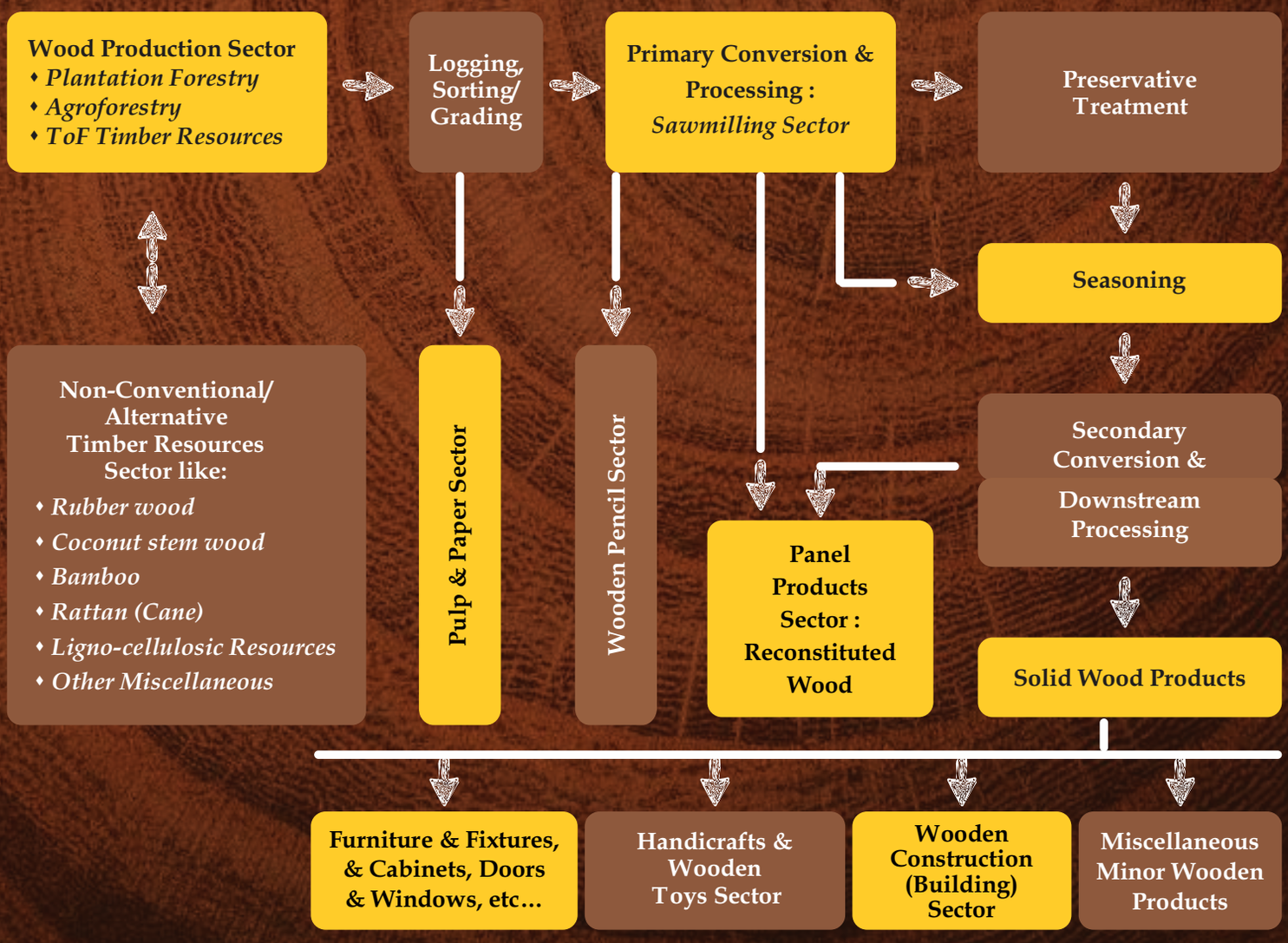
IWST

wood is good

GROW MORE, USE MORE

ICFRE

INDIA WOOD SECTOR REPORT



Vol. 2, Issue 3, October - December 2021

INSTITUTE OF WOOD SCIENCE AND TECHNOLOGY, BENGALURU

Indian Council of Forestry Research and Education

(An Autonomous Body Under Ministry of Environment, Forest & Climate Change)

My reputation is built on the quality of my work.

I CHOSE CENTURYPLY.

OUR PRODUCT PORTFOLIO: PLYWOOD | LAMINATES | VENEERS | DOORS | MDF

Follow us on: CenturyPlyOfficial CenturyPlyIndia CenturyPly1986

For any queries, call us on **1800 5722 122** or **SMS 'PLY'** to **56070**

wood *is* good

GROW MORE, USE MORE

Submissions for publication of articles & advertisments
may be made to extension_iwst@icfre.org

INDIAN COUNCIL OF FORESTRY RESEARCH AND EDUCATION

(An Autonomous Council of Ministry of Environment Forest and Climate Change, Government of India)

VISION

To achieve long-term ecological stability, sustainable development and economic security through conservation and scientific management of forest ecosystems

MISSION

To generate, advance and disseminate scientific knowledge and technologies for ecological security, improved productivity, livelihoods enhancement and sustainable use of forest resources through forestry research and education

ZiBOC

- A new wood preservative which is comparable to CCA.
- Judicious use of preservative in a non-durable wood greatly enhances (6-8 folds) life of products.

Varieties/ Clones developed

- Developed improved germplasm of many forest tree species.
- Released 47 high performing and disease resistant clones of *Eucalyptus, Casuarina, Shisham, Melia* and *Sarpagandha* with a envisaged production gain of more than 20%. The developed germplasm are being made available to the State Forest Departments and farmers for use in plantations.

High performing and disease resistant clone of *Melia* sp.

CYCUS v. 1.0

- Casuarina Yield Calculator Utility Software (CYCUS v1.0) software has been developed to facilitate the farmer and other user agencies in yield estimation which requires only observations on girth of 100 sample trees per acre of plantation.

Wood Welding

Wood welding is new to our country. In this technique wood joints can be made without using nails and adhesives making them more natural and chemical free. A wood welding machine has been designed and fabricated at Forest Research Institute, Dehradun. Success has been achieved in spin welding of wood pieces of few species.

Wood Welding Machine

Indian Council of Forestry Research and Education

New Initiatives

- Transparent wood- a flexible and biodegradable transparent wood has been fabricated using poplar wood veneer and water soluble polymer- polyvinyl alcohol. The transparent wood exhibited high optical transmittance, high haze and light diffusing property.

Natural wood (Left most), Lignin modified wood (middle) and Transparent wood (right most) placed on a paper with letters "IWST"

Heat storage based modified Solar Kiln

- Solar heat storage system based solar kiln has been developed by Forest Research Institute, Dehradun for timber drying. The solar heat is trapped using suitable phase change material (PCM). The New solar kiln is able to trap 39 % more heat in winters as compared to traditional green-house based traditional FRI solar kiln developed during 1970.

