To carry out this extensive review, the authors used Google Scholar, Government reports, Telangana State Forest Department websites, Indian State of Forest Reports (ISFR), NITI Aayog, MyScheme,Newspaper articles to cover related publications to review for their contribution to related topics. The literature review intents to highlight the afforestation efforts made by State Government to improve the forest cover of the State and to achieve the National Development Goal under forest cover.

Results and Discussions

Forest and Tree cover dynamics of Telangana:

The quantitative data has been collected from the India's State of Forest Reports (ISFR) which is biannual report published by the Forest Survey of India, Dehradun. The first edition has been published in the year 1987 (ISFR, 1987). The ISFR provides valuable data for planning, policy formulation, and decision-making regarding forest resources.

Table 1. Telangana's Forest cover and Tree cover during (2017-2023).

Year	Geographical Area (km^2)	Forest Cover (km^2)	Tree Cover (km^2)	Forest Cover + Tree Cover (km^2)	Change in forest cover and tree cover wrt previous reports (km^2)
2017	1,12,077	20,419	2,669	23,088	565
2019		20,582	2,514	23,096	163
2021		21,214	2,848	24,062	632
2023		21,179	3,518	24,697	-35

(Source: ISFR reports 2017 to 2023.)

Table 1 describes the Forest Cover, Tree cover, Forest & Tree cover combined and Change in Forest Cover with respect to previous reports.

Forest cover

The Forest cover is shown in three (3) density classes i.e. very dense forest (VDF) with > 70% canopy density, moderately dense forests (MDF) with canopy density between 40% and 70% and open forests (OF) with canopy density between 10% and 40% (Ravindranathet al, 2008).

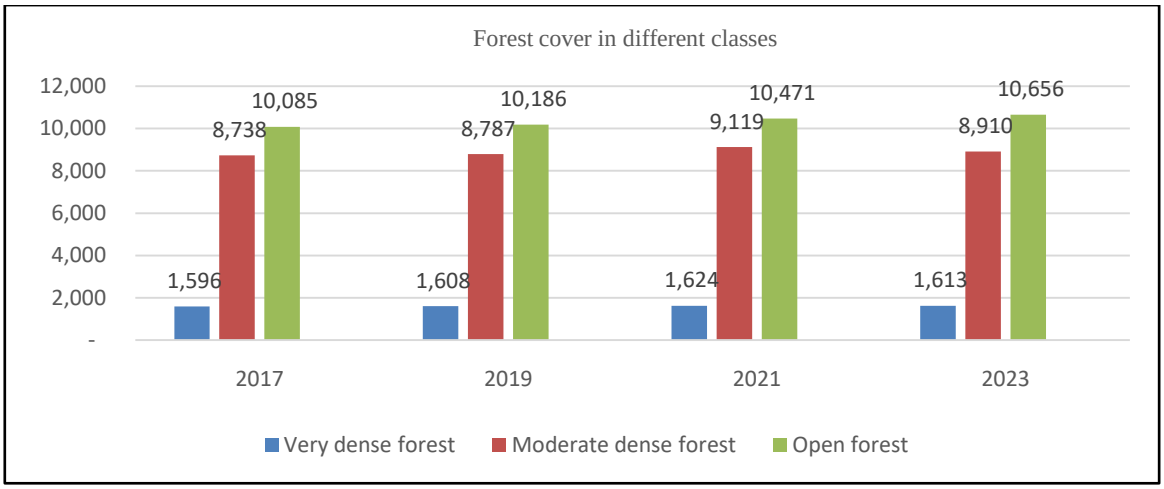


Figure 1: Graphical representation of Forest cover in different classes from (2017-2023)**.**

Based on the figure 1 the VDF in Telangana is 1,596 km^2 in the 2017, further in 2019 a gradual increase of 12 km^2 has seen compared to the previous 2017 report. And in 2021 the VDF has seen gradual increased to 16 km^2 wrt to the previous 2019 report. The increase of VDF may be with various attributes such as better management practices. In 2023 a decline of 11 km^2 has seen due to the various reasons such as deforestation, illicit felling of commercial plantations, and wildfires etc.

MDF in 2017 is 8738 km^2. Further in 2019 MDF is gradually increased 49 km^2 compared to the previous report of 2017. In 2021 the MDF has seen significant increase 332 km^2 with respect to the previous report of 2019. The significant increase of MDF IN 2021 a result of successful implementation of TKHH in Telangana. Further in 2023 MDF has decreased to 209 km^2 with respect to the previous report of 2021. The shift of decreasing MDF in 2023 might be the reason of Illicit felling and pressure of developmental activities in the State.

OF in 2017 is 10,085 km^2. Further in 2019 OF is gradually increased 101 km^2 compared to the previous report of 2017. In 2021 the OF has seen significant increase 285 km^2 with respect to the previous report of 2019. Further in 2023 OF has increased to 185 km^2 with respect to the previous report.Overall, the OF has consequently increased from 2017 to 2023 which indicates the strategic

implementation of Harith Haram in the Telangana State.

The Figure 2 represents the trends in forest cover and tree cover in Telangana State from 2017 to 2023. In 2017 the forest cover is around 20, 419 km^2 and followed by tree cover is 2,669 km^2. Further, in 2019 the forest cover has around 20,582 km^2, indicates that the forest cover has increased, reflecting a growth of 163 km² compared to 2017 data and the tree cover has decreased to 2,514 km^2 a gradual decrease of -155 km^2. However, the total forest and tree cover in the State has increased to 23,096 km^2 with respective to the previous report of 2017. In 2021 the forest cover increased to about 21,214 km², registering an addition of 632 km² compared to the 2019 data. The tree cover showed an upward trend, reaching 2,848 km² an increase of 334 km² with respective to the 2019 data. In 2023, the forest cover was recorded at approximately 21,179 km², indicating a slight decrease of 35 km² compared to 2021. On the other hand, the tree cover showed a significant rise, reaching 3,518 km² an increase of 670 km² with respective to the previous report of 2023.

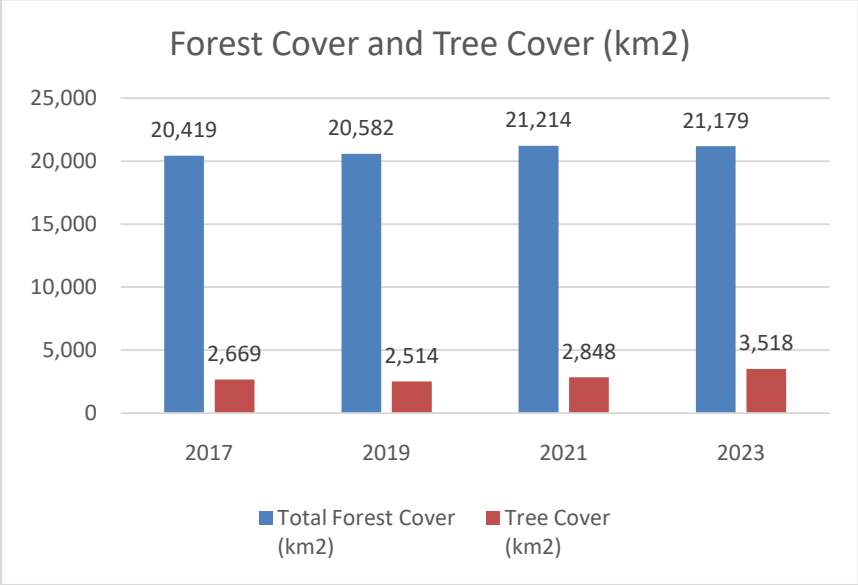


Figure 2: Forest cover and Tree cover from 2017-2023.

Overall, the data shows a consistent increase in tree cover from 2017 to 2023. This positive trend can be attributed to the large-scale plantation initiatives undertaken by the Telangana State Government, particularly under programs aimed at enhancing green cover in urban spaces, avenue plantations, open lands, degraded areas, government premises, educational institutions, gram panchayats, village parks, urban parks, and other public spaces.The diverse range of species have been selected for the massive afforestation programme. In the Haritha Haram 104 native plant species are used for the plantation enumerated by Murthy et. al. (2021). The major green achievementHyderabad (Capital city of Telangana) was awarded with the title "Tree City of the World" for the two consecutive years 2020 and 2021 (Telangana Today, 2024). Telangana

ranked top in all over the environmental performance for improving the forest cover through massive plantation programme “Haritha Haram” (CSE, 2023).

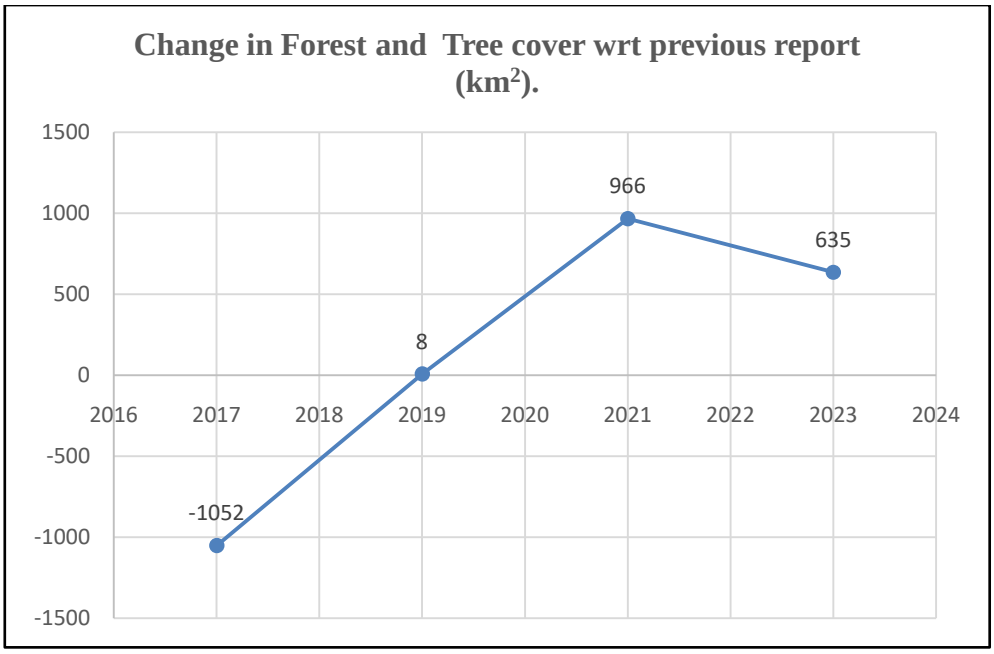


Figure3: Graphical representation of change in forest and tree coverwrt previous years.

The figure 3 represents the variation in forest and tree cover in square kilometres across the time. The changes are as, in 2017 the forest and tree coverdecreased by 1052 km^2 with respect to 2015 ISFR report (ISFR, 2015, 2017). The reasons for decrease are mainly due to rotational/clear felling’s of commercial plantations, encroachment and other biotic pressures.In 2019 there was anincrease in the growth rate, with an increase of only 8km^2 compared to the previous report of 2017. In the 2021 a remarkable recovery was seen, with an increase of 966km^2, the highest growth among the reported years. Further, in the year 2023consecutiveincrease was observed with forest and tree cover showing a positive trend of 635km^2. This could be attributed to large-scale afforestation program Haritha Haram, government policies, and community participation in forest conservation.

Conclusion

The Telangana Haritha Haram program has had a significant impact on increasing forest cover and tree cover in the State, contributing to environmental sustainability, aligning with Sustainable Development Goal 15 and Bonn Challenge. The program's large-scale plantation efforts, combined with community involvement resulted in notable increases in tree cover.However, the recent decline in forest cover reported in the Indian State of Forest Report 2023 highlights ongoing challenges posed by urbanization, infrastructure development, and potential climate-related impacts anyhow there is a significant increase in the total forest and tree cover. To ensure the long-term success of the program, it is

essential to maintain sustained monitoringby regularly assessing seedling survival rates, monitoring the growth and health of the trees, regularwatering especially during pinch periods, regular surveillanceof each sapling through the geotagging techniques. Implement strategic interventions like selecting indigenous species as they are better adapted to the local climate, soil conditions, and ecological conditions. Selecting an exotic species such as *Conocarpus erectus* for plantation in afforestation programs have become an area of conflict, moreover various concerns are raised about its impact on public health and environment (The Hindu, 2025). Its better to select a suitable local or indigenous or endemic species for the plantation in future to make the program more successfuland enhance community engagement which creates a sense of ownership and responsibility among local people.Promote the use of technology like GIS and RS for continuous monitoring and mobile applications for data collection and reporting to improve the efficiency and effectiveness of the program. By taking these steps, Telangana can continue to make significant progress in achieving its afforestation goals and contribute to a greener future.

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Case Study: Wooden handicraft clusters/industries of southernmost part of Kerala- products, problems, and possible solutions

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Abstract

The wooden handicraft industry plays a crucial role in the economy of Thiruvananthapuram district, Kerala, India. This study aimed to explore the current scenario of the wooden handicraft industry in the district and identify the challenges faced by the artisans and the industry. A sample of four industries/clusters was interviewed to gather the required data. The study highlighted the major challenges faced by the industry, including limited access to credit and the absence of proper marketing strategies. Based on these findings, it is recommended that the government and relevant organizations provide technical and financial support to the artisans and industry owners to improve the quality of their products and become more competitive in the market.

Keywords

Wooden Handicraft, Handicraft Industry, Raw Material, Thiruvananthapuram, Kerala

Introduction

Wooden handicraft industries play a vital role in the Indian economy, providing employment and income for many people. Kerala is well known for its articulate craftsmanship, which is an intimate part of her tradition. The local arts and crafts industry in Kerala is so strong that you can find handcrafted articles made of a wide range of materials, including wood, bell metal, brass, coconut shell, banana fibre, screw pine, straw, other natural fibres, papermache, textiles, cora grass, cane and bamboo, buffalo horn, and so on(Devaraj, 2021). Kerala handicrafts, due to their unique, original creative characteristics and an unsurpassed sense of colour, have earned a place on the Indian handicrafts map.

Wooden handicrafts have been a traditional art form in the Thiruvananthapuram district of Kerala for centuries. The industry has been a vital source of livelihood for many artisans and has played a significant role in the economy of the region by producing high-quality wooden handicrafts, including furniture, toys, and decorative items (Mahgoub andAlsoud, 2015). However, in recent years, the industry has been facing numerous challenges, including declining demand and competition from other materials (Upadhyay and Jain, 2019; Radhika, 2018). In this research article, we aim to provide a comprehensive overview

of the current state of the wooden handicraft industry in Thiruvananthapuram district, Kerala.

Our conclusions are based on in-depth interviews with artisans, industry leaders, and experts in the field; they also provide a critical evaluation of the challenges faced by the industry and suggest recommendations for its revival and sustained growth. The findings of this research can inform policymakers, industry stakeholders, and the broader public about the importance of preserving and promoting this traditional art form in the region.

Materials and methods

Study area

The present study was carried out in some handicraft industries located in the Thiruvananthapuram district of Kerala, India. Due to strict COVID protocols, we could only cover four industrial units within the district. We visited each enterprise and collected various details based on the questionnaire provided.

Data Collection

A structured questionnaire was used to collect data from the sample population. The questionnaire consisted of questions on the demographic profile, type of wooden handicrafts produced, production process, raw materials used, market demand, employment, sales, and challenges faced by the industries. Both primary and secondary data were collected for this study. Personal interviews with industry owners and managers were used to collect primary data, while secondary data was collected from government reports, academic journals, and websites.

Data Analysis

The collected data were analyzed using descriptive statistics such as frequency distributions and percentages. The findings were presented in the form of tables and charts.

Ethical Considerations

Ethical clearance was obtained from the Institutional Review Board before the commencement of the study. The purpose of the study was explained to the participants, and their informed consent was obtained. Confidentiality of the data was maintained, and the identities of the participants were not disclosed.

Results and discussion

Distribution

Due to strict COVID protocols, we could only cover four industrial units within the district (Table 1). They are Nambeesan's handicrafts, Rahul handicrafts, Handicrafts Development Corporation Kerala Govt. (HDCK), and Kerala Arts and Crafts Village.

Table 1. Table indicating the Wooden Handicrafts Industrial units surveyed in Thiruvananthapuram.

Sl. No.	Name of the Industry	Location	Year of establishment
1	Nambeesan's handicrafts	Karaali, Vallakkadavu PO	2014
2	Rahul handicrafts	Muttathara, Vallakkadavu PO	2013
3	Handicrafts Development Corporation Kerala Govt.	Press Club Rd, Puthenchantha	1969

	(HDCK)		
4	Kerala Arts and Crafts Village	Vellar, Vazhamuttom	2021

Raw materials and Products

Most of the raw materials are bought locally and also from outside the district. Marayoor and Nilambur's depots are the major places from where timber species are collected. Species like rosewood and teak are mainly obtained from outside the district. In the case of teak, the main reasons for using it are the golden yellow colour as well as the resistance to termites.

Unlike other wood-based industries, raw materials are unlikely to be imported from outside sources, except for industries such as Rahul handicrafts, which imply countries such as Myanmar for Burmese teak. Government enterprises like HDCK acquire their raw materials only through government auctions, as there are rules and regulations governing such industries.

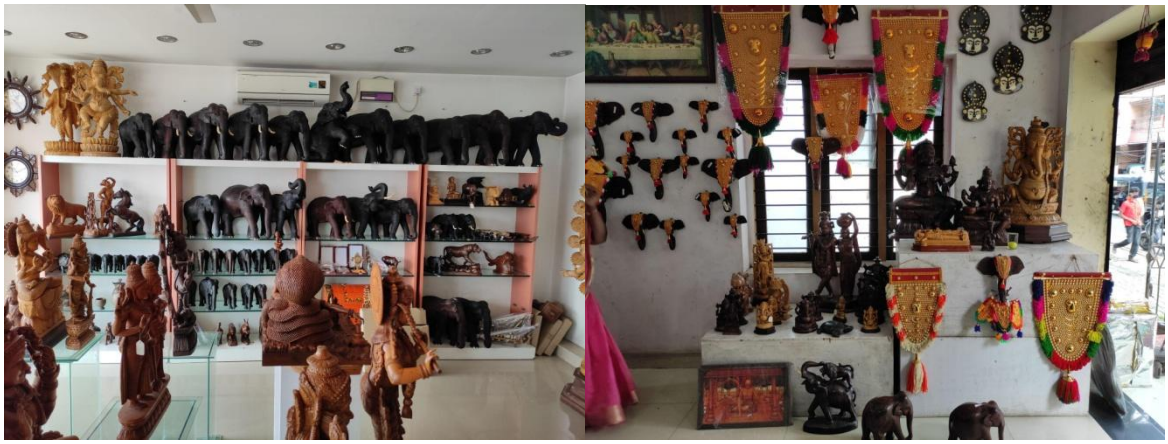

Fig No. 1 and 2: Wooden Handicrafts products

Table 2. Table indicating the principal product and subsidiary product and the major wood species used in industries.

Sl. No.	Name of the Industry	Major wood species used	Principal Product	Subsidiary Product
1	Nambeesan's handicrafts	● *Dalbergia sissoo*	● Nettur petti (Amadapetti)	● Snake boat (Chundanvallam)
2	Rahul handicrafts	● *Tectona grandis* ● *Thuja occidentalis*	● Wooden sculptures ● Statues	● Kerala traditional mural painting ● Coconut shell products

3	Handicrafts Development Corporation Kerala Govt. (HDCK)	● *Tectona grandis* ● *Dalbergia sissoo* ● *Santalum album* ● *Thuja occidentalis*	● Wooden sculptures	● Mementos ● Ice-cream bowl ● Teacup ● Spoon ● Utensils ● Mobile stand
4	Kerala Arts and Crafts Village	● *Tectona grandis* ● *Pandanus utilis* ● *Santalum album* ● *Dalbergia sissoo* ● *Liriodendron tulipifera* ● *Saccharum officinarum*	● Handicrafts products	

Consumer Category

The handicraft industry serves a diverse range of consumers, including individuals, private institutions, government institutions, and other firms. According to the scientific findings, individuals represent the largest consumer category at 34%, followed by government institutions at 33% and private institutions at 22%. The remaining 11% of the market is made up of other types of firms (Fig No. 3). It is worth noting that in most of these industries, the final products are purchased by individuals and government institutions. Only a few handicraft industries have purchase agreements with private institutions and other firms.

This diversity of consumers highlights the importance of producing a range of handicraft products that meet the needs and preferences of different types of buyers. It also suggests that the market for handicrafts is relatively stable, as government institutions and individuals are likely to continue to be reliable consumers of these products. This information may be useful for policymakers and industry stakeholders who are interested in supporting the growth and development of the handicraft industry.

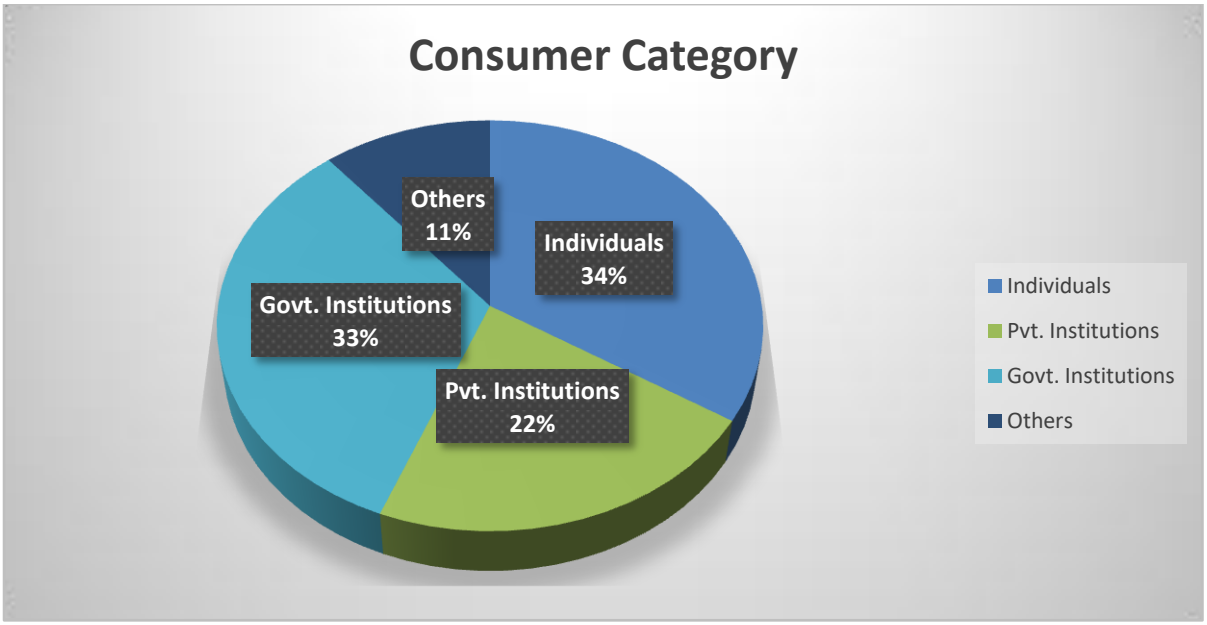

Fig No. 3: Consumer Category

Nature of Production and Competitors

In all these surveyed industries, the nature of production is continuous, and products are mainly sold wholesale or retail. It has been inferred that the entire market structure is competitive and is heavily influenced by the competitors within it. In the case ofNambeesan's handicrafts, small scale industries are the major competitors. This suggests that the industry is fragmented and characterized by numerous small players. Rahul handicrafts, on the other hand, faces competition from both small scale industries and public enterprises, indicating a more diverse market structure. Similarly, Handicrafts Development Corporation Kerala Govt. (HDCK) competes with small scale industries and public enterprises.Finally, Kerala Arts and Crafts Village faces competition from individuals, suggesting that the industry is more decentralized and characterized by independent craftsmen rather than organized entities. Overall, understanding the competitive landscape is crucial for firms to develop effective strategies and succeed in their respective industries.

Annual Production

It can be observed that annual production for the past 5 years has been almost unaffected till 2018, and thereafter there is a slight decline in the production unit due to the invasion of COVID-19, especially in the case of the Rahul handicrafts industry. The production is continuous and as per the needs of the customer. The graphical representation of annual production in the wood-based industry is mentioned in Fig No. 4.

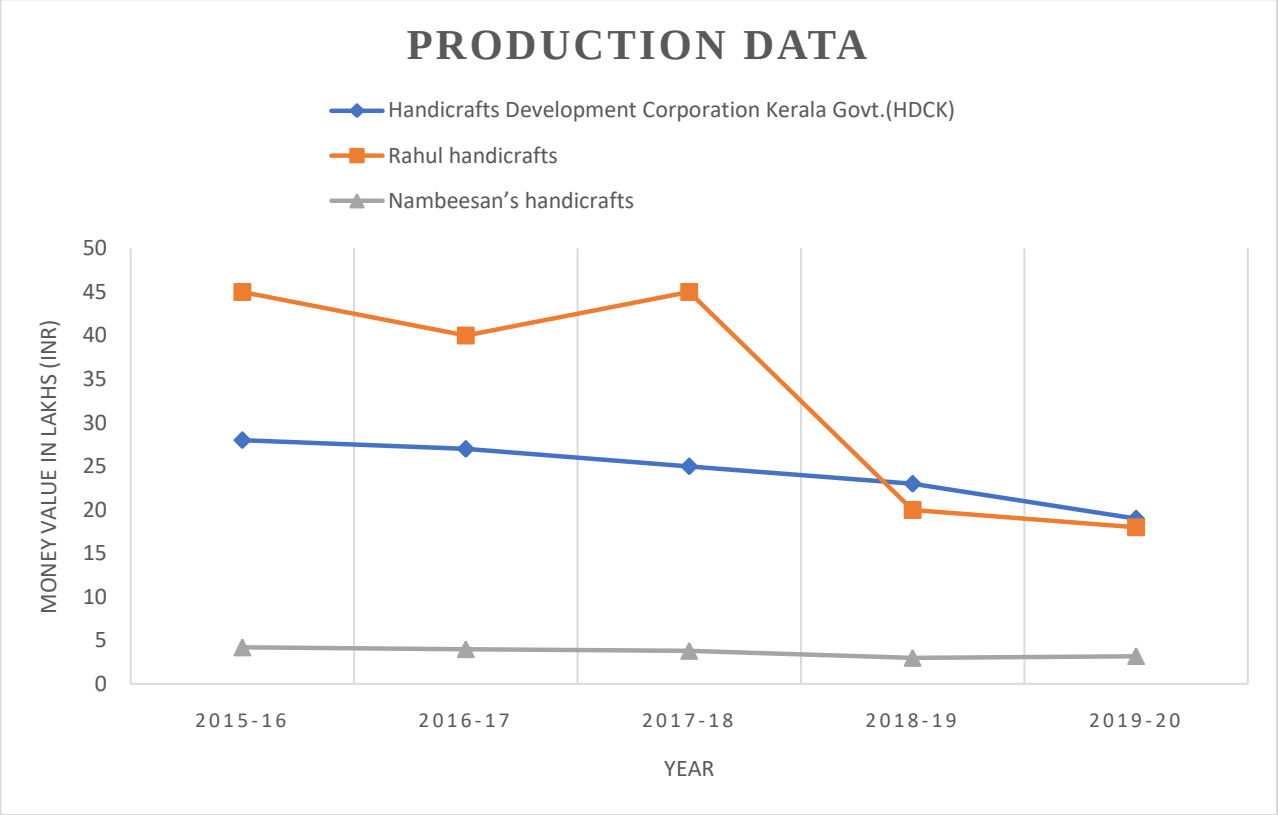

Fig No. 4: Production data of studied clusters or industries

Other industrial parameters (Workforce, Organizational pattern, and Machinery)

Workforce in industries

The industry employs both skilled and unskilled workers who assemble wooden pieces and then convert them. The casual workforce also includes migrant workers from other states too. The workforce in the handicraft industries varies significantly, with some having a higher proportion of skilled workers than others.

For instance, Nambeesan's Handicrafts employs 8 skilled workers and 4 unskilled workers, while Rahul Handicrafts employs 17 skilled workers and no unskilled workers. HDCK has 20 skilled workers and no unskilled workers, whereas Kerala Arts & Crafts Village employs 60 skilled workers and 38 unskilled workers (Fig No. 5). It is worth noting that these industries involve both skilled and unskilled workers, and the casual workforce also includes migrant labourers from other states. The workers are involved in setting up wooden pieces and converting them into finished handicraft products.