Head based storage Solar Kiln

Xylarium

- Collection of authentic wood samples both from India and other countries, depicting wood biodiversity of the country like lightest, heaviest, sweet-smelling, foul smelling, smoothest, streaked, variegated wood and wood of different coloures, etc. The collection of wood cross sectional discs depicting variation in sapwood and heartwood colour is a unique feature of the xylarium.
- Wood identification services.

Xylarium- Collection of Authentic wood samples

Tree hollowness detection technique based on ultrasonic waves

- Forest Research Institute, Dehradun has developed ultrasonic techniques (Non-destructive testing) to detect the location and magnitude of the hollowness of the standing tree. This will help to remove the potential human hazards by way of falling down of such trees during a high wind regime in Urban Forestry.

Measurement of hollowness in a tree using ultrasonic detector

Agroforestry models

- Various agroforestry models (Poplar, Eucalyptus, Melia, Casuarina and Babool) have been developed to improve green cover, enhance farmers income and to mitigate climate change .

Poplar based agroforestry model with wheat

Innovative Bamboo Bottles

- Techniques for making bamboo bottles by using Bamboo Treatment Technologies of ICFRE. Most suitable bamboo species for making bottles are Shil Barak (*Bambusa salarkhanii*) & Barak (*Bambusa balcooa*). One full bamboo is sufficient for making 21 full size bottles and 12 small bottles.

Bamboo bottles

For further details please contact :
Assistant Director General, Media & Extension Division,
Indian Council of Forestry Research and Education,
Dehradun - 248 006
Phone:- +91-135-222 4814, +91-135- 2755221,


RDL
EASY CLEAN, EASY GO.
Wouldn't it be great if surfaces could keep themselves clean? Well, now they can. Presenting VIR's Easy-to-clean range of laminates; they're water-resistant, stain-resistant and easy-wipe too. Now get rid of stubborn splashes and stains in one go.
EASY-TO-CLEAN & MAINTAIN
TERMITE, BORER AND FUNGUS RESISTANT
STAIN RESISTANT
RESISTANT TO MOLD FORMATION
HYGIENIC
ANTI-FINGERPRINT
VIR
LAMINATE
Banao apna jahaan
1800 233 7952 | www.virlaminate.com | info@rushil.com

चन्द्र प्रकाश गोयल
CHANDRA PRAKASH GOYAL

सत्यमेव जयते

वन महानिदेशक एवं विशेष सचिव
भारत सरकार
पर्यावरण, वन एवं जलवायु परिवर्तन मंत्रालय
DIRECTOR GENERAL OF FOREST & SPL. SECY.
GOVERNMENT OF INDIA
MINISTRY OF ENVIRONMENT, FOREST AND CLIMATE CHANGE

FOREWORD

The wood and forestry sectors can make a significant contribution towards meeting green economy objectives owing to its importance in climate change mitigation. Wood is natural renewable, carbon neutral and sustainable material for diverse application such as building structures, bridges, furniture, handicrafts etc. It sequesters carbon during its production and locks it for long duration while in use. There is considerable pressure to reduce wood use through the substitutions of synthetic materials such as aluminum, steel, PVC, glass, cement and plastics. However, most of these synthetic materials require far more energy to produce, are non-renewable and create environmental pollution. Enhancing use of wood has been advocated as one of the effective strategies in climate change mitigations. Appreciating role of wood use in climate change mitigation, Central Public Works Department has recently lifted the ban on use of timber in constructions and habitat development. Greater production and uses of wood products will also contribute in creating additional carbon sink of 2.5 to 3 billion tones of carbon dioxide equivalent the year 2030.

In order to meet deficit of demand and supply of wood, a number of fast growing and short rotation timber species are being grown in natural, plantation and in agricultural land. However, most of the plantation timbers have inherent problems and have limited service life. The solution to this is optimized processing, better storage and handling of products, improved designs and better methods for protecting wood from physical and biological degradation. Over a period of time, wood processing industries have advanced significantly in the developed world. However, these advancements remain still elusive to the wood based industries in the country, which is largely unorganized.

Institute of Wood science and Technology, Bengaluru (an institute under Indian Council of Forestry Research and Education) has been publishing a quarterly magazine **"Wood is Good: Grow More, Use More"** which includes popular articles on existing wood based technologies, success stories, industry perspective, emerging

Contd. 2/-

इंदिरा पर्यावरण भवन, जोर बाग रोड, नई दिल्ली–110 003
फोन: (011) 20819239,20819209 फैक्स: (011) 20819195
INDIRA PARYAVARAN BHAWAN, JOR BAGH ROAD, NEW DELHI-110 003
Ph.: 011-20819239, 20819209, Fax: 011-20819195, E-mail : dgfindia@nic.in

trends and products. The main aim of this publication is to create awareness about emerging issues in the sector of wood-based industries and to develop synergy between different stakeholders (researchers, industry professionals, consumers and other stakeholders) by creating a platform for regular interaction.

The current issue presents a comprehensive report on status of timber resource availability, demand, supply, trade scenario and technological issues pertaining to different wood sectors. The entire Wood Sector of India has been thoroughly reviewed with emphasis on Bamboo & Rattan; Non-conventional/Alternative Timber Resources; Plantation Forestry, Agroforestry & Trees Outside Forests; Forest and Timber Certification; Timber harvesting, Logging, Sawmilling - Primary and Secondary Conversions; Construction; Furniture, Handicrafts, Toys, Pencil making, & Packaging Sectors & Miscellaneous Products; Reconstituted Wood Panel Boards; Pulp and Paper. The understanding of issues and needs of different sectors will help formulation of future action plans for the wood based industry of the country.

(Chandra Prakash Goyal)

सत्यमेव जयते

अरूण सिंह रावत, भा.व.से.
Arun Singh Rawat, IFS

कुलाधिपति, व.अ.सं. विश्वविद्यालय
Chancellor, FRI University

महानिदेशक
भारतीय वानिकी अनुसंधान एवं शिक्षा परिषद्
डाकघर न्यू फॉरेस्ट, देहरादून - 248006
(आई.एस.ओ. 9001:2008 प्रमाणित संस्था)

Director General
Indian Council of Forestry Research and Education
P.O. New Forest, Dehra Dun - 248 006
(An ISO 9001:2008 Certified Organisation)

Preface

The Institute of Wood Science and Technology (IWST) is a premier research institute under the aegis of Indian Council of Forestry Research and Education (ICFRE). The Institute has been carrying out frontier research in wood science and technology for more than eight decades. Considering the significant contributions of the Institute, it has been recognized as a Centre of Excellence in Wood Science Research, keeping research mandate of the Institute in mind, ICFRE appointed Dr. T.K. Dhamodaran as Chair of Excellence (CoE) for IWST to carry out an in-depth analysis of existing research activities in wood products, identify cutting edge technologies used across the globe for developing wood products and come up with strategies for their adoption in India to boost the wood sector.

Upon completing the study, the CoE has submitted a detailed report on "present status of forest products research in the country and its relevance and applicability to the industrial sector". A part of the report submitted by the CoE is being published in the current issue of quarterly magazine **"Wood is Good: Grow More, Use More"**by the IWST, Bengaluru. This issue highlights upon status of wood based industries in India, particularly of primary wood processing industries like milling, seasoning, preservation, and processing for product manufacturing, with special reference to their technological status, constraints and requirements to boost the growth of wood sector in India. The wood-based industries existing in forest products sector of the country were categorized into different groups which include Timber and Sawn Wood Industries, Furniture, Fixtures & Joinery Industries, Building Construction Industries, Veneer and Plywood Industries, Reconstituted Wood Panel Board Industries, Handicrafts & Toys, Match Industries, Wooden Pencil Manufacturing Industries, Packaging Industries, Pulp Paper and allied Industries etc. The most important constraint in wood industry sector is unavailability of required quantity of raw material with wood species of desired quality.

This issue is published with an intention to provide a glimpse on status of wood sector in India to all the stakeholders associated with wood based industries, so that they can reflect upon it and provide appropriate feedback to prepare a road map for Wood Sector as part of "Vision India @2047". It is hoped that in the forthcoming issue of "Wood is Good: Grow More, Use More"magazine the IWST will publish a clear road map for wood sector to make India as net wood exporting country by 2047.

I congratulate Dr. T.K. Dhamodaran and Director, Institute of Wood Science and Technology, Bengaluru for this comprehensive report. I hope this issue of Wood is Good: Grow More, Use More"magazinewill be useful to all the stakeholders and will form basis for growth of wood based industry in the country.

Date:

(Arun Singh Rawat)

दूरभाष / Phone : 135-2759382 (O)
EPABX : 0135-2224855, 2224333 (O)
ई–मेल / e-mail : dg@icfre.org
फैक्स / Fax : 0091-135-2755353

COSTAA® WOODS

Working the Sustainable Way in Diversified Multi-Disciplined Wood Business Enterprises in India

COSTAA®
Heal the world!

We utilize wood judiciously to preserve for Future

PRODUCTS

- Solid Wooden Doors Frames
- Flush Doors
- Shuttering Ply
- Plywood and Block Board
- Solid Wooden Flooring
- Decorative Hardwood Lumbers
- Outdoor Decking
- Sports Infrastructure
- Softwood Lumbers
- Wooden Pallet
- Face Veneer and Core Veneer

COSTAA Heal the world!
QUALITY
FSC CERTIFIED
IGBC MEMBER
ISI CERTIFIED
ISO 9001-2008

CONTACT US

+91-8697973600 / 9374539020
info@costaawoods.com
connect@costaawoods.com
www.costaawoods.com

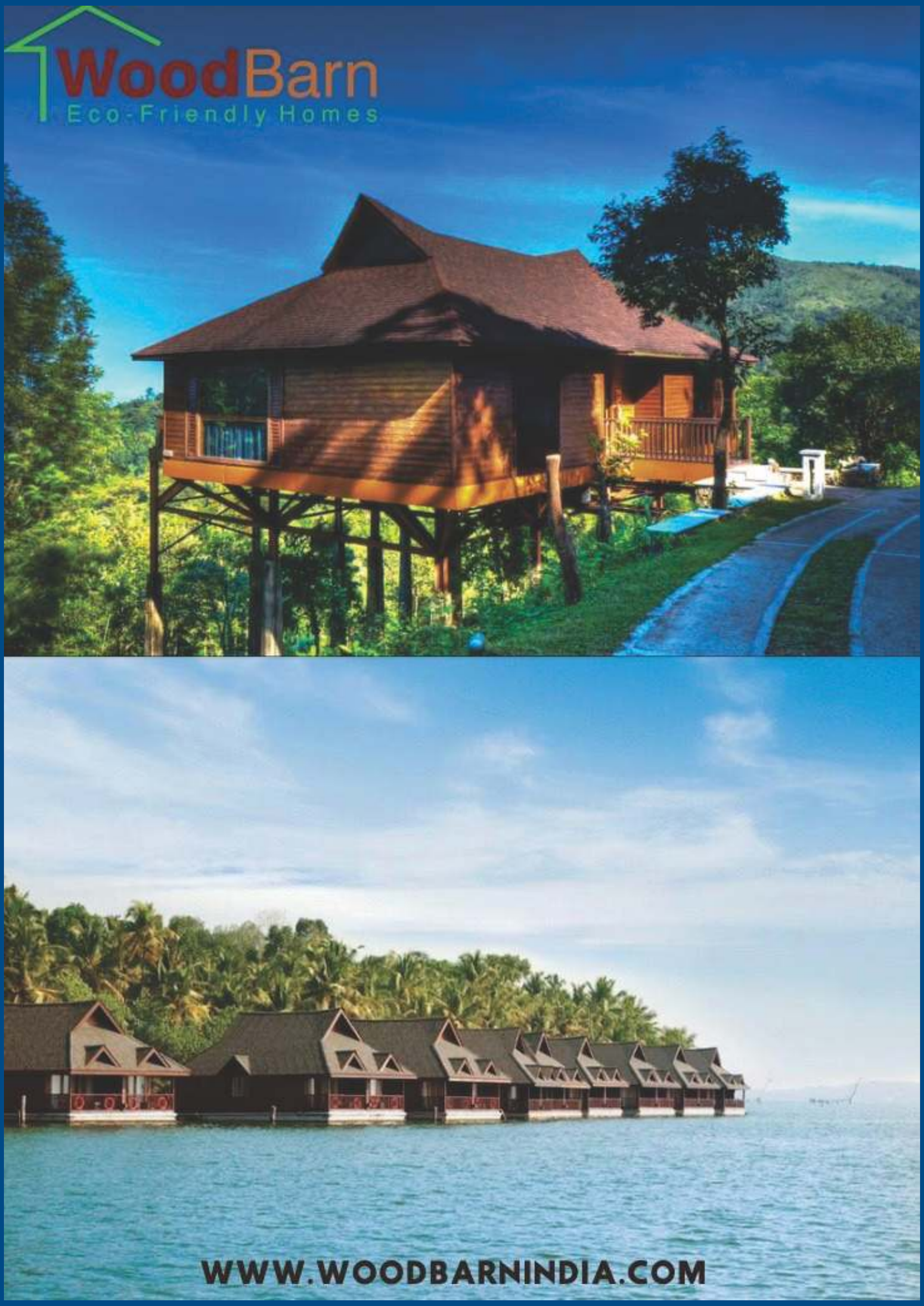
costaawood | costaawoods | costaa woods | costaawoods

CONTENT

IWST Activities during October-December 2021

India Wood Sector Report

Dr. T.K. Damodaran, Chair of Excellence (Forest Products),
Indian Council of Forestry Research and Education (ICFRE)


WoodBarn
Eco-Friendly Homes
WWW.WOODBARNINDIA.COM

IWST activities during October–December, 2021

Azadi Ka Amrit Mahotsav (India@75)
Webinar on Sandalwood Farming and Management of its Health

As part of Azadi Ka Amrit Mahotsav celebration, Institute of Wood Science and Technology (IWST), Bangalore conducted webinar in Hindi on **Sandalwood Farming and Management of its Health** on 11 October 2021. Shri Giriraj Singh, Hon'ble Minister of Rural Development & Panchayati Raj inaugurated the program. Change in policy on sandalwood cultivation by states and central government has encouraged farmers and entrepreneurs to grow sandalwood on private lands. With sandalwood farming gaining momentum, the webinar envisaged to educate farmers to grow sandalwood in a more healthy and sustainable way. About 252 participants, predominantly farmers from across the country participated in the program.