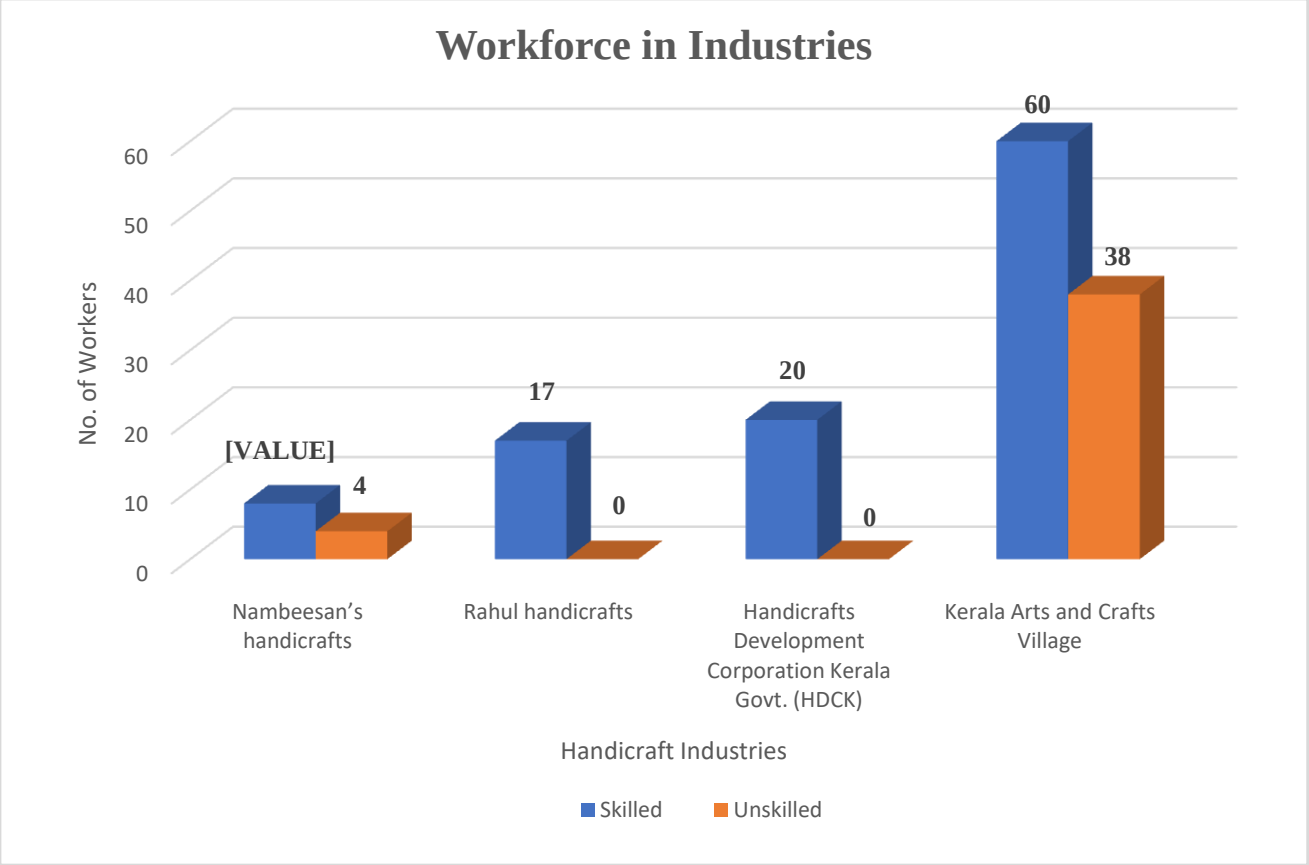

Fig No. 5: Workforce in industries

Organizational pattern

The organizational pattern of handicraft industries varies, with some being owned by private individuals and others being run by the government. Nambeesan's Handicrafts and Rahul Handicrafts are both proprietorships, while HDCK and Kerala Arts & Crafts Village are government-owned enterprises (Fig No. 6). Interestingly, none of the industries studied fall under the category of the cooperative or public sectors. It is worth noting that the major shares of these industries belong to either the proprietorship or government categories. This suggests that the organizational pattern of handicraft industries is diverse and that different types of ownership structures can be successful in this sector.

Machinery

Machinery plays a crucial role in the production of wooden handicrafts, and the scientific findings indicate that the major types of machinery and tools used in the handicrafts industries include band saw, planer, mitre saw, circular saw, and wood router. Interestingly, most of the industries studied are still using the machinery that was initially used, suggesting that there has been relatively little investment in upgrading or modernizing production processes.

In contrast to machinery, many of the tools used in handicrafts do not require any maintenance and are used lifelong without sustaining damage. The findings also suggest that most industries are still using traditional techniques for crafting wooden handicrafts, with only a few using modern techniques such as CNC cutting. This

information highlights the importance of traditional craftsmanship in the handicraft industry and suggests that there may be opportunities to integrate modern techniques and machinery to improve production efficiency and quality.

Major problems faced by the industries/clusters

The handicraft industry is facing several major constraints that are affecting its growth and profitability. One of the main challenges faced by the industry is a decrease in sales during the COVID-19 pandemic, which has led to a downturn in the economy. Nambeesan's Handicrafts and HDCK both face challenges in accessing markets for their products, which can limit their sales and revenue. Also, private industries like Rahul Handicrafts face challenges in accessing financial resources to invest in their businesses and expand their operations. The lack of financial support from the government for private industries has further compounded the situation.

Proprietorship enterprises are particularly affected by the increase in workload, as the owner must manage investment, manufacture, and sale, leading to burnout. The unavailability of skilled labourers and the labour shortage in some industries have also posed a challenge. Rahul Handicrafts, HDCK, and Kerala Arts & Crafts Village faced challenges in attracting and retaining skilled labour, which can limit their production capacity and quality. The depreciation of the tourism sector has had a significant impact on the demand for handicraft products.

Another major constraint faced by the industry is the lack of use of the latest technology in government enterprises, leading to lower efficiency and competitiveness. HDCK faces challenges in maintaining and upgrading its machinery, which can limit its production efficiency and quality. The inconsistent market conditions and lack of support for individual artisans have made it difficult for the industry to grow. Moreover, the younger generation is not interested in pursuing traditional sectors like handicrafts, leading to a shortage of skilled workers in the future (Arif *et al.*, 2018). Customers are mainly focused on variability, looks, and price rather than quality, which is a major concern for the industry. The introduction of GST has led to a sudden drop in demand due to the hike in price. Finally, the handicraft industry is also facing competition from plastic and metal products, which are cheaper and more readily available.

Possible solutions for the improvement of Clusters/Industries

The survey was done to understand the demand and marketing trends of handicraft industries. From the survey conducted in Thiruvananthapuram, the handicraft industries in the district need enough support from the government in the form of subsidies, grants, etc. Increased wood technology research and development efforts should be initiated to screen out more industrially potential "lesser known" indigenous timber species useful for different manufacturing units. Electronics and computer-assisted machines for greater precision and better-quality sharpening can be used in industries. Lack of awareness of new wood application technology is the major problem faced by artisans. So, artisans need to be made aware of the new wood technologies.

Wood waste in terms of oversizing and planning appears to be rather low because the wood is cut according to the specific requirements of the specific handicraft product. The upliftment of these types of wood-based industries is necessary for the development of the industrial sector. For this reason, authorities should promote these types of industries by helping them with easier licensing procedures, grants, funds, power subsidies, etc. The government should take appropriate steps to bring small-scale industries together. Encouraging industries to raise plantations would help them meet their raw material requirements. Controlling plastic-made crafts through legislation not only reduces environmental pollution but also boosts the handicraft industry.

New generations should be encouraged to come up with innovative startups in the field and made aware of the prospects of online marketing and online sales. They should be made aware of the new experiments in the market and the scope of coconut wood processing, along with government support. Coconut wood is a raw material that is available in plenty in our state. So, the conversion and processing of coconut could give a larger profit to the sawmill owners and the small-scale wood industries. Another inference is that small-scale industries should join as a consortium for a bigger market, and this could increase the demand for their products (Ghouse, 2012). They should be made aware of the prospects of forest certification.

Conclusion

Decentralized, unorganized, and labour-intensive are three characteristics of the wooden handicraft industries/clusters found in the Thiruvananthapuram district. The industry has the best potential to provide rural areas with a significant number of jobs. However, the sector is currently confronted with a variety of problems, such as a shortage of loan options, problems with raw materials, fierce competition from mechanized items, technical improvements, etc. Proper legislative changes, awareness campaigns, market facilities, the reinforcement of wooden handicraft clusters through increased financial support, etc. are essential solutions to solve several issues in the industry, and an integrated stakeholder-specific strategy is the need of the hour.

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Tulsi: queen of medicinal herbs through the ages

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Globally various plants have been used for the treatment of several diseases or their healing goals. In the Indian system of medicine various kinds of *Ocimum tenuiflorum* were preferred and apt as pharmaceutical constructions. The holy basil shrub is native to South East Asia and has presumably originated in Indian subcontinent. It is revered as a sacred plant in India. Historically, it is widely used in Ayurveda and traditional folk systems of medicine in India for thousands of years. Each part of a plant like stems, roots, seeds, leaves, flowers, and fruits have their own curative properties and functions reported by many researchers.Due to the high number of remedial potentials, it has contributed in the area of science from ancient till now in modern practices. According to Ayurveda *Ocimum tenuiflorum* is known as: "Mother medicine of nature", "The incomparable one", "Queen of Herbs", "Elixir of Life", etc. Rama Tulsi (most common one, broad bright leaves and slightly sweet), Shyama Tulsi (least common one and have purplish leave), and Vana Tulsi (wild Tulsi andgrows in the forests) are the 3 morphotypes, cultivated in India.

Among the hundreds of botanicals celebrated in Ayurvedic texts, *Ocimum sanctum* holds a place of singular importanceboth as a daily tonic and a sacred emblem of wellbeing. According to our traditional wisdom, Tulsi is a tonic for the body, mind and soul that offers solutions to all health problems resulting from our lifestyle, due to the unique composition of its essential oil, containing eugenol, camphor, flavonoids, and various terpenes. Daily consumption of Tulsi is said to prevent disease, promote general health, wellbeing and longevity. In traditional systems of medicine, different parts of Tulsi plant have been recommended for the treatment ofvarious ailments: e.g., fresh flowers for bronchitis, leaves and seeds for malaria, whole plant for diarrhoea, nausea, and vomiting, ointment for eczema, alcoholic extract for stomach ulcers and eye diseases, and essential oil from leaves for insect bites.

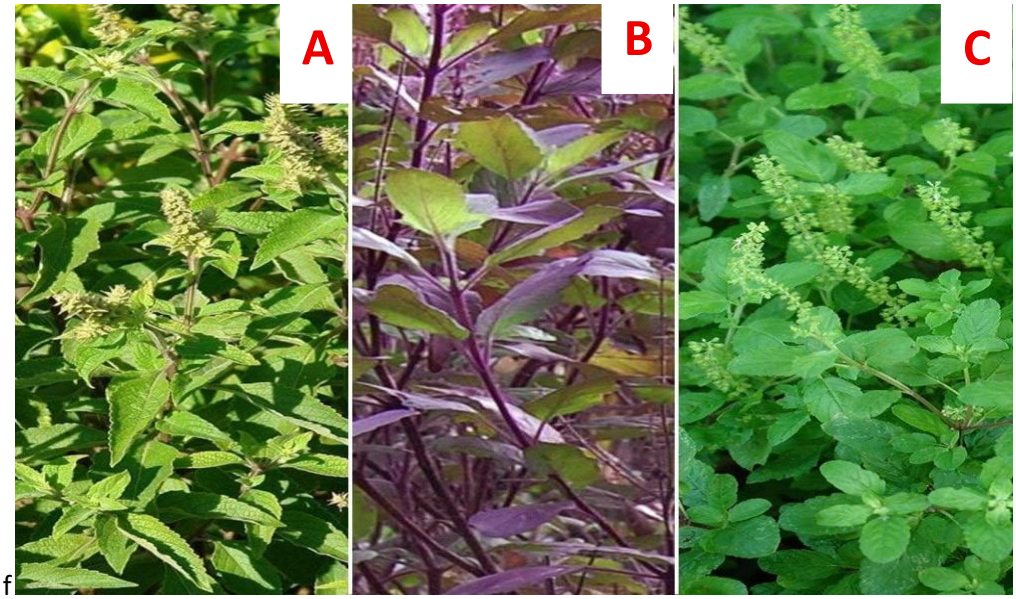

Fig. 1: Vana Tulsi (A), Shyama Tulsi (B) and Rama Tulsi (C)

Botanical Profile

Botanical name: *Ocimum tenuiflorum L. or Ocimum sanctum L.*

Table 1: Taxonomic position of *Ocimum sanctum L.*

Rank	Classification
Kingdom	Plantae
Sub kingdom	Tracheobionta
Super division	Spermatophyta
Division	Magnoliophyta
Class	Magnoliopsida
Subclass	Asteridae
Order	Lamiales
Family	Lamiaceae
Genus	*Ocimum Linn*
Species	*Ocimum tenuiflorum Linn.*

Table: 2 Vernacular names of *Ocimum sanctum L.*

Language	Name
English	Holy Basil
Hindi	Tulsi
Sanskrit	Tulasi
Gujrati	Tulsi
Bengali	Tulsi
Marathi	Tulasa
Tamil	Thulasi
Telegu	Tulasi
Malayalam	Trittavu

Health Benefits of Holy Basil

Adaptogenic Stress Relief

Daily consumption of Tulsi leaves assists in coping with all types of stress in daily life. Tulsi, as a potent adaptogen, promotes resilience and relieves anxiety. It is scientifically validated that Tulsi helps in adaptation to all types of stress – chemical, physical, infectious, and emotional (Jamshidi et al. 2017). The benefits on chemical stress stem from its ability to detoxify and protect the body from toxins- and pollutants-induced damage, owing to its high content of phenolic compounds (e.g., rosemarinic acid) endowed with antioxidant properties (Guptaet al. 2007). Stress during prolonged physical exertion, exposure to cold or noise pollution causes metabolic strain and disturbs homeostasis. Intake of adaptogenic herbs like Tulsi safeguards against further damage by enhancing various cellular and physiological adaptive functions.

Tulsi has anti-depressant and anti-anxiety properties comparable to diazepam and standard antidepressants. In one randomized trial, participants who took 500 mg of holy basil extract daily for 60 days felt significantly less anxious, stressed, and depressed (Bhattacharyyaet al. 2008). Its antioxidant compounds, besides repairing free-radical damage, also help soothe nerves, lower blood pressure and reduce inflammation. Minerals such as potassium may further moderate stress-related blood pressure by displacing sodium and promoting vasodilation. The phytochemicals ocimumosides A and B have been identified as anti-stress agents that can lower plasma corticosterone and positively alter neurotransmitter balance (Guptaet al. 2007). Another compound4-

allyl-1-O-β-D-glucopyranosyl-2-hydroxybenzenehas demonstrated antistress effects in animal studies, normalizing corticosterone levels and reducing adrenal hypertrophy (Pradhanet al. 2022)

Natural immunity booster

Tulsi has significant anti-bacterial, anti-fungal and anti-viral properties which protect us from a variety of infections. In a double-blind, placebo-controlled trial, healthy volunteers taking 300 mg/day of Tulsi leaf extract for four weeks showed significant increases in T-helper cell counts and natural killer cell activity—key players in immune surveillance (Mondal et al. 2011). Being rich in antioxidants, such as Vitamin C and β-carotene, and other phytonutrients viz., zinc can protect our body against infections. These components of Tulsi protect the body from damages caused by free-radicals which are produced during cellular metabolism and are responsible for all degenerative diseases, including cancer. In the traditional Ayurvedic system, Tulsi is considered as a tonic to retain youthful vigour and prevent premature aging.

Anti-Infective & Wound Healing

Tulsi leaf extract helps in wound healing and acts as an anti-inflammatory and analgesic. Tulsi also functions as an antibacterial, antifungal and antiviral agent, hence active against many pathogens responsible for human infections. By enhancing immune responses, Tulsi would boost defense against infective threats. Studies have indicated that Tulsi would slow down the growth of HIV cells (Rege et al. 2014). Tulsi may help in the treatment of bacterial infections, such as urinary tract infections, cholera, measles, mumps, tuberculosis, gonorrhea, herpes, pneumonia, and fungal infections, as well as mosquitoborne diseases such as dengue, malaria and filariasis. This herb effectiveness against water-borne and food-borne pathogens makes it suitable for the preservation of food as well as for water purification and as a hand sanitizer. Tulsi's antibacterial antioxidant, anti-inflammatory and analgesic activities make it useful in wound healing. It is particularly used after surgery to heal and protect the wounds. Research has validated that Tulsi may work against infections and wounds such as mouth ulcers.

Fever Reduction

The undisputable therapeutic properties of Tulsi come from its essential oil containing bioactive compounds and the phytonutrients. Tulsi is an excellent antibiotic, germicidal, fungicidal, and disinfectant, and as such very effectively protects our body from bacterial, fungal and viral infections. Fever is caused due to infections from protozoa (malaria), bacteria (typhoid), viruses (flu), and even fungus. Tulsi has anti-bacterial and anti-viral properties which help to fight infections, thus reducing fever. It is a traditional practice in India to consume a decoction of Tulsi leaves and flowers during fever.

Protects the Stomach

Tulsi counteracts the stress-induced ulcers. It naturally increases the stomach's defense by decreasing stomach acid, increasing mucus secretion, and prolonging the life of mucus cells. Tulsi accelerates wound healing in laboratory animals, particularly the ulcer in different ulceration models in animals. Tulsi may be

a preferred alternative to many drugs used for peptic ulcers and having side effects. An animal study has shown that 200 mg of Tulsi extract reduces both the number and index of peptic ulcers significantly (Kath and Gupta 2012).

Lowers the risk of diabetes

Tulsi plant can help reduce the blood sugar in pre-diabetics and can help prevent symptoms of pre-diabetes such as weight gain, hyperinsulinemia, high cholesterol, insulin resistance, and hypertension. Tulsi is understood to have the ability to control blood glucose as demonstrated by animal studies as well as human trials. Tulsi leaves administered to non-insulindependent diabetic patients exerted significant decrease in fasting blood glucose levels, postprandial blood sugar levels, urinary excretion of sugar as well as blood cholesterol level (Agrawal et al, 1996).

Cardiovascular & Lipid Support

Tulsi can also help with weight loss and blood cholesterol levels. Animal studies have endorsed significant lowering of LDLassociated cholesterol and enhancing HDLassociated cholesterol (Suanarunsawat et al, 2011). The essential oil of Tulsi is shown to lower stress-induced cholesterol accumulation in the kidney, liver, and heart in rats treated with Tulsi leaf powder. Tulsi contains vitamin C and other antioxidants such as eugenol, which protect the heart from the harmful effects of free radicals. Additionally, the blood cholesterol lowering property also contributes to the cardio protective potential of Tulsi.

Anticancer Properties

Tulsi may inhibit the development of various cancers including oral cancer due to the presence of antioxidant phytochemicals like eugenol. Scientific research has revealed that people who regularly consume Tulsi leaves are less likely to be immunecompromised and less susceptible to developing cancer. Tulsi and its phytochemicals such as eugenol, rosmarinic acid, apigenin, myretenal, luteolin, β-sitosterol, and carnosic acid are likely to help prevent chemical-induced lung, liver, oral and skin cancers because they suppress oxidant stress in the body organs, induce cancer cell death (apoptosis), prevent blood vessel growth contributing to cancer cell growth and prevent metastasis (spread of cancer cells) (Kumaret al. 2023).

Skin Care & Acne Management

Tulsi helps kill bacteria and remove infections, hence a great natural cure for skin disorders such as acne and other skin irritations. This property mainly comes from its essential oils, which are highly antibiotic, disinfectant, antibacterial, and antifungal. Among the therapeutic components including eugenol, camphene, γ-caryophyllene and methyl eugenol, the primary active compound of Tulsi oil is eugenol which is widely believed to help combat many skin disorders. When applied in coconut oil, Tulsi is absorbed better and hence more effective (Ahidinet al. 2024). Camphene in it gives a soothing and cooling effect. Rubbing Tulsi leaves or its oil on the body keeps mosquitoes and other insects away.

Ocular Health

Our eyes are susceptible to viral, bacterial and fungal infections that would cause conjunctivitis, boils, and other problems of the eyes. Washing the eyes daily with Tulsi leaves-soaked water is prescribed in

Ayurveda to fight against conjunctivitis - also commonly known as pink eye - due to its anti-inflammatory and soothing properties. Tulsi may also help prevent a range of eye issues such as cataracts, macular degeneration, glaucoma, vision defects, and ophthalmia. Topical administration of an herbal eye drop mixture containing turmeric and Tulsi extracts helps to counter the oxidative stress due to the high antioxidant content of its essential oils and insoluble protein formation in the eye lens that lead to lenticular opacity.

Tulsi can also protect the body from radiation-induced damages. It protects the normal tissues against the destructive effects of radiation; hence it can be used after surgery to help heal wounds quickly and protect from infections. As an expectorant it is effective in curing cough and cold. Tulsi is an excellent remedy for cough; it soothes the throat, effectively reduces chest inflammation and facilitates to expectorate the mucus and thus decongest the respiratory tract. Its dried leaves can be mixed with food grains to be used as an insect repellent.

Additional Benefits

Table 3: Nutritive Valueof Fresh Tulsi Leaves (Per 100 g)

Major nutrient	Nutrient value	Phytonutrient	Nutritive value
Energy	23 KCal	B-Carotene	3.142 mg
Protein	3.15 g	Lutein-zeaxanthin	5.65 mg
Carbohydrate	2.65 g	Cryptoxanthin-B	46 µg
Total fat	0.64 g		
Dietary fibre	1.60 g		
Vitamin	**Nutrient value**	**Mineral**	**Nutrient value**
Vitamin-C	18.0 mg	Calcium	177 mg
Niacin	902 µg	Copper	385 mg
Pantothenic acid	209 µg	Magnesium	64 mg
Vitamin B6	155 µg	Manganese	1.15 mg
Riboflavin	76 µg	Iron	3.17 mg
Thiamin	34 µg	Zinc	0.81 mg

Vitamin E	800 µg	Potassium	295 mg
Vitamin K	415 µg	Sodium	4.0 mg
(Source: USDA National Nutrient database)			

Chemical Constituents

The plant shows various therapeutic and medicinal properties, due to the presence of chemical constituents or phyto components. The essential oil extracted from *O. tenuiflorum L.* consists high amount of Eugenol (near about 70 %), other constituents are 11% of Beta-Elemene, 8% of Beta-Caryophyllene, and 2% Germacrene. The leave of the plant consists of volatile oil (0.7%) made up of eugenol and methyl eugenol in 71% and 20% respectively. The major chemical constituents of O. tenuiflorum Linn which are possessed in high amounts and leads to several remedial activities are; Eugenol ($C_{10}H_{12}O_2$), Oleanolic Acid ($C_{30}H_{48}O_3$), Linalool ($C_{10}H_{18}O$), Ursolic Acid ($C_{30}H_{48}O_3$), Beta-Caryophyllene ($C_{15}H_{24}$), Rosemarinic Acid ($C_{18}H_{16}O_8$), Estragole ($C_{10}H_{12}O$), Carvacrol ($C_{10}H_{14}O$), Methyl Cinnamate ($C_{10}H_{10}O_2$).

H

Linalool

Eugenol

Rosemarinic Acid

Estragole

Ursolic Acid

Methyl Cinnamate

Carvacrol

Beta-Caryophyllene

Oleanolic Acid

Ways of consuming tulsi herb

Tulsi leaves have a sweet, aromatic smell and a minty taste. Fresh leaves are less commonly used in cooking, but are used in garnishing sauces and soups. They are also commonly used to make flavoured juices and Tulsi tea. People preferably eat fresh Tulsi leaves raw to fight off cough or cold. One can also make Tulsi tea from the leaves, flowers, or dried leaf powder. Freshly brewed tea can be made by steeping Tulsi leaves in boiling water for a few minutes. Tulsi is also available in supplement form, usually in capsules. Tulsi is also used in the form of its essential oil. Essential oil of Tulsi is distilled from leaves and flowers of the plant. The essential oil extracted from Tulsi plant is used in lotions, soap, perfume, shampoo and conditioner.

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Bamboo: Nature's green fuel

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Introduction

There are several ways to recover energy from bamboo biomass, each process results in different products, which can be utilized in many aspects. Energy production from bamboo biomass can be classified into 2 main ways: thermochemical conversion and biochemical conversion. In the former methods, heat is used to transform bio-matters in bamboo biomass into various products. Biochemical conversion involves the action of microorganism to transform biomass to biogas or biofuel. A diagram of bioenergy conversion is provided below

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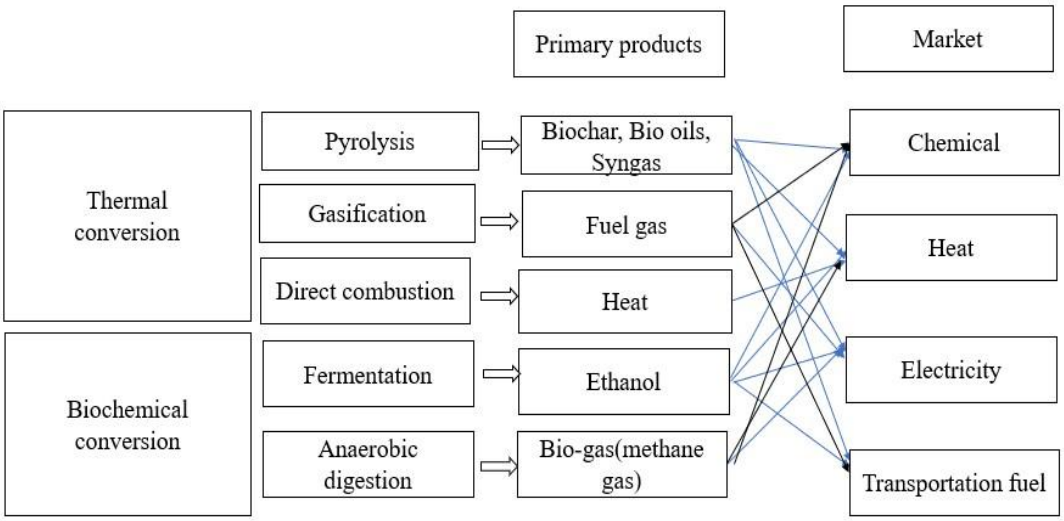

Fig. 1 Main bioenergy conversion routesDirect combustion

Dry bamboo biomass can be used as firewood to generate heat for cooking, boiling and warming in households. It is a good source of energy for remote area where people cannot access electricity. Direct combustion of bamboo biomass can also applied in industrial scale, for example, in form of co-generation to produce heat and power in thermal power plant for electricity production or other plants such as cement or steel. The co-generation helps reduce the amount of

fossil fuel used in these plants. The technical principle of combustion is very simple. It consists in burning any fuel composed of carbon and hydrogen atom, under controlled conditions. The product of combustion process is water (H2O) and carbon dioxide (CO2). Combustion usually takes place inside a chamber, followed by a heat exchanger where the hot gas stream transfers its heat to another fluid. This fluid then can be used for power production through an engine or turbine. When combustion heat water, the heat exchanger is called a boiler. Water boilers are used for large-scale steam generation at medium and high pressure (>20 bar). To achieve good efficiency, combustion control is required to completely burn out of the biomass in order to maximized energy recovered and to avoid and tars production and emission of non-oxidized gases such as carbon monoxide (CO) and volatile organic compounds (VOC). Factors that affect biomass combustion process includes air supply, temperature control and biomass quality and distribution. (Kerlero de Rosbo and de Bussy, 2012)

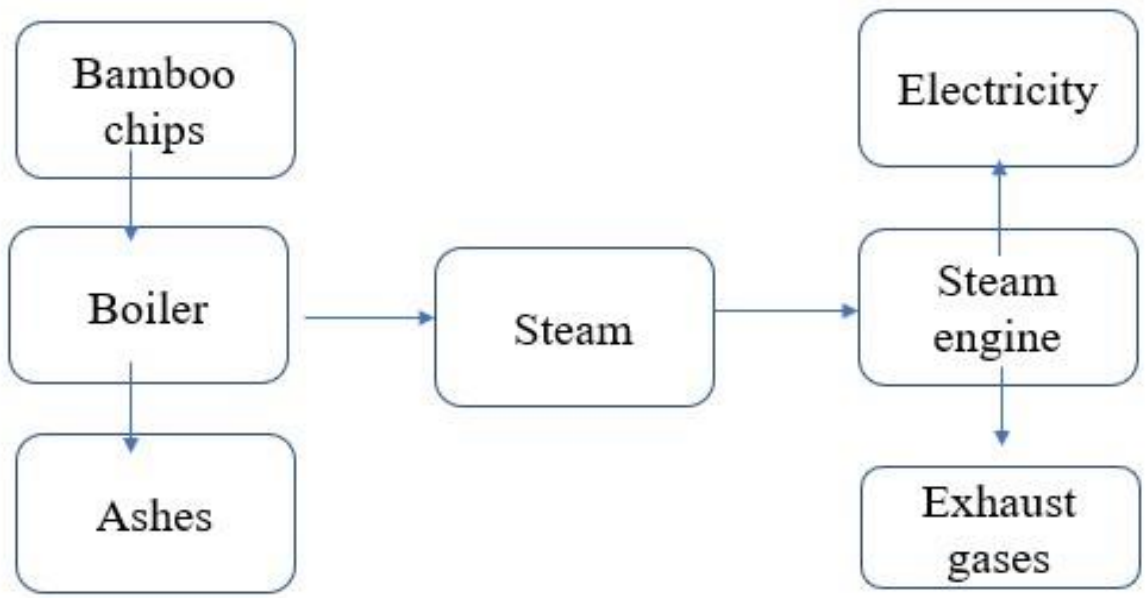

Fig. 2: A diagram of combustion process from bamboo biomass to electricity

Bioenergy production methods

Pyrolysis

Pyrolysis is the thermal ("pyro") degradation ("lysis") of organic materials at a moderate temperature (350 to 600ºC) in the absence of oxygen. The products of pyrolyisis process consist of charcoal, condensable pyrolysis oils (heavy aromatic and hydrocarbons) and tars and concondensable gases or syngas. Charcoal can be used as a secondary fuel the same way that coal has been used. Syngas, consists of carbon monoxide, hydrogen and methane, can be burnt in a boiler for electricity generation or in a gas engine for power production. Pyrolysis oils can be further processed in "bio-refinery", very similar to the current crude oil refinery process, to produce bio-fuels and other

useful chemical products. The quantities of pyrolysis products are depended on the operating conditions (temperature and residence time).