Azadi Ka Amrit Mahotsav (India@75)
Webinar on Wood Protection Practices & Way Forward

Under Azadi Ka Amrit Mahotsav celebration, IWST conducted webinar on Wood Protection Practices & Way Forward on 30 October 2021.The webinar stressed on the importance and technologies of wood seasoning and preservation. It also discussed on different wood modification procedures. About 500 members representing wood based industries, researchers, foresters, architects, wood users and students participated in the program.

Azadi Ka Amrit Mahotsav (India@75)
Webinar on Timber Identification and its Prospects

IWST conducted webinar on Timber Identification and its Prospects on 12 November 2021 as part of Azadi Ka Amrit Mahotsav celebration. The webinar focused on identification of soft woods and hardwoods by anatomical approach, molecular markers and artificial intelligence. Utilization of lesser known species for various end uses was also discussed. About 180 participants from academic institutions, forestry colleges and training centres, research institutes, wood industries and forest departments benefited from the program.

Forestry Training and Capacity Building: Training of Other Stakeholders on Basics of wood processing and utilization, wood protection & wood modification

IWST organized a two day /online training program on **"Basics of wood processing and utilization, wood protection & wood modification"** to sensitize and educate stakeholders like NGOs, students from educational institutions, nature clubs/eco-clubs, panchayats, elected representatives, personnel from banking institutions, social activists, press and media persons etc. during **17-18 November 2021.** The training was sponsored by Ministry of Environment, Forest and Climate Change under the Umbrella Scheme: Forestry Training and Capacity Building - Training to Other Stakeholders.

Azadi Ka Amrit Mahotsav (India@75) Webinar on Utilization of plant tissue culture techniques in forestry

As part of Azadi Ka Amrit Mahotsav celebration, Institute of Wood Science and Technology (IWST) conducted a sensitization program for college students on **Utilization of plant tissue culture techniques in forestry on 17 November 2021.** About 240 UG, PG students along with faculty members participated in the program. The training covered plant tissue culture techniques, micropropagation techniques for Bamboos, techniques for in vitro regeneration of sandalwood and secondary metabolite production from medicinally important trees – Mappiafoetida". The advantages of in vitro production of secondary metabolites was also explained .

Azadi Ka Amrit Mahotsav (India@75) Webinar on Demonstration of Bamboo Management and Harvesting in the field

Training cum Demonstration program on Cultivation and management of bamboo was organized by IWST on 26 November 2021 at IWST-Field/Research Station at Gottipura, Hoskote, Bangalore- Rural (Dt) under Azadi Ka Amrit Mahotsav celebration. The program aimed towards capacity building of farmers on cultivation of bamboo in their fields and effective adoption of agro-forestry systems. About thirty farmers from nearby villages of Gottipura, Attivatta, Hosakote and Dasarahalli who are primarily millet and vegetable growing farmers attended the program with enthusiasm & showed keen interest.

Vigilance Awareness Week

Vigilance Awareness Week was observed by IWST, Bangalore from 26 Oct-01 Nov 2021. Dr. M. P. Singh, Director, IWST led the staff in taking the Integrity Pledge. During the week, Poster designing & Elocution Competitions on theme "Independent India @ 75: Self Reliance with Integrity" were organized for the staff and students. The weeklong celebration concluded with address by Dr. M. P. Singh, Director and prizes were distributed to the winners of Poster Designing & Elocution Competitions.

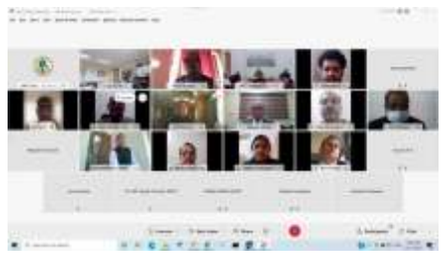
Kannada Rajyotsava

Kannada Rajyotsava - State Formation Day of Karnataka was celebrated by staff of IWST on 16 Nov 2021 with great enthusiasm. Director IWST wished all the employees on the occasion and the program commenced with hoisting of Karnataka flag by Director, followed by his address, felicitation of retired employee, distribution of prizes to winners of various competitions and cultural events by staff & students of the institute.

Azadi Ka Amrit Mahotsav (India@75)
Rivers of India Day

As a part of Azadi Ka Amrit Mahotsav Celebration, IWST organized Poster competition on "Rejuvenation of Rivers through Forestry Interventions" and Elocution Competition on "Importance of Rivers to Human Life and Current Scenario of Indian Rivers" on 10th December 2021. The staff and students of institute actively participated in both the competitions and prizes were distributed to the winners.

Two day online training workshop for IFS Officers on Integrated Pest and Disease management in Nurseries, Plantations and Forests



IWST organized two days online training workshop on "Integrated Pest and Disease management in Nurseries, Plantations and Forests" for the serving IFS officers during 16-17 December, 2021 sponsored by Ministry of Environment Forest and Climate Change, Government of India. Dr. M. P. Singh, Director, IWST, Bangalore inaugurated the training program and 22 officers of 1988 to 2018 batch attended the training. Panel discussion on "Improvement in the working of Forest Departments – Need for career development through training and improvement of skills" was held with the panellists Dr M. P. Singh, IFS, Director, IWST, Dr Deleep Kumar, IFS, APCCF & CEO (MFPPARC), Madhya Pradesh and Shri B. K. Singh, IFS, Secretary SED, Jammu and Kashmir. The participants also expressed their views and suggestions on the need for improvement in the working of the forest departments.

AzadiKaAmritMahotsav (India@75)
Good Governance Week

The Good Governance week would symbolize the strides made by India in promoting citizen centric governance and improving service delivery in consonance with AzadikaAmrutMahotsav celebrations to commemorate 75 years of progressive India.

At Institute of wood Science and Technology, Good Governance Week was celebrated during 20-23 Decemeber 2021. During the week, refresher course and introductory course for new recruits on topics related to office procedure, filing, noting and drafting, roster and pension procedure, income tax procedure, GST procedure, budget, control of expenditure, receipts and payments, categorization & management of office files, recruitment & compassionate appointments together with stress management for balanced life and issues related to gender sensitization was organized for the benefit about 22 administrative staff of IWST. The lectures were delivered by subject experts serving in various Government organizations. The Good Governance Week concluded with deliberation on administrative issues with Head of Divisions and Administrative staff of IWST.