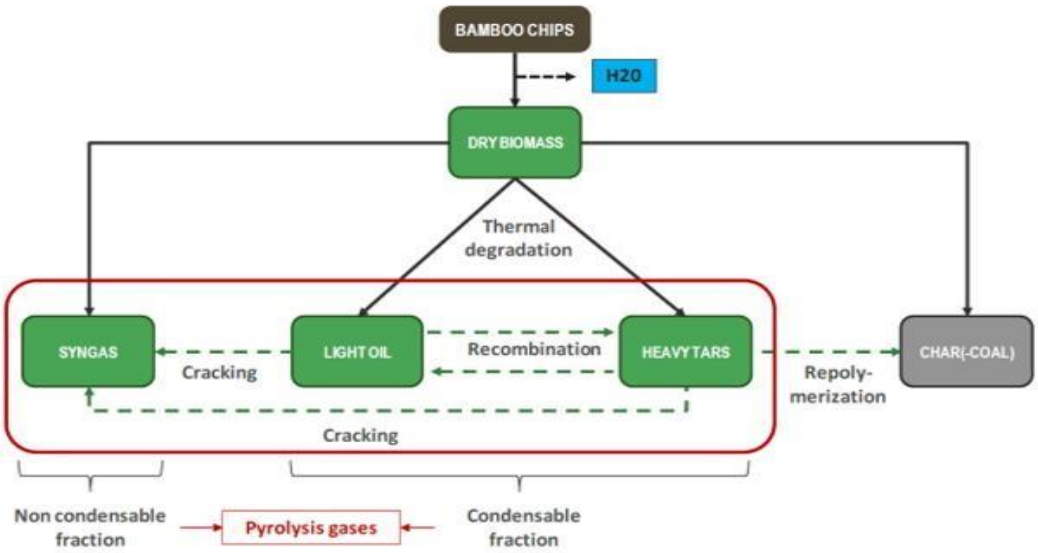

Fig. 3: Pyrolysis reactions and its product (Kerlero de Rosbo and de Bussy, 2012)

Gasification

Gasification is the production of a gaseous fuel from a solid fuel. It consist a complex thermal and chemical conversion of organic material at high temperature under restricted air supply.

Gasification process includes both a pyrolysis step and a partial combustion. It is occurred at very high temperature, typically between 750ºC and 1200ºC, with little oxygen. Products of gasification process include syngas and ash. The syngas is a mixture of combustible gases (carbon monoxide, hydrogen and methane) and incombustible gases (carbon dioxide, nitrogen and other gases). Around 40% of volume of syngas made of combustible gases that can be used for power or heat generation. The heating value of 12 syngas depends on oxygen supply source. If air is used, the produced syngas has a low calorific value (4-7 MJ/m^3), however, if oxygenenriched air is used, the heating value can reach 10-15 MJ/m3 . In practice, as the oxygen enrichment process is expensive, air is normally used.In comparison to combustion; gasification shows lower thermal losses and better energy recovery of the fuel. The theoretical efficiency of fuel conversion by gasification under optimal conditions is 95% mass,dryIn reality, due -to heat losses and secondary reaction, the efficiency is reduced to 70-80% energy in the biomass recovered in produced gases.

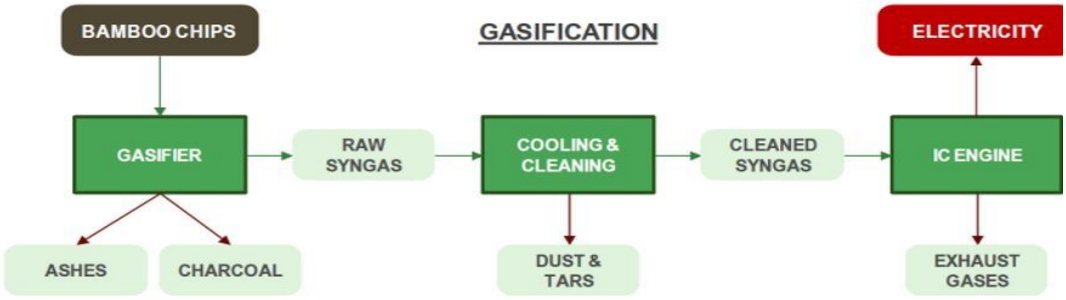

Fig. 4: Gasification general process flow

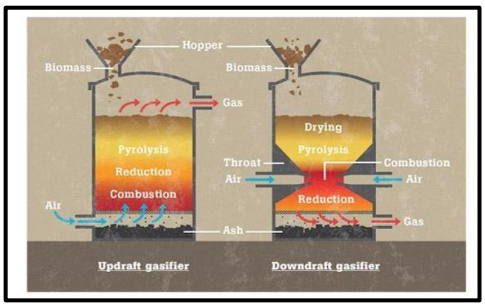

Plate 1 Gasifiers

Biochemical conversion

In biochemical conversion pathway, different strains of microorganisms are utilized to produce various biofuel products. The basic principle of biochemical conversion is the fermentation of sugar or other substances contained in biomass by microorganism into ethanol, methane and other fuels, chemical and heat. There are two main ways of bioconversion:

Anaerobic digestion is the biological degradation of organic matters in biomass by microorganisms (anaerobic bacteria) with the absence of oxygen (anaerobic). This process produces biogas (methane) (60%) and CO2 (40%)

Fermentation is the decomposition of starch/sugar by microorganisms (yeasts and bacteria) to produce ethanol

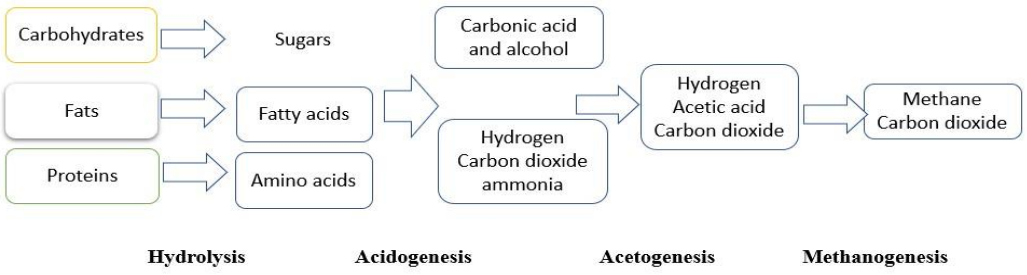

Fig. 5: Anaerobic digestion pathway

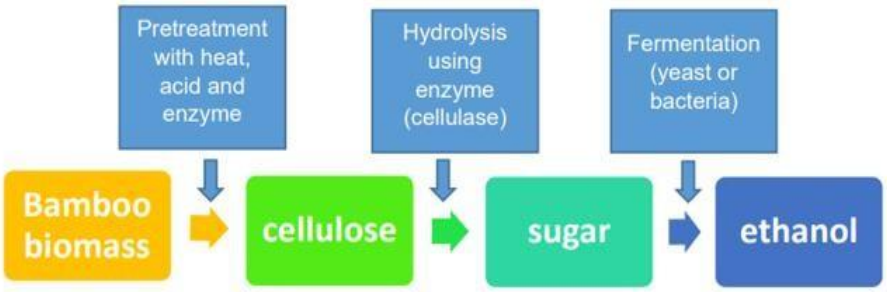

Fig. 6: Simplified process of producing ethanol from bamboo biomass

Different Biofuel Products of Bamboo

More than 90% of the world's main energy supply is produced by direct combustion. This is the most commonly used and established technology.

There are different form of biofuel includes solid biofuel, liquid biofuel and gaseous biofuel

Solid biofuels: Bamboo Charcoal, Briquet, Chips and Pellets

Liquid biofuels: Bamboo Ethanol, Butanol and Acetone

Gaseous biofuels: Biogas or Syngas, Bio-CNG (compressed natural gas)

Conclusion

Bamboo can comply with the EU sustainability requirements for biofuels through related recognised forest certification schemes (e.g., FSC and PEFC). The GHG emission savings achieved by replacing fossil fuels with bamboo biofuels can comply with and exceed those required by the EU regulations. Bamboo systems can store a high amount of carbon and produce a feedstock with negative carbon emissions. In terms of market opportunities, solid biofuel trade (e.g. chips, pellets and charcoal) is an established and competitive market, while advanced biofuels (e.g. liquid and gas) from lignocellulosic feedstocks are expected to be competitive in the longer term.

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Taur: a source of economy

Ashwani Kumar and Sakshi

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Botanical name: *Phaneravahlii* (Wight &Arn.) BENTH.
Synonym: *Bauhinia vahlii* Wight &Arn.
Family: Fabaceae
Common names: Taur, Bauhinia creeper, Mahul
Part used: Leaf, bark and seed

Description

Tauris a large, typically evergreen climber also commonly known as Mahul. This species is found in the Sub-Himalayan region at altitudes up to 3,000 meters above sea level, as well as in the tropical moist and dry deciduous forests of Central India, Bihar, and the Eastern and Western Ghats.It is also referred to as the "camel's foot climber" due to the resemblance of its leaves to a camel's footprint.

Distribution

Taur is an evergreen woody climber (liana) native to the Indian subcontinent, with a distribution that extends to various Asian countries, including Bhutan, India, Mauritius, Nepal, Pakistan, Sri Lanka, as well as parts of Africa. It is commonly found in the lower Himalayas at altitudes up to 1500 meters and is widespread in the deciduous forests from western to southern India, particularly in the hilly forest regions. This species is commonly seen in the states of Punjab, Uttar Pradesh, West Bengal, Bihar, Assam, Maharashtra, Odisha, Andhra Pradesh, Karnataka, Tamil

Nadu, Jammu & Kashmir, Himachal Pradesh, Uttarakhand and Sikkim.

Morphology

It is characterized by its bifid (bilobed) leaves and striking flowers that range in color from white and yellow to purple. The leaves are simple, broad and either entire or 2-lobed at the apex, with a swollen and pulvinate base. The flowers have a corolla composed of five somewhat unequal petals, typically narrowed into a claw shape. The flowering in Taur occurs between April and June. Fruit is in the form of pods, woody, rusty, tomentose, 6-12 seeds in each pod, sub orbicular, 2.5 cm diameter, flat and dark brown in colour. The flowerhas 10 stamens, although this number can sometimes be reduced to as few as three, with some stamens possibly bearing sterile filaments. The number and fertility of the stamens are key features for identifying the species.

	
Taur plant(woody climber)	Leaves pattern of Taur
	
Flowering in Taur	Pods of Taur

Pods of Taur with seeds

Seeds of Taur

Plates of Taur

Bundle of Taur plates

Economical value

Taur is an important NTFP of economic value in the tribal regions of central India. Its leaves are widely used by grocery shops and eateries as plates and packing material. These plates, made from taurleaves, are particularly favored during community feasts and rituals. The plant stem fiber is used for making ropes, basketry and wickerwork. The outer bark contains 17% tannin and 19% non-tannins and both the root and bark possess medicinal properties. The seeds are consumed both raw and fried.

Taur leaves are available for collection for about 9 to 10 months each year, providing a nearly year-round livelihood option for local tribal communities. On average, a

person can collect around 5 to 6 kilograms of leaves per day, which are then sold in the market without additional processing. The demand for Taur leaves, both domestically and internationally, has been rapidly increasing.

However, the leaves are often harvested unscientifically, with collectors damaging the plants to maximize leaf yield. These unsustainable harvesting practices lead to a decline in the plant's vigor and a reduction in its population in natural forests at an alarming rate.

Utilization

This plant is highly valued for its various uses, including fiber, fodder, food, medicine, and thatching. The bark is utilized for making fiber, while the leaves serve multiple purposes such as fodder, making containers for food stuffs and wrapping tobacco. In rural areas, villagers stitch 3 or 4 leaves together to create "pattals," which are used as plates for serving food. The tender leaves are also cooked as vegetables. The seeds can be eaten raw, roasted, or fried and a paste made from the seeds is applied to boils and given to children suffering from indigestion.

Medicinal values

The seeds are gathered, roasted, and thengrind to make the powder. The powder is given with milk before bed to treat infertility issues among women. It was noticed that although leaves paste is applied to cuts as an antibacterial, root decoction is utilised to treat food poisoning.

Role of weather forecasting in agricultural management

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The Indian farming community is in great need to have access to weather information for planning and managing crops for their livelihoods. Agriculture is dependent on the weather as it plays an important role in the agricultural production system by influencing growth, development and yield of crops, incidence of pests and diseases, water needs and fertilizer requirements. Temperature, rainfall, sunlight, relative humidity, wind speed and wind direction have major effects on the crops. Therefore, accurate prediction of weather is essential so that farmers can make an informed decision for crop at optimum time. This will reduce losses in crops due to extreme weather.

Keywords: Weather Forecasting, Agricultural Productivity,Crop Management, Climate Resilience

Introduction

Agriculture is the foundation of our life, which is completely dependent on natural factors with weather playing a major role. Due to the irregularity of climate and weather, agricultural activities are affected and farmers need accurate information and forecasts to make their production successful and reduce farming risks. In this context, weather forecasting becomes extremely important. It helps farmers plan their agricultural activities better and avoid uncertainties. It assists farmers in making critical decisions regarding planting, harvesting, fertilization, and irrigation. Accurate forecasts can help optimize these activities to improve crop yield and reduce losses due to adverse weather conditions (Chattopadhyay *et al*., 2021).In India, weather forecasting is issued through several major institutions and departments, but the most prominent being the India Meteorological Department (IMD). It provides information on weather, rainfall, temperature, storms and other natural disasters across the country. The IMD uses satellite, radarand other modern technologies for forecasting weather and has an extensive network of weather centres and radar stations. Additionally, the National Disaster Management Authority plays a key role in the preparation and management of weather-related disasters. It enhances the effectiveness of agricultural insurance and government policies by providing data that can be used to design better risk management strategies and disaster relief programs (Li *et al*., 2022). The Indian Space Research Organisation (ISRO) gathers weather data through satellites, while the National Medium Range Weather Forecasting Centre uses modelling and simulation techniques for weather prediction. In addition, State Meteorological Centres provide local weather information. This weather forecasts are disseminated to the public through mobile apps and social media platforms. Thus, in India, weather forecasting operates under a comprehensive and integrated system,

providing crucial weather information to farmers and the general public.

Types of weather forecasting

Depending on spatial and temporal scales of atmospheric systems and the details of the accuracy desired, the weather forecasts are divided into the following categories.