AzadiKaAmritMahotsav (India@75)
Webinar on Sandalwood Oil: Uses, Adulteration and Detection Techniques

As part of AzadiKaAmritMahotsavcelebration, Institute of Wood Science and Technology (IWST) conducted webinar on Sandalwood Oil: Uses, Adulteration and Detection Techniqueson 24 December 2021.The topics coveredin the webinar included extraction methods, quality assessment techniques and heartwood estimation in standing sandalwood trees using Electric Resistance Tomograph (ERT). About 40 stakeholders like academicians, researchers, sandalwood growing farmers participated in the webinar.

Chapter 1
Timber : Resources, Demand, Supply and Trade Scenario

Resources

Forests were managed for revenue generation during the British colonial period (1857-1947) which resulted in unregulated extraction of timber. Until the 20th century, forest policies across the globe were mainly focusing primarily on timber production. Subsequent loss of forest land at late prompted many countries to review and amend such policies in an attempt to incorporate the principles of conservation and sustainable forest management. One of the countries to implement such changes was India, which introduced new policies, acts and programmes to regulate forest conversion and degradation, beginning in the 1980s. These policies, acts, and programmes included the Forest Conservation Act (FCA) of 1980, the National Forest Policy (NFP) of 1988 and the Hon. Supreme Court Order of 1996banning all felling. Forests, even though are primarily considered as a source of timber, are no longer so with the advent of the National Forest Policy of India (1988) which necessitated the paradigm shift of production to conservation, and the then *'forest-based'* industries to *'wood-based'* industries, as the forests are required to be maintained and improved for various ecosystem services and conservation of bio-diversity contained in them for the society at large. All of these regulations affected the timber supply from government forest areas, and created a huge gap in supply and demand. Currently, this deficit is met through imports and Trees Outside Forests (TOFs). Timber production from government forest areas is abysmally low (@3.4% of total demand) compared to potential timber production from TOFs, which fulfil 45% of the total timber demand in India. This implies that TOFs have immense potential in meeting the growing timber demand; however, they have not been fully utilized due to discrepancies in state level TOFs' policies. Dwindling scenarios of imports due to the price escalations of the wood raw material in the international markets and related import tax issues paused challenges in the timber import markets. The contribution of recycled/reclaimed wood is considered as not significant so as to consider to the total availability of timber. Thus, in brief, plantation timber and ToFs become the principal sources of timber for wood-based industries. The absence of an exclusive policy on timber production and inconsistent and unavailable data on such production further poses challenges in establishing the causal relationship between forest policy and timber production in the country (Ghosh and Sinha 2016).

Over the 150 species of timber which are produced in India, a list of major plantation timbers is available with Anon. (2020a). The commonly harvested species from natural forests in India include, among others: Teak (*Tectona grandis*), both from natural and planted forests; Sal (*Shorea robusta*); and Khair (*Acacia catechu*). Common planted species include, among others, fast-growing (and short-rotation) species: Teak (*Tectona grandis*) most widely planted timber species and most of it is harvested from planted forests; Eucalypts (*Eucalyptus spp.*);Poplar (*Poplus spp.*); Acacia (*Acacia spp.*); and Subabul (*Leucaena leucocephala*).

As per the latest official statistics (FSI – ISFR 2019), the country's forest cover (including all patches of land with a tree canopy density of more than 10% and more than 1 ha in area, irrespective of land use, ownership and species of trees) is reported as 71.2 million ha (21.7% of the total geographical area – TGA), accounts 7% of the world's biodiversity; the total of forest and tree cover (including all patches of trees less than 1 ha) is recorded as 80.7 million ha accounting to 24.6% TGA (TGA is recorded as 328.7 million ha). Out of a TGA of 328.7 million ha of the country, the total Recorded Forest Area (RFA; all such lands which have been notified as forest under any government act or rules or recorded as forest in the government records) as on 2019 is reported as 767.4 million ha representing 23.3% of the country's TGA. The extent of ToFs is reported as 29.4 million ha

(8.9% of TGA). The growing stock of wood in the country is estimated as 5915.8 million m^3 comprising of 4273.5 million m^3 inside forest areas and 1642.3 million m^3 outside recorded forest areas (ToFs); with an average growing stock per ha in forest of 55.7 m^3. Vide, State of World's Forests (FAO, 2020), the forested land of India is reported as 72 million ha, constituting 24.2% of the total land area, accounting 7% of the world's biodiversity. 2 Per cent of the Global Forest Area is reported for India (FAO – GFRA 2015).

The country is reported to be consuming around 333 million m^3 (equivalent to 216.4 million tonnes) fuel wood (FAO 2009). The latest figures for the dependence of people in the forest fringe villages (FFVs) on forests are as follows:

Fuel wood (Million Tonnes)	Fodder (Million Tonnes)	Small Timber (Million m3)	Bamboo (Tonnes)
85.3	1053.0	5.8	1.8

(Source: FAO – GFRA 2015)

Production and Trade - Export & Import

	Production quantity (x 1000 m^3)	Imports quantity (x 1000 m^3)	Domestic consumption (x 1000 m^3)	Exports quantity (x 1000 m^3)
Logs (Ind. Roundwood)	49 517	4 383	53 881	19
Sawnwood	6 889	869	7 744	14
Veneer	295	415	702	8
Plywood	2 537	141	2 627	51

ITTO (2019), data 2017

According to ITTO (2017) the Wood Industry of India produced in 2015 almost 50 million m3 of logs, of which only a minor portion was exported. In this year, the export value of primary timber products exceeded 72.6 million US dollars. Paper and paper boards and furniture are the categories in which India exports most of its timber products; annual figures for export of industrial round logs varied from 1-5 million m^3 during the period 2001-2005. Indian timber exports are projected to reach 2.4, 2.9 and 3.5 million m^3 in 2020, 2025 and 2030 respectively (Shrivastava and Saxena, CSE Report 2017). India has a thriving range of industries for semi-processed and value-added timber products, including wooden handicrafts, pulp and paper, plywood and veneer and wooden furniture to be considered for export. Exports of wooden handicrafts in particular are on the rise.

With the advent of the sudden dip in domestic timber production following to the legal reforms in the forestry scenario of the country coupled with a growing domestic demand for timber due to rising living standards and urbanization, taking advantage of the liberalized import policy of wood and wood products by the Government of India (GoI), at present, India is a net importer of timber and timber products. Timber trade is not regulated in India; there is no fixed domestic pricing pattern for timber available in the country. Generally, the auctions held by the Forest Department report an annual increase in the minimum price. The large scale import of timber affects the domestic pricing pattern of timber, and therefore the import-export policy (EXIM) of the country should be reviewed to rectify the pricing in the market, so that it is economically viable to grow trees on farmlands.

In 2015, India imported 18.01 million cum of timber, pulpwood and allied products worth US $ 6,701.3 million, which included wood logs, panel and plywood, pulpwood, paper, furniture and other wooden products. Under all categories of timber, wood logs and paper constitute the major part of Indian wood imports. Most timber imports are in the form of logs, whereas the import of sawn wood is in lesser quantities (only 3% of the total imports), and veneer and plywood is almost negligible. Logs enjoy

a lower tariff and satisfy the general policy of shifting value addition to India whenever possible. While logs comprised a significant (75%) portion of the value of India's wood product imports, that share is declining as imports diversify to other higher value processed wood products as wood-based projects and applications increase in sophistication and quality. More than two thirds of log imports come from Malaysia, Myanmar, Indonesia and New Zealand due to freight advantage (nearness) and relatively lower prices. Major log imports from these countries include hardwood species of teak, meranti and mahogany, eucalyptus, and temperate hardwoods such as ash, maple, cherry, oak, walnut, beech, hemlock and pine ash; along with plantation poplars, spruce and fir. Sawn wood/lumber import from the US is dominated by shipments of softwoods, mostly coniferous species of the southern yellow (loblolly) and the western yellow (ponderosa) pines and Douglas fir along with hardwoods such as hickory, birch, walnut, white oak and hard maple. Other major suppliers of logs to India are Cote D'Ivoire, Papua New Guinea, Gabon, Ecuador, Costa Rica, Panama and Cameroon. Sizeable quantities of hardwoods are also sourced from Central Africa (Nigeria, Ivory Coast, Ghana, Togo and Gabon), the Americas (Brazil, Panama, Papua New Guinea, Costa Rica and Ecuador), and even as far away as New Zealand. Maximum share (49%) of import of wood logs was being received in the Kandla port, followed by the adjoining Mundra port (17.2%), Tuticorin port (11.5%) and Kolkata port (8.2%) (Upadhyay et al. 2021). Global Agricultural Information Network (GAIN) Report 2019 provides detailed figures on Forest Products imports as on 2018, especially from the US. The country's total import bill for Forest Products in 2018 was around 2073 million US $, out of which 49.5 million US $ worth was from the US. Logs alone was accounted for US $ million 1052 for 2018, out of which 20 million US $ was the share to US and 187 to the rest of world. India's timber import in 2020, 2025 and 2030 are projected to be 22.5, 27.0 and 31.5 million m^3 respectively (Shrivastava and Saxena, CSE 2017). The top five major exporters of timber and timber products to India, as on 2010 was Malaysia, Myanmar, New Zealand, Papua New Guinea and Ivory Coast (American Hardwood Export Council 2016). The main products imported into India since 2010 include pulp, logs, sawn wood, and veneer to support a growing construction, manufacturing and processing industry. Together, these four products accounted for 79% of India's forest product imports by value in 2019. Log imports have been declining since 2014. Sawn wood and veneer imports have been slowly increasing.

India is heavily dependent on imports to fulfil its wood requirements. Exports of timber are much lower than imports. While the average annual timber imports from 2001 to 2015 were 11.2 million m^3, average timber exports during the same period were just 1.2 million m^3. In terms of volume, the major import categories are wood logs, wood pulp and paper, while the major export categories are paper and furniture; furniture is the only category in which Indian exports exceed its imports. India's timber imports accounts to 19-26% of the total annual timber availability and have been growing at a rate of 9.3% since 2001. Imports are bound to rise in the future as well, as there is no indication that domestic production of timber is keeping up with the pace of increasing demand;outcry for captive plantations are frequent from the pulpwood sector.

Timber Demand

It has been estimated that India demands over 80 million m^3 of wood to meet its multifarious utility. The demand for raw wood by different industries increased from 52 million m^3 in 1998 to 95 million m^3 in 2010, and was projected to increase further to 123 million m^3 in 2015 and 153 million m^3 in 2020 when it is estimated that more than 50 % of total Indian wood supply will come from non-forest sources (Pandey and Rangaraju 2008). The increase in demand for paper and the paper board industry has increased the most since 1998. Similarly, the demand for raw wood in the construction, packaging, plywood and furniture industries is consistently growing, and is projected to increase further due to economic growth and a rise in population. Moreover, it is interesting to mention that timber production from government forest areas caters to less than 4% of the total demand, whereas potential timber production is 45% of the total demand. This implies that there is a need for enhanced timber production on a sustainable basis, or through enabling policies and programmes to

meet domestic demand and reduce the reliance of India on imports.

The National Forest Policy (1988) and the National Agroforestry Policy (2014) directed to promote agroforestry in order to meet the timber demand besides augmenting the tree cover in the country. Various institutions and organizations both at state and central levels are involved in promoting timber species in agroforestry.

Although India is one of the world's top producers of tropical logs, it is also one of the world's largest consumers of wood products. India cannot meet its own demand for wood products with domestic supply and hence is one of the top most importing countries of tropical woods. India's imports have continued to decline steadily, dropping to 2.6 million m3 in 2017 and 2.4 million m^3 in 2018. The World Bank (2006) Reported that *"India is facing serious imbalances between the supply of and demand for wood; and the over harvesting of fuel wood, about 139 million m^3 above the sustainable supply from regulated sources.*

Industrial Wood: Production & Consumption

As per ITTO (2015), India produced 50 million m^3 of wood logs in 2014 and the export value of primary timber products exceeded USD 80 million. As per the 2017 estimate of the Forest Survey of India (FSI 2017), the annual production of timber from Agroforestry/ToFs is in the tune of 74.5 million m^3 (reported to be increased to an annual yield of 85.2 million m^3 vide FSI 2020); the annual availability of timber from Government forests was estimated to be another 2.4-3.0 million m3 plus 6-7 million m^3 from imports, totalling to an availability of 83.5 million m3 timber for industrial purposes (the contribution of recycled/reclaimed wood is considered as not significant so as to consider to the total availability of timber). Thus, Government Forests accounts only for less than 4% of the total timber availability for industrial purposes; 90 % of the industrial wood requirements are met from Agroforestry sector (Pandey and Roy 2020). While the annual availability of timber being estimated as 83.5 million m3, according to ICFRE's 2012 estimation, the requirement of timber for the various wood sectors are as follows (Bhajanka 2021):

Sector	Wood Requirement (million m^3)
Saw Mills	23
Ply & Veneer Mills	19
Paper Mills	9
MDF & Panel Based	5
Total	**62**

Kulkarni (2020) states that the CSE (Centre of Science and Environment) 2016 Report gave the picture that out of the total wood production in the country, 3-3.5% is used by the pulp & paper sector, 7-8.5% by plywood and sawn wood and the remaining 88-90% is used as fuel wood. Vanam (2019) projected a reported timber demand of 153 million m^3 round wood equivalent (RWE) for 2020 and potential timber production is 45% of the total demand, implying the need for enhanced timber production on a sustainable basis, or through enabling policies and programmes to meet domestic demand and reduce the reliance of India on imports.