A. Now-casting (NC)

B. Short range weather forecasts (SRF)

C. Medium range weather forecasts (MRF)

D. Long range/Extended range weather forecasting (LRWF/ ERWF).

Each forecast type is associated with a level of confidence of probability of occurrence or success.

Types of forecasts	Definition	Temporal resolution	Characteristics
Now-casting (NC)	Descriptions about current weather and forecasts up to a few hours ahead are given	Minutes	Relatively complete set of variables can be produced (air temperature/relative humidity, wind speed and direction, solar radiation, type, cloud amount.
Short range weather forecasts (SRF)	Description of weather variables in each successive 24 hrs interval up to 3 days	Eight times a day at 3 hr interval	This forecast range is mainly concerned with weather systems observed in latest weather charts, although generation of new systems is also considered.
Medium range weather forecasts (MRF)	Forecast is valid for 4–10 days and area of applicability is much large than that for SRF	Twice a day	In this forecast, average weather conditions and weather on each day may be prescribed with progressively lesser details and accuracy than that for short range forecasts.
Long range/Extended range weather forecasting (LRWF/ ERWF)	Forecast is valid for a month to a season and a large area applicability of a state or for combinations of many state	Once a month	This type of weather forecast is usually restricted to some fundamental weather parameters.

Source: India Meteorological Department, Ministry of Earth Sciences. Government of India

Importance of weather forecasting in different agricultural operations and production systems: Weather forecasting is crucial for agriculture as it helps farmers plan key operations like sowing, irrigation, fertilization, and harvesting. Accurate forecasts reduce crop losses by preparing for extreme weather events like droughts, storms, and frost. It also optimizes resource use, improving yield and efficiency in different production systems.

Optimising the timing of sowing and harvesting

The primary benefit of weather forecasting is its role in determining the optimal timing for sowing and harvesting crops. Since agriculture heavily depends on weather conditions, having prior knowledge of weather enables farmers to make informed decisions about when to plant and harvest their crops. For instance, an accurate monsoon forecast can help farmers in anticipating low rainfall, allowing them to adjust their sowing accordingly. Similarly, during harvesting if farmers are aware of rain or storms predication in the coming days, they can hasten harvesting to protect their crops from damage. This timely weather information plays a crucial role in enhancing agricultural productivity.

Irrigation Management and Water Conservation

Irrigation plays a crucial role in agriculture, especially in regions where there is a shortage of natural rainfall. Weather forecasting significantly enhances irrigation management by enabling water conservation, optimizing irrigation schedules, and managing risks. It provides farmers with information about when it will rain or when a drought may occur, allowing them to manage water resources more efficiently. Short-term weather forecasts are used to develop more efficient irrigation schedules. By predicting rainfall events, farmers can adjust irrigation timing and volume, which reduces water wastage and drainage (Mishra *et al*., 2013). For example, there is a predictionof rainfall, farmers can conserve water by reducing irrigation. Similarly, if there is a possibility of no rain, farmers can prepare in advance by managing their water resources for irrigation, ensuring the protection of their crops.

Effective use of fertilizers and pesticides

Weather forecasting plays a crucial role in the effective use of fertilizers and pesticides by helping farmers apply them at the right time. Through it, farmers can predict the right time to apply fertilisers, the type of fertilisers, and the application rate. It guides fertilizer and pesticides application by predicting rainfall patterns, which influence crop yield potential. This approach helps in adjusting fertilizer inputs to match expected yields, reducing over-fertilization in low-yield seasons and maximizing returns in high-yield seasons (Asseng *et al*., 2012). Weather data helps farmers determine the time they should put more effort into their day-to-day operations. If rain is expected, farmers can avoid applying fertilizers and pesticides to prevent them from being washed away, ensuring better absorption and effectiveness. Similarly, during dry or windy conditions, spraying pesticides can be ineffective or harmful due to drift. By using weather forecasts, farmers can

optimize their input usage, reduce costs, and minimize environmental impact.

Post-Harvest Crop Storage and Marketing

Weather forecasting plays a crucial role in reducing post-harvest crop storage losses and optimizing marketing strategies by providing accurate predictions of crop yields, enabling better management of storage conditions, and informing market decisions. If forecasts predict high humidity or heavy rainfall, proper storage measures, such as drying and airtight storage can be implemented to prevent spoilage. Similarly, extreme temperatures or storms may impact transportation and market prices, allowing traders to adjust their strategies. Accurate forecasts enable better decision-making, reducing post-harvest losses and maximizing profits.

Crop Insurance Plans

Weather forecasting plays a crucial role in crop insurance plans by helping farmers and insurers assess potential risks such as droughts, floods, and storms. Accurate forecasts enable timely decision-making, allowing farmers to take preventive measures and insurers to set appropriate premium rates. It also helps in quick claim settlements by providing reliable weather data to verify crop damage. Overall, weather forecasting enhances the effectiveness of crop insurance, ensuring better financial protection for farmers**.**Weather forecasts combined with agriculture policies and insurance can play an important role in securing farmers' profits and providing climate risk management guidance for agriculture production**.**

Conclusion

The importance of weather forecasting in agricultural management is very high. It not only helps farmers protect themselves from natural disasters but also promotes crop production. As complexities of agricultural systems and uncertainties of climate forecasts recommended that a coordinated effort is needed, if this technology is to be routinely used in agriculture in future. By receiving timely weather information, it assists farmers in making better decisions, which enhances the productivity and profitability of agricultural activities. Weather information should be given by agro-meteorological stations one or two month before the onset of the rainy season that can allow farmers to change critical decisions i.e. sowing schedule, crop varieties, cropping ratio, intensification of production, allocation of labour and capital. Access to accurate weather predictions empowers farmers to enhance their agricultural practices, ensuring sustainable and resilient farming systems.

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Natural fibres and their composites: Opportunities, challenges and a pathway to a green and sustainable future

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Introduction

Growing environmental awareness and depleted petroleum reserves have propelled interest in natural fibres as eco-friendly, affordable and renewable alternatives driven by the urgent need for sustainable materials in combating global warming. Rising sustainable resource awareness drives the substitution of synthetic fibres with eco-friendly natural fibres, yielding advantages such as weight reduction, cost savings and reliance on renewable materials for enhanced environmental conservation (Ahmed *et al.*,2021). Consequently, natural fibres are increasingly being employed as supporting or filling components in composite manufacturing (Jotiram *et al.*, 2022). Despitedecades of technological advancements in artificial fibres like carbon, aramid and glass it is noteworthy that natural fibres such as kenaf, flax, jute, hemp and sisal continue to garner renewed interest.

A majority of natural fibres can be extracted from lignocellulosic fibrous plants including flax, jute, hemp, kenaf, sisal, ramie, nettle, abaca, curaua, coir, cabuya, pineapple, bamboo and more (Kozłowski *et al.*, 2020).The term "lignocellulosic fibres" refers to fibres that contain both lignin and cellulose. However, it is worth noting that some of the fibres included in this category such as cotton may have minimal or no lignin content. For a number of reasons, natural fibresare becoming increasingly popular, due to their potential to replace synthetic fibre-reinforced polymers at a lower cost while enhancing sustainability (Sapuan *et al.*,2022).Banana, sisal, coconut and oil palm lignocellulosic fibres offer biodegradable, cost-effective, low-density and recyclable benefits with their unique lignin, hemicellulose and cellulose composition which significantly influences their physical and mechanical properties (Kini and Shenoy, 2022). Jute, kenaf, bamboo, coir, sisal and pineapple plant-based fibres excel in load-bearing applications offering eco-friendly alternatives with lightweight, strong, and low-density mechanical attributes. (Aisyah*et al.*,2021).

About Natural Fibres

For millennia, humans relied on plant and animal sources for natural fibres like flax, hemp, silk, wool and cotton until the emergence of synthetic fibres. Predicted to reach 40 million tons annually by mid-century, natural fibre production's growth is estimated at around 3% per year (Kozłowski *et al.*, 2020). These photosynthesis-derived plant fibres, termed "natural fibres", are pivotal resources for textiles and composites, also known as vegetable, biomass or photosynthetic fibres. Natural fibres

consist of cellulose micro-fibrils embedded in a mix of hemicellulose and lignin, with cellulose comprising 60-80% and lignin 5-20% of their weight(Kini and Shenoy 2022). Fibres are categorized as synthetic or natural. Synthetic fibres are derived from non-renewable petroleum-based resources making them non-biodegradable. Fibres, derived from plants (vegetables, leaves and wood), animals and geological processes are collectively referred to as natural fibres. Natural fibres are favored for reinforcement due to affordability, renewability, strong yet lightweight properties, easy handling and eco-friendly, sustainable characteristics driving recent popularity (Jotiram *et al.*,2022).

Natural fibreshave lower density than synthetic fibres and metals, making them stronger and lighter. This may prove to be an advantageous in transportation and applications for better energy efficiency. Natural fibres possess remarkable qualities including renewability, biodegradability and desirable properties like excellent hygroscopicity and air permeability. Importantly, they do not release harmful substances that could jeopardize human health or the environment (Kozłowski *et al.*, 2020). The usage of natural fibres, notably jute, hemp, flax and kenaf fibres has garnered significant interest for structural applications. Additionally, these fibres possess the advantageous qualities of being biodegradable, lightweight and renewable.

Due to their eco-friendly nature, natural fibre materials have gained significant attention in technical fields such as construction and automotive industries as a reinforcing material (Kini and Shenoy, 2022). Natural fibres are becoming increasingly popular due to their potential to replace synthetic fibre-reinforced polymers at a lower cost while enhancing sustainability (Sapuan *et al.*, 2022). Compared to synthetics (carbon, Kevlar, glass), natural fibres are non-toxic, lighter, compostable, support rural economies; gentle on equipment, cost-effective, insulate heat/noise, safe without skin irritations.

Classification of Natural Fibres

Plant Fibres

Plant-based fibres comprise cotton, hemp, jute, flax, ramie, sisal, bagasse, specialty fibres derived from wood and are predominantly composed of cellulose. Cereal straw, corn stalk, cotton, bagasse and grass are agricultural crop residues that are generated in large quantities worldwide. These residues serve as an abundant, cost-effective and easily accessible source of lignocellulosic biomass for fibre extraction.

Natural fibres (leaf, bast, seed) are common in composites, especially bast fibres (flax, jute, hemp) boost tensile and bending strength. Wood processing, coir, agave, rice/nut hulls, straws (oat, rye, wheat), corn cobs are used for stability and stiffness enhancement. Natural fibre composites are widely used in industries like automotive, construction, furniture and packaging, providing eco-friendly alternatives to synthetic fibres, promoting environmental sustainability (Aisyah*et al.*, 2021).

Animal Fibres

Animal fibres are derived from animal hairs or secretions, primarily consisting of proteins. Notable examples include wool and silk. These fibres find applications in

textiles and rank as the second most abundant natural fibres after plant-based options. Common sources include sheep, alpacas, cashmere goats, silkworms, chickens and ducks.

Animal-based fibres (e.g., wool, silk) find use in biomedical applications, prioritizing biodegradability and biocompatibility. Animal fibres, excluding wool and silk are primarily utilized in outwear apparel with around 25,000 tons of exotic animal fibres produced annually.

Advantages and Disadvantages of Natural Fibres

Advantagesof Natural Fibres

In recent times, the utilization of natural fibres as an alternative reinforcement in polymer composites has gained significant interest from researchers and scientists, owing to their advantages over traditional synthetic materials. Natural fibres like jute, hemp and flax offer competitive mechanical properties and cost-effectiveness compared to synthetic fibres. They are recyclable, renewable and eco-friendly with benefits including reduced energy consumption and minimal health risks. Unlike glass fibres, natural fibres are cost-effective, half the density and better at absorbing energy. Natural fibres find applications in aerospace, packaging, automotive, construction, railway interiors and storage, serving as an economical alternative to high-cost glass fibres. Compared to synthetic fibres, NFs have a notable advantage in superior specific characteristics (property-to-density ratio) in potential compositions along with abundant availability of natural sources or remnants.

Natural fibres offer numerous advantages for developing countries, including biodegradability, recyclability, efficient energy recovery, strong strength and specific modulus, reduced health risks, low density, affordability, minimal skin irritation, abundant availability, cost-effective production, lightweight materials, decreased equipment abrasion, less tool wear, improved energy recovery, and reduced skin and respiratory irritation.

Disadvantages of Natural Fibres

Natural fibres exhibit drawbacks such as inconsistent attributes, variable quality, heightened sensitivity to humidity and processing temperatures, reduced durability and strength, and increased vulnerability due to hydrophilicity. Some drawbacks associated with natural fibres include reduced impact strength, limited moisture resistance, lower durability, and inadequate adhesion with matrix fibres. Natural fibre composites face challenges of moisture absorption and matrix-fibre compatibility; absorption varies by type such as cotton and ramie absorb more; hemp and flax absorb less. Water absorption by natural fibres weakens the interfacial strength of the matrix fibres.

Natural Fibre Composites (NFC)

Natural fibre reinforced composites have emerged as a pivotal research area in the field of materials science. In recent decades, fibres derived from natural sources have emerged with the objective of replacing conventional high-strength synthetic fibres, giving rise to a new class of composites known as Natural Fibre Reinforced Polymer (NFRP) composites. Natural fibre reinforced composites (NFRCs) are gaining attention in industry and academia due to their potential to address environmental impacts and meet the growing demand in diverse sectors.

NFRCs are used in bicycle frames, door and window frames, columns, ceilingsand more. NFRCs consist of a polymer matrix, sourced from petroleum-based or natural biopolymers, and a reinforcing material in the form of fibres or particles. Natural Fibre Reinforced Composites (NFRCs) are lightweight due to the lower density of natural fibres (1.2 to 1.6 g/cm^3) compared to synthetic fibres (e.g., glass fibre: 2.4 g/cm^3). Researchers have explored various options like sisal, luffa, kenaf, bamboo, coir, pineapple, flax, and jute as fillers in natural fibre polymer composites. (Jotiram *et al.*, 2022).

The combination of natural fibres and biodegradable polymers yields bio based green composites, which can be further categorized as hybrid and textile composites. Hybrid composites consist of a blend of two or more fibre types (Aisyah*et al.,* 2021). Natural fibres are utilized in high-performance applications by incorporating them into hybrid composites with other materials (Ahmed *et al.*, 2021). Abundant natural fibres offer an appealing alternative to synthetic fibres in composites due to easy processing, favorable fatigue properties, corrosion resistance, and high stiffness-to-weight ratio (Kini and Shenoy, 2022).

Compatibility of Natural Fibres with matrix material

Natural fibres have moderate hydrophilicity, inherent rawness, and a range of physicochemical attributes that affect how well they bond with matrix materials in composites. Weak interfacial adhesion can lead to structural defects within the composite due to insufficient bonding. Natural fibres are primarily susceptible due to non-compatibility and the presence of hydroxyl (–OH) groups in their structure, particularly in cellulose, which is composed of repeated glucose units found in plants, as well as hemicellulose segments. Due to the presence of hydroxyl groups in the constituents of all-natural fibres and other polar components, these fibres demonstrate elevated moisture absorption.