As the annual timber production estimate from Agroforestry (AF) sector alone itself (85.2 million m^3 as per FSI 2020; 74.5 million m^3 as per FSI 2017; 70.9 million m^3 vide CSE Report 2017 by Shrivastava and Saxena, *c. f.* Bansal 2021) is found sufficient to meet both ends of the whole annual industrial wood requirement [69.0 million m^3 as per the CSE Report 2017 by Shrivastava and Saxena *(c. f.* Bansal 2021); 62 Million m^3 as per ICFRE 2012 estimation (*cf.* Bhajanka 2021); all figures considered only industrial wood requirement excluding fuel wood consumption; even though as usual, bit of tolerable inconsistencies are found existing between the various reports published such as Anon. 2020b (*cf.* Bansal 2021) & CSE Report 2017 by Shrivastava and Saxena], the setting up of more Agro wood based industries could be promoted without hesitation, provided sincere and continued efforts to promote *'AgriWood'* cultivation of the farmers is ensured with a view to gradually reduce the import of wood to the extent possible.

India's annual total wood production (including bamboo) has been estimated at 438.1 million m^3; excluding fuel wood production, the rounded timber volume falls to 52.9 million m^3 (cf. Norman and Canby (2020). Excluding fuel wood, the total Round

Wood Equivalent (RWE) Wood Balance of India is as given below:

Availability (million m^3)		Consumption (million m^3)	
Sources	Quantity	Sectors	Quantity
Natural Forests	3.2	Construction, Furniture, & Agricultural Implements	48.01
ToFs	44.3	Plywood & Panel Products	8.5
Imports	5.4	Paper & Paper Boards	12.5
Bamboo	18.0		
Total	**70.0**	**Total**	**Rounded to: 69.0**

[1] The estimate for wood consumption under the non-fuel wood category is available only for the three formal/organized industrial sectors: housing, furniture and agricultural implements. The combined annual consumption of timber in the three categories is 33.61 million cum, the round wood equivalent (RWE) of which is 48 million cum. These calculations are made assuming a wood lifespan of 20 years in construction, 15 years in household furniture, 10 years in commercial furniture, and five years in agricultural implements.

(Source: Shrivastava and Saxena, CSE 2017 Report)

Timber production from ToFs is nearly 14 times that from the forests; ToFs growing stock in 2015 was assessed as 1,573 million m^3.

Factually, India is the second largest importers of wood (around 6 Million m^3), which has consistently increased to the tune of Rs. 50,000/- crores per annum presently (Kumar 2020). At any given time, around 30% of all tropical logs in trade are destined for India. Import of logs represents over 74% of the total imports of forest products in the country. Among the reasons for importing logs into India are the simple and cost-effective 23,000-odd saw mills in the country, 98% of which are small units with an annual log intake of only 3,000 cubic metres; the total production capacity of the entire sawmilling sector is estimated at around 27.1 million cubic metres per annum. Almost 70% of imports are hardwoods, mostly logs, sawn wood accounted for only 3% of imports and the import demand for sawn timber is increasing due to supplier bans on log export. Log consumption in the Indian panel industry is met largely from plantations, agro-forestry and to a very limited extent from natural forests. The concept of industry-owned plantations of eucalyptus, poplar, casuarina and Acacia mangium is gaining popularity, and this helps prevent illegal felling in state-owned forests. A good portion of timber import could be reduced if proper promotion to Agroforestry sector is given for the cultivation of trees of suitable species. The growing stock of top 10 species in forests and ToFs are detailed below:

Sl. No.	Species	Forests Total Volume (million m^3)	Percent of Total Growing Stock in Country's forests (%)	Species	ToFs Total Volume (million m^3)	Per cent of total growing stock in Country's forests (%)
1	*Shorea robusta*	453.8	10.6	*Mangifera indica*	207.2	12.6
2	*Tectona grandis*	194.5	4.6	*Azadirachta indica*	133.2	8.1
3	*Terminalia tomentosa*	165.7	3.9	*Madhuca latifolia*	81.5	5.0
4	*Pinus roxburghii*	156.5	3.7	*Cocos nucifera*	63.9	3.9
5	*Abies pindrow*	129.2	3.0	*Borassusflabelliformis*	62.4	3.8
6	*Anogeissus latifolia*	124.1	2.9	*Acacia arabica*	52.3	3.2
7	*Pinus wallichiana*	119.3	2.8	*Butea monosperma*	45.7	2.8
8	*Cedrus deodara*	118.7	2.8	*Tamarindus indica*	42.5	2.6
9	*Lannea coromandelica*	101.4	2.4	*Pinus wallichiana*	42.5	2.6
10	*Abies smithiana*	94.5	2.2	*Ficus religiosa*	40.7	2.4

(Source: FSI – ISFR 2019)

As far as the bamboo bearing area in the RFA is concerned, around 16 million ha is recorded from all over the country; estimated total quantity of the green and dry culms from all over the states is around 277.8 million tonnes at the national level, the total quantity with an equivalent green weight of 19.7 million tonnes of bamboo were reported for the ToFs sector (FSI – ISFR 2019).

Growing of trees such as poplar, eucalypts, acacia, silver oak, casuarina, rubber wood, subabul, etc., on private lands outside forests in certain parts of the country has played an important role in catering to domestic timber demand in India. These plantations have also played an important role in stabilizing the forest and tree cover of the country by not only adding to area under tree cover but also by providing substitute to the timber harvested from forests and hence, conserving the same for ecological functions. However, suitable environment needs to be created for hassle free transportation, marketing and utilization of wood grown on agroforestry lands, as legal constraints exists in their trouble-free consumption, as they are still forest products and not agricultural products. It is, therefore, necessary to have further legal framework to promote the hassle-free utilization of wood cultivated trees from AF/ToFs. Proactive steps were taken by the Institute of Wood Science and Technology in advocating a draft act to promote 'AgriWood' production by the farmers and to support the revival of agro-wood based industry sector (Singh & Singh 2021). It is very important to realize the potential role of ToFs and promote it.

EXIM Bans

Import of sandalwood is restricted and subjected ceiling in each licensing year (import will be permitted only against an import authorization issued in consultation with Ministry of Environment, Forest and Climate Change (MOEF & CC). MOEFCC; ceiling for each financial year will be monitored by MOEFCC; license will be valid for a period of one year only from the date of issue and no further revalidation is allowed). Import of Red sanders (*Pterocarpus santalinus*) is prohibited. Also, only those species of timbers that are listed in the Indian Plant Quarantine Schedule VI & VII are permitted to import; other species require special permission and pest-risk analysis.

All import is restricted to methyl bromide (MBR) fumigated (48g/m^3 for 24 hrs. at 21^{0}C or above) or kiln dried wood (at 56^{0}C for 30 minutes), endorsed by agencies approved by Directorate of Plant Protection, Quarantine and Storage under the Ministry of Agriculture, Cooperation and Farmers Welfare (MoA) regulating the import of timber. MBR being toxic and environmentally unfriendly (class I ozone depleting chemical), gradual phase-out and alternative treatments are under consideration. The kiln drying at 56^{0}C for 30 minutes for quarantine purpose is ambiguous as it has primarily no relation with wood seasoning and secondarily, there is no assurance that once dried at 56^{0}C for 30 minutes and subsequently exposed to atmosphere for unlimited periods will get infected! These conditions need a review for alternatives.