The hydrophilic nature of natural fibre surfaces, marked by hydroxyl groups, reduces their compatibility with hydrophobic polymers, impeding fibre-matrix bonding and leading to processing challenges in NFRCs, ultimately yielding inferior mechanical properties. Moreover, excessive fibre moisture can cause the formation of water vapor and porosity during NFRC processing, as observed by Balla et al. in 2019. Additionally, the hydrophilicity-induced inability to establish robust bonds with hydrophobic polymer matrices affects the fibre-matrix interface, which is pivotal for stress transmission in NFRCs, thereby influencing their mechanical traits as highlighted by the same study. Hence, in order to attain the intended mechanical properties in NFRCs, it's essential to either treat the fibres or enhance the fibre-matrix interfacial adhesion by incorporating compatibilizers/coupling agents into the polymer matrix. Common fibre treatment methods encompass grinding, acetylation, steam explosion, electron beam irradiation, gamma-ray irradiation, plasma irradiation, alkali treatment (mercerization), silanization, and graft copolymerization of monomers or polymers onto fibres. For instance, vapor-phase acetylation can reduce hydrophilicity and enhance thermal stability (Balla *et al.*, 2019).

Conclusions

Natural fibres and their composites are gaining importance with growing environmental consciousness. Various attributes such as cost-effectiveness, renewability, light weight, easy workability contributes towards the increasing popularity of natural fibres. However, one of the major challenges in developing natural fibre-reinforced composites is the hydrophilic nature of the fibres, which can hinder their compatibility with hydrophobic polymers. To address this, various treatment methods have been explored to enhance the bonding between natural fibres and hydrophobic matrices. Various treatment methods have been developed and assessed towards improving the compatibility of natural fibres with hydrophobic polymers.Although considerable progress has been made, further exploratory studies are needed to improve the utilisation potential of various natural fibres and development of value-added products out of them. Additionally, overcoming challenges related to scalability, cost-effectiveness, and supply chain logistics will also be crucial in advancing the adoption of natural fibre-based composites in various applications, promoting both environmental and economic benefits.

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Computational approaches for assessing genetic diversity

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Introduction

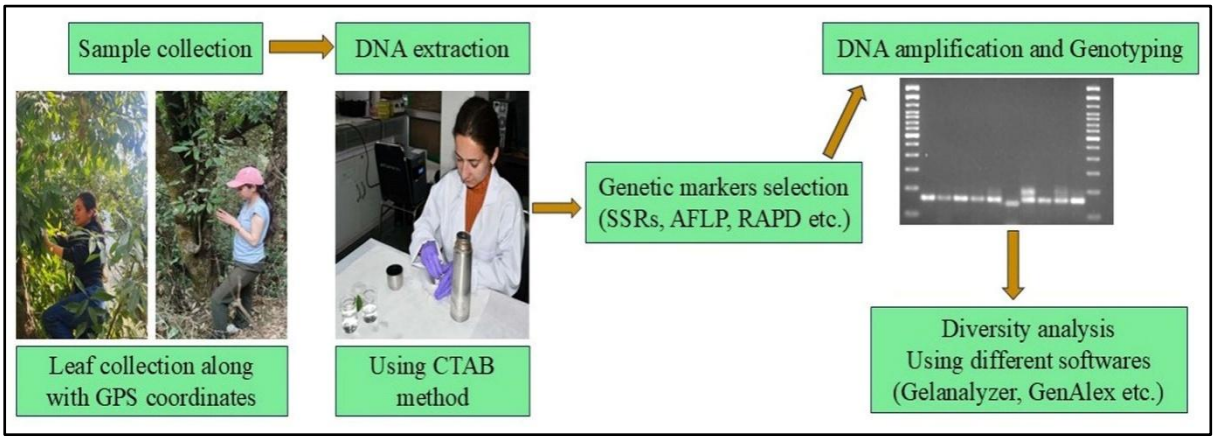
Genetic diversity refers to the variation in genetic material within and among populations of species (Hughes et al., 2008; Ennos et al., 2000). It encompasses the differences in DNA sequences, alleles, and genotypes that contribute to individuals' unique traits and characteristics. High genetic diversity within a population is essential for the survival and adaptability of species, as it increases their ability to cope with environmental changes, diseases, and other challenges. Conversely, low genetic diversity can lead to inbreeding and an increased risk of extinction, as populations become more susceptible to genetic disorders and less adaptable to changing conditions.Genetic diversity is a fundamental concept in evolutionary biology, conservation genetics, and biodiversity studies (Frankham et al., 2002). Understanding genetic diversity helps in monitoring the health of populations, designing conservation strategies for endangered species, and studying evolutionary processes. Moreover, it provides insights into the genetic basis of traits that are important for agriculture, medicine, and biotechnology.

Molecular markers are essential tools for assessing genetic diversity in plants. Commonly used markers include Microsatellites (SSRs), which are highly polymorphic and co-dominant; RAPD markers, which are quick and inexpensive but dominant; AFLP, which generates numerous polymorphisms across the genome; SNPs, which are abundant and useful for fine-scale variation studies; ISSRs, which are more reliable than RAPDs and can assess genetic diversity effectively; and EST-SSRs, which focus on functional genomic regions. Additionally, DNA barcoding is used to distinguish species and study biodiversity. The choice of marker depends on the specific objectives, species, and resources.

Software tools for estimating genetic diversity play a crucial role in modern genetic research, allowing scientists to analyse and interpret complex genetic data with accuracy and efficiency. These tools utilize a range of statistical and computational methods to assess the genetic variation within and between populations, helping to quantify parameters such as allele frequencies, genetic distances, and heterozygosity. By integrating data from molecular markers like SSRs, SNPs, or AFLPs, these programs provide insights into the genetic structure of populations, evolutionary processes, and the effects of environmental or human-induced factors on biodiversity. Software such as GenAlex, STRUCTURE, and PAST is widely used in fields such as conservation biology, evolutionary genetics, and plant breeding, enabling researchers to assess the health and

adaptability of species, design effective conservation strategies, and study the genetic basis of traits. These tools have become indispensable for understanding the genetic complexity of organisms and managing genetic resources.Therefore, this article provides an overview of various software tools used to estimate genetic diversity, highlighting their features, applications, and significance in genetic research. These tools are essential for analysing genetic variation within and between populations, enabling researchers to gain valuable insights into genetic structure, evolutionary processes, and biodiversity conservation.

Process for estimating genetic diversity



Software tools for diversity analysis and population structure analysis

Gel analyzer software (23.1.1) is used to estimate the molecular weight of bands in gel electrophoresis by comparing them to a known molecular weight ladder. The software helps identify the size of the molecular bands by analyzing their migration through the gel matrix. Typically, smaller molecules travel faster and thus appear lower in the gel, while larger molecules travel slower and remain higher. The software not only estimates molecular weight but also provides precise measurements, visual analysis, and automated band detection, making it an essential tool for quantifying and comparing protein or DNA samples in research and diagnostics.

GenAlex software (6.503) is a robust and advanced tool designed to estimate genetic diversity by analyzing molecular data across various populations, genotypes, and loci. To use this software, you first need to gather and input data on the molecular weights of the bands obtained from Gel analyzer software. This data should include information from different populations and genotypes across various loci. Once the data is organized into an Excel sheet, the software can analyze it to calculate key genetic diversity parameters, such as allele frequencies, heterozygosity, and genetic differentiation. GenAlex allows for the assessment of genetic variability within and between populations, helping researchers to better understand evolutionary processes, gene flow, and the genetic structure of populations. The software also provides various statistical outputs and graphical representations, AMOVA and Principal

component analysis (PCoA) making it a valuable tool in population genetics studies.

HP-rare software (1.1) is used to estimate allelic richness, which is a measure of the number of different alleles present in a population, normalized for sample size. This software is particularly useful in population genetics studies, as it helps quantify genetic diversity by providing insights into how many distinct alleles are present across different loci. HP-rare can analyse data from multiple populations and account for variations in sample sizes, ensuring that comparisons of allelic richness are not biased by unequal sample sizes.

Structure software (2.3.4) is used to analyse population structure by identifying and estimating the genetic composition of populations, including the number of distinct genetic clusters (or subpopulations) within a dataset. It uses genetic data, typically from multiple loci, to assign individuals to different populations based on their genetic similarities. Structure can reveal the underlying patterns of genetic differentiation among populations and provide insights into gene flow, migration, and the historical processes that shape population structure. By running simulations for various numbers of populations (K), the software helps researchers determine the most likely number of genetic clusters in the data. It is widely used in conservation genetics, evolutionary biology, and studies of human and plant genetic variation, offering graphical outputs and statistical estimates to support inferences about population connectivity and genetic diversity. Further, the best K value (the optimal number of genetic clusters) is determined using ΔK, which can be calculated through an online tool called **Structure Selector.** This tool is specifically designed to assist in selecting the most appropriate K value by analysing the results of multiple Structure runs. It uses the ΔK method, which evaluates the rate of change in the likelihood of the data between different K values, helping to identify the point where the model best fits the genetic data. Structure Selector provides an easy-to-use interface for visualizing and interpreting the results, making it a valuable resource for researchers working with Structure software. By accurately selecting the optimal K, researchers can more confidently interpret population structure and genetic differentiation in their studies.

PAST (Paleontological Statistics) software (4.0.3) is a versatile statistical tool widely used for analyzing and clustering genetic diversity data. It provides a range of statistical methods, including clustering algorithms, that help researcher's group populations or individuals based on their genetic similarities. Using genetic data such as allele frequencies or molecular markers, PAST can perform various types of clustering, such as hierarchical clustering or principal component analysis (PCoA), to identify patterns of genetic variation. This makes it particularly useful for studying population structure, evolutionary relationships, and genetic diversity across different groups or species. In addition to clustering, PAST offers a variety of other statistical tests, data visualization options, and graphing tools, making it

comprehensive software for conducting genetic diversity assessments in both ecological and evolutionary research.

Darwin software (6.0.021) is a tool used for analyzing molecular data and estimating genetic diversity in populations. It is particularly useful for handling large datasets derived from genetic markers such as microsatellites, SNPs, and other molecular techniques. Darwin software allows researchers to calculate various genetic parameters, including allele frequencies, genetic differentiation (Fst), and heterozygosity, making it an essential tool for population genetics studies. The software also supports various statistical analyses, such as clustering, principal component analysis (PCoA), and multivariate analysis, to assess genetic structure and relationships among populations. Its user-friendly interface and robust analytical capabilities make it popular in both basic and applied genetic research, including conservation genetics, evolutionary biology, and breeding programs.

PowerMarker (3.2.5) is a widely used, though older, software tool designed for analyzing genetic data, particularly for assessing Polymorphism Information Content (PIC). PIC is a measure of the informativeness of a genetic marker, reflecting its ability to differentiate between different genotypes within a population. PowerMarker calculates PIC values for various molecular markers, including SSRs (simple sequence repeats), SNPs, and AFLPs, helping researchers assess the diversity and variability of genetic traits. In addition to PIC, PowerMarker can also compute other genetic parameters like allele frequencies, gene diversity, and heterozygosity.

Table 1: Links for downloading software tools online

Software Tools	Link for downloading
Gelanalyzer (23.1.1)	http://www.gelanalyzer.com/?i=1
GenAlex (6.503)	https://biology-assets.anu.edu.au/GenAlEx/Download.html
HP-rare (1.1)	https://www.montana.edu/kalinowski/software/hp-rare.html
Structure (2.3.4)	https://web.stanford.edu/group/pritchardlab/structure_software/release_versions/v2.3.4/html/structure.html
PAST (4.0.3)	https://past.en.lo4d.com/download
Darwin (6.0.021)	https://mybiosoftware.com/darwin-diversity-phylogenetic-analysis.html
PowerMarker (3.2.5)	https://brcwebportal.cos.ncsu.edu/powermarker/downloads.htm

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Medicinal and Aromatic Plants - A Boon for Shallow basaltic Landsof the Deccan plateau region of India

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Medicinal and aromatic plants are gifts of nature to humanity to cure various diseases and ailments. These species are underutilized, sparingly cultivated in arable lands and mainly collected from natural sources.Only herbs are commercially grown for industrial use, requiring good soil and better management practices. As Charaka rightly said, "All the plants in nature have medicinal properties." This is true; wildly growing trees, shrubs, and climbing plants with potential medicinal properties and industrial use may be cultivated forhumankind. This will also helpto conserve rare, endangered,and threatened species for future use.

Shallow basaltic soils are primarily found in Deccan plateau regions of India, which are large volcanic rockswith shallow soil depths of varying intensity. These lands are characterized by thin soil cover, rocky outcrops, poor fertility, and low moisture retention, making them challenging for conventional agriculture.India has 6.4 million hectares (2.04 % gross area of India) of barren rocky land, which is unsuitable for the cultivation of commercial crops due to poor soil conditions such as salinity, shallowness, rocky lands, and inadequate water holding capacity (Harisha and Singh 2019).

In India Maharastra (Nashik, Pune, Ahmednagar, Satara, Kolhapur, Beed, Aurangabad), Madhya Pradesh (Malwa Plateau, Chhindwara, Betul, and parts of Mandla), Gujarat (Saurashtra, Kutch, and parts of Surat), Telangana & Andhra Pradesh (Adilabad, Karimnagar, Mahbubnagar, Anantapur) and Rajasthan (Udaipur, Chittorgarh, Bhilwara) are considered to be Deccan region with featured soil of rocky basaltic nature.

The major challenges faced in the cultivation of any crop species in Shallow Basaltic Lands include

1. Low fertility due to limited organic content and topsoil erosion
2. Poor water retention leads to drought conditions.
3. Rocky and uneven terrain make mechanized farming difficult.
4. Soil erosion due to sparse vegetation cover.
5. Shallow soil depth leads to poor vegetation and establishment.

Even though there are several challenges, growing vegetation in these shallow soils and rocky lands can be effectively managed by interventions such as pit planting, mulching, water harvesting, bunds, etc. Agroforestry with medicinal plants or trees suitable for the region to improve soil condition and biodiversity.Adoption of rainwater conservation to enhance moisture retention in soil.Use of organic wastes to improve moisture holding and soil fertility.Preparation of terracing in high

slopes and contour bunds to prevent soil erosion.

Advantages of cultivating medicinal and aromatic plants in wastelands

1. Utilization of natural resources such as land and available water for the cultivation of plants
2. Conservation of rare, endangered and threatened species of native origin.
3. Reduces the pressure on natural sources like forests for raw drug materials
4. Uniform quality and continuous supply of raw materials
5. To meet the demand of pharmaceutical industries for herbal drugs
6. To stabilize the ecosystem by cultivating trees, helping with carbon sequestration in the atmosphere.
7. Diversification of cropping practices helps get additional income compared to conventional systems.
8. Mitigation of climate change causes such as hot winds, soil erosion, evaporation etc., by covering the ground witha green belt.
9. Creates awareness of the health benefits of medicinal plants
10. Encourages agro-eco tourism, where more species diversity and enhanced habitat for birds, insects, and animals are available.

Table 1: plant species suitable with potential uses and ideal for dry location

Plant Name	Scientific Name	Uses	Suitable Regions
Aloe Vera	*Aloe barbadensis*	Skincare, digestive health	Maharashtra, Gujarat, Karnataka, Telangana
Ashwagandha	*Withaniasomnifera*	Stress relief, immunity booster	Madhya Pradesh, Rajasthan, Maharashtra
Shatavari	*Asparagus racemosus*	Women's health, anti-inflammatory	Gujarat, Madhya Pradesh, Maharashtra
Tulsi	*Ocimum sanctum*	Immunity, respiratory health	Maharashtra, Karnataka, Telangana
Giloy	*Tinosporacordifolia*	Immunity, anti-fever	Madhya Pradesh, Rajasthan, Gujarat
Guggul	*Commiphorawightii*	Joint pain, cholesterol control	Rajasthan, Gujarat
Vetiver	*Chrysopogonzizanioides*	Cooling agent, soil stabilization	Karnataka, Maharashtra
Neem	*Azadirachtaindica*	Antibacterial skin diseases	All basaltic regions
Senna	*Cassia angustifolia*	Laxative, detoxification	Rajasthan, Gujarat, Madhya Pradesh
Sarpagandha	*Rauvolfiaserpentina*	Blood pressure, anxiety relief	Maharashtra, Madhya Pradesh

Butea	*Butea monosperma*	Natural colour	Maharashtra, Madhya Pradesh

Table 2: Plants species suitable for improving the soil organic matter and physical properties

Plant Name	Scientific Name	Role in soil conservation
Gliricidia	*Gliricidiasepium*	Nitrogen fixer, soil stabilizer
Moringa	*Moringa oleifera*	Leaf litter improves soil nutrients
Aonla	*Phyllanthusemblica*	Deep roots stabilize soil
Arjuna	*Terminalia arjuna*	Grows in poor soils, prevents erosion
Neem	*Azadirachtaindica*	Grows in poor soils, adds org matter
Agnimantha	*Premna sp.*	Grows in poor soils, adds org matter
Arjun	*Termineliaarjuna*	Grows in poor soils, adds org matter
Mahua	*Maducalatifolia*	Adds org matter
Pongemia	*Millettiapinnata*	Nitrogen fixer, soil stabilizer
Cashew	*Anacardiumoccidentale*	soil stabilizer
Vetiver	*Chrysopogonzizanioides*	soil binder and stabilizer
Mucuna	*Mucunapruriens*	soil binder and N fixer

Soil characters of the herbal garden at ICAR-NIASM

The herbal garden was established in shallow basaltic soil with a depth of 20 cm below which hard murrumbasaltic rocks exist.

Figure 1: Soil showing hard stones on the opening of pits

Spacing requirement for plant species

Plant type	Spacing (m)
Trees	6 x 6 or 5x 5
Shrubs/small trees	4 x 4
Climbers	4 x 4

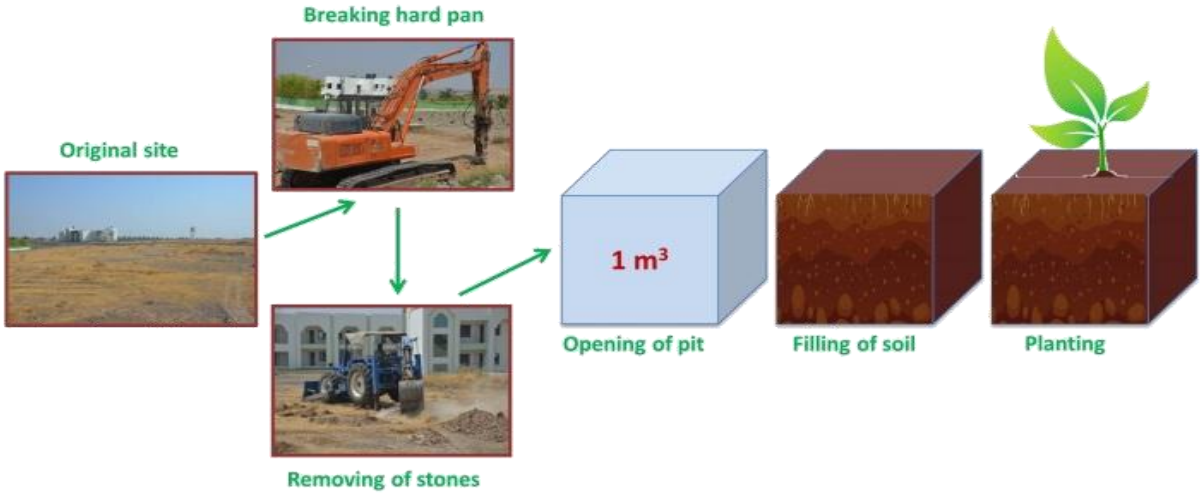
Procedure of planting of medicinal trees in shallow basaltic soils

1. Layout and marking for opening of pits in the designated area


2. Layout and pit opening and of the garden into different blocks


3. Pits opening and filling of black soil mixed with native top soil.


4. Plantation of various medicinal trees, shrubs, and climbers



Land development for planting medicinal plants in shallow basaltic soils

Table 3: Plant species highly suitable for dry lands and shallow soil conditions

No	Common name	Scientific name	No	Common name	Scientific name
1	Agnimantha	***Premnaintegrifolia***	21	Indian oleander	*Nerium oleander*
2	Laurel	***Calophylluminophyllum***	22	Jamun	*Sizigiumcumini*
3	Annato	*Bixaorellana*	23	Mahuva	*Maducaindica*
4	Arjuna	*Terminalia arjuna*	24	Malabar Nut	*Adathodazylanica*
5	Beal	***Aegle marmelos***	25	Neem	***Azadirachtaindica***
6	Behda	*Terminalia bellarica*	26	Pongemia	*Pongemiapinnata*
7	Black currant	***Carissa caronda***	27	Purging cassia	***Cassia fistula***
8	Bone setter	*Cissusquandrangularis*	28	Putranjeeva	*PutranjeevaRoxburgaii*
9	Bullet wood	*Mimusopselengi*	29	Red Sanders	*Ptreocarpussantalinus*
10	Champaka	***Micheliachampaka***	30	Sandal wood	*Satalum album*
11	Hirda	*Terminalia chebula*	31	Shamee	***Prosopis cineraria***
12	Coral tree	***Adinantherapawonia***	32	Soap Nut	*SapindusSp*
13	Cutch Tree	*Acacia catechu*	33	Soap Pod	*Cassia sinuat*
14	Eucalyptus	***Eucalyptus globra***	34	Lemon grass	***Cymbopogonflexuosu***
15	Fever nut	*Caesalpiniabonduc*	35	Citronella	***C. winterianus***
16	Nirgudi	*VitexNigundo*	36	Vetiver	***Chrysopogonzizanioides***
17	Palash	***Butea monosperma***	37	Asparagus	*Asparagus racemosus*
18	Guggal	*Commiphorawightii*	38	Rosary Pea	***Abrusprecatorius***
19	Henna	***Lawsoniainermis***	39	Butterfly pea	***Clitoriaternatea***

20	Indian Aloe	***Aloe vera***	40	Giloy	***Tinosporacordifolia***

Figure 2: The transformation of shallow basaltic terrain into a model medicinal garden

Use of soil and moisture conservation measures

Soil and water conservation measures are essentialwhen using available water and soil. Moisture conservation and irrigating the plants in the summer seasons is the biggest challenge in shallow soils where roots are on the surface and prone to drought stress very quickly. In this case, ideal moisture conservation and irrigation practices are very important. Half-moon-shaped bunds were made across the slope to conserve the soil moisture in the root zone. Running water during rains will be collected in the plant basin, enabling soil erosion control and water harvesting.

Adopting a drip irrigation system with a fertigation facility enables irrigating the crop regularly as and when required. Apart from the precise irrigation use of live mulch, waste mulch light digging is essential to conserve the moisture in the root zone.

Figure 3: use of half-moon shaped bund filled with crop mulch for moisture conservation in summer months

Training and pruning of plant species

- Plants must be trained and pruned periodically for proper management of the canopy and to keep them in good shape.
- Pruning of trees once a year during March-April to remove lower branches and also dead and diseased

Figure 4: Properly trained climber plants onto the concrete pole

Adoption mechanisms by MAP to high temperature and shallow soils

1. Plants can extend their roots more profoundly and longer in search of anchorage and moisture. The best example is that the ficus group of plants can extend the roots even in rocks and buildings to anchor the roots and absorb the moisture. In the same way, many plant species can utilize moisture properly for their survival

2. Having a cooler canopy by reduced transpiration during high water and stressed condition make them adapt to less moisture and high temperatures

3. Hardier plants such as *Aloe*, guggul, agave, *and Opuntia have mucilaginous mesocarp leaves*. They can survive for long periods without moisture and alsohigh temperatures. They can survive in

poor soils with shallow and rocky conditions, too.

Conversion of barren shallow soils in this manner will help to establish tree gardens with multiple species, making the environment stable by carbon sequestration, improving soil condition by reducing soil erosion, improving species diversity, and conserving native plant species. This also conserves native herb insects, enriching soil organic matter and microbial population.

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Declining Population of *Syzygium jambos* (Rose Apple) in Chhattisgarh: A Call for Conservation

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Summary

Syzygium jambos, commonly known as Rose Apple or White Jamun, is an important member of the Myrtaceae family, known for its nutritional, medicinal, and ecological significance. The species, once abundant in the forests of Pendra Road and Marwahi in Chhattisgarh, is now facing a drastic decline. This study highlights the critical importance of conserving this species by examining its botanical characteristics, medicinal properties, ecological contributions, and the factors leading to its depletion. The paper emphasizes the urgent need for conservation strategies, including afforestation and community awareness programs, to prevent the species from local extinction.

Introduction

Syzygium jambos (L.) Alston, commonly referred to as Rose Apple, is a tropical fruit species known for its fragrant, apple-like fruit and its wide-ranging medicinal benefits. Native to South and Southeast Asia, the tree thrives in tropical and subtropical climates and has traditionally been used for its fruit, leaves, and bark, which possess significant pharmacological properties.

In India, particularly in the state of Chhattisgarh, Rose Apple trees were once found in abundance in the forests of Pendra Road and Marwahi. However, their numbers have significantly dwindled due to habitat destruction, climate change, and unsustainable land use. The objective of this paper is to assess the current status of *Syzygium jambos* in Chhattisgarh, explore its medicinal and ecological significance, and propose conservation measures.

Botanical Description

Syzygium jambos is a medium-sized, evergreen tree that grows up to 10–15 meters in height. It belongs to the Myrtaceae family and is characterized by the following features:

Leaves: Opposite, lanceolate, glossy, and aromatic.

Flowers: White to pale yellow, fragrant, with numerous stamens, appearing in clusters.

Fruits: Ovoid, 2–4 cm in diameter, ripening from light yellow to pinkish-red. The ripe fruit emits a distinct rose-like fragrance, leading to its common name, "Rose Apple."

Seeds: Generally one or two per fruit, encased in a spongy, edible pericarp.

The tree typically flowers between March and April, while the fruit matures from May to July. The species thrives in well-drained soils and humid climatic conditions, making it well-suited for tropical and subtropical regions.

Nutritional and Medicinal Properties

Rose Apple is rich in bioactive compounds that offer multiple health benefits.

Nutritional Composition

Vitamin C: Supports immune function and skin health.

Calcium: Essential for bone development and maintenance.

Dietary Fiber: Aids in digestion and promotes gut health.

Antioxidants: Help combat oxidative stress and free radical damage.

Medicinal Benefits

Antidiabetic Properties: The seeds and bark contain hypoglycemic compounds that may help regulate blood sugar levels.

Antimicrobial Activity: Extracts from leaves and bark exhibit antimicrobial properties against bacterial and fungal infections.

Gastroprotective Effects: Traditionally used in herbal medicine to treat digestive disorders.

Dermatological Uses: Paste made from leaves has been applied to treat skin ailments and wounds.

Ecological Importance

Apart from its medicinal and nutritional benefits, *Syzygium jambos* plays a vital role in the environment:

Soil Conservation: Its extensive root system stabilizes riverbanks and prevents soil erosion.

Biodiversity Support: The flowers attract pollinators like bees and butterflies, while the fruit serves as a food source for birds and small mammals.

Carbon Sequestration: As a perennial tree, it contributes to carbon absorption, mitigating climate change effects.

Factors Contributing to Population Decline

The population of *Syzygium jambos* in Chhattisgarh has seen a significant reduction due to several anthropogenic and environmental factors:

Deforestation and Habitat Loss: Large-scale deforestation for agriculture and urbanization has led to habitat fragmentation.

Overexploitation: Unregulated harvesting of fruit, leaves, and bark for commercial and medicinal purposes has contributed to species decline.

Climate Change: Unpredictable rainfall patterns and rising temperatures have negatively impacted the growth and reproductive cycle of the species.

Lack of Conservation Initiatives: Despite its ecological and medicinal significance, *Syzygium jambos* has not been a focus of conservation efforts in the region.

Conservation Strategies

To prevent the local extinction of Rose Apple trees, the following conservation measures should be implemented:

Afforestation and Habitat Restoration

- Large-scale planting of *Syzygium jambos* should be undertaken in its native habitat.
- Agroforestry models can be introduced to encourage sustainable cultivation along with other crops.

Community Participation and Awareness

- Educating local communities about the ecological and medicinal importance of the species.
- Promoting community-led conservation programs involving traditional knowledge and sustainable harvesting practices.

Legal and Policy Measures

- Implementing protective regulations to prevent unauthorized logging and overharvesting.

- Integrating *Syzygium jambos* conservation into state and national biodiversity action plans.

Scientific Research and Sustainable Utilization

- Conducting studies on propagation techniques, including tissue culture, to enhance survival rates.
- Promoting sustainable harvesting methods to ensure the species' longevity without overexploitation.

Conclusion

Syzygium jambos, an ecologically and medicinally valuable species, is facing a serious decline in Chhattisgarh due to habitat destruction, overexploitation, and climate change. Urgent conservation measures are required to preserve this species, including afforestation, legal protections, and community-driven initiatives. By integrating traditional knowledge with modern scientific research, effective strategies can be developed to ensure the survival of this invaluable tree. The conservation of *Syzygium jambos* is not only crucial for biodiversity but also for sustaining the medicinal and nutritional benefits it provides to local communities.

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