Customs duty for wood and wood products varies from 5-60% depending on the nature of product and HS code (Harmonized Commodity Description and Coding System, generally referred to as 'Harmonized System' or simply 'HS' is a multipurpose international product nomenclature developed by the World Customs Organization, WCO).

India has banned the export of unprocessed logs. It has placed an export ban on sandalwood (Santalum album) timber. Logs and sawn timber of Rosewood (*Dalbergia latifolia)* is also banned from export under the Indian Forest Act.

The Government of India has banned the export for commercial purposes of all wild-taken specimens of species included in Appendices I, II and III, but permitted the export of cultivated varieties of plant species included in Appendices I and II - Notification 1999/039 of CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora, an International Agreement to which States and regional economic integration organizations adhere voluntarily). Tree species listed on CITES Appendix II from India includes: Agarwood (*Aquilaria & Gyrinops spp.*), Chinese yew (*Taxus chinensis*), Himalayan yew (*Taxus wallichiana*), Himalayan may-apple (*Podophyllum hexandrum*), Ramin (*Gonystylus macrophyllus*) and Red sandalwood/red sanders (*Pterocarpus santalinus*) with an authorization of the export of specimens of any type, from 310 metric

tonnes of wood per year from artificially propagated source (Source "A") and a one-time export of specimens of any type, from 9090.09 metric tonnes of wood from confiscated or seized source (Source "I"), Serpentine wood (*Rauvolfia serpentine*), and Taxus fauna. During CoP (Conference of Parties) 17 in 2016, CITES decided to protect all the species under genus Dalbergia under Appendix II making the trade in this wood illegal without a CITES permit. In December 2016, India entered a reservation with reference to the inclusion of Dalbergia spp. in Appendix II of the convention. In 2017, MOEFCC Authorised EPCH in addition to WCCB (Wildlife Crime Control Bureau) as a one of the authority to issue comparable document in lieu of CITES permit, i.e., the VRIKSH Shipment Certificate for export of handicrafts products made from Dalbergia sissoo and Dalbergia latifolia (EPCH 2018).

As CITES has listed the entire genus *Dalbergia spp*., except the Brazilian rosewood Dalbergia nigra in its Appendix II requiring CITES permit, each shipment of wood or wood products containing *Dalbergia* wood need endorsement from the MOEFCC empowered competent authority, EPCH (Export Promotion Council for Handicrafts). Hence, for the export/import of rosewood and sheesham products requires comparable document in lieu of the CITES permit. EPCH is issuing such certificates under its VRIKSH Timber Legality Certification Standard. Later in the CITES CoP 2019 exempted musical instruments and parts and accessories of the same made with rosewood from requiring CITES permit.

75% of India's exports of timber products are to countries that now having laws in place to restrict import of illegal wood [wood from illegal logging – wood from uncertified forests/plantations and without Chain of Custody (CoC) Certificate – including the European Union Timber Regulation (EUTR), Lacey Act of USA, Australian Illegal Logging Prohibition Act of 2012, California Air Regulation Board (CARB) Regulations, etc.]. Importers those are non-compliant with these laws risk enforcement actions including fines, penalties and prosecution, while Indian suppliers risk losing out to other countries that can provide the legal assurances required for import to EU, USA, Australia, Indonesia, Japan, etc.

Provisions of Draft National Forest Policy (DNFP) 2018

DNFP, 2018 includes provisions for increasing productivity of forest plantations and forest management, intensive scientific management of forest plantations of commercially important species to address poor productivity of plantations, encouraging agro-forestry and farm forestry through commensurate incentives and operational support systems, establishing systems for certification of improved planting material, promotion of cultivation, harvesting, transportation and marketing of wood by relaxing the existing felling and transit regime, institution of a credible certification process which can provide premium on the products and enhance value of forest product harvested sustainably, setting up of a forum for interaction and collaboration for forest-based industries with forestry institutions and concerned stakeholders to create demand for trained professionals in the sector.

Future Options

Greater focus needs to be made on the production and use of wood as a carbon negative eco-friendly multi-purpose product whose production system is cost effective, coupled with climate change mitigation strategy. To meet the country's sustainable development goals in the wood sector, it is necessary to evolve a National Wood Use Policyto realize and promote the full potential of wood based production systems involving optimum use of scarce land resources, skilled/semi-skilled manpower, and contribution of wood based industries in green development and the use of wood in housing, construction, and all other important development sectors in all possible ways with continuous research for development of processing technologies, accelerated adoption of available technologies, and skill development to bridge the gaps.

The productivity of Indian forests (0.045 m^3/ha./year) being much lower than world average (2.1 m^3/ha./year) or in other words, since it has only one tenth per capita forest area (0.06 ha.) compared to the world average (0.6 ha.), and the annual productivity of ToFs is reported to be in the tune of 3.1 m^3/ha which is much higher than the timber productivity in FDCs (Forest Development Corporations) (0.77 m^3/ha), there is a serious need to explore the potential of ToFs from the Agroforestry/Farm-Forestry sector for timber production. ToFs provide themeat of India's timber needs, and agroforestry and farm forestry are the backbone of TOF. Agroforestry sector has been fulfilling most of the wood as well as fuel wood demands n India (Plywood: 8%, Paper: 60%).

Over the decades, market saturation, farmers not being paid remunerative prices by the paper mills, and legal restrictions on the transport and sale of wood have doused the initial enthusiasm in nurturing wood growing through agro/farm forestry. If farm or agro forestry is to be revived to feed the growing timber hunger of Indian industry,dishonest middlemen need to be weeded out and the legal processes involved in the growing, sale and transport of wood need to be smoothened. The gap between the policies and their implementation is large. The growing dependence on imports also means more illegal trade, and a question mark on the nation's integrity.The lack of adequately-sized timber markets for farmers and price support mechanisms are also limiting growth in this sector. Farmers are finding it difficult to adopt timber-based agroforestry and farm forestry because the returns are low and the points of sale are far off. Plywood industry's monopoly over the market in many regions has constrained farmers, making them feel that they have been deprived of equity in the wood trade,to a point where they are made to feel as if they are not the owners of their produce.

The path for reviving Wood Based Industries (WBIs) is through promotion of Agro Forestry (AF) and introducing actions for enhancing the use of wood products (preferably by introducing 'Green Public Purchasing' facilities in Government e-Marketplaces, establishing Wood Markets across the country, introducing strengthened Engineering courses in Wood Technology, etc.) and by addressing policy gaps in the Wood Commerce as well as by making use of certified timber obligatory along with adherence of minimum product quality standards to ensure efficient utilization of timber and other resources by the WBIs. The WBIs should need to be to adopt voluntary certification for domestic markets by making certification as a requirement in public procurement policies, as envisioned in the NFP 2018:

"… A credible certification process can provide premium on the products, which can enhancevalue of forest product harvested sustainably. Adoption of appropriate certification regimes will be encouraged though phase wise adoption of compatible standards and institutionalframework in forest management …"

Conclusion

Timber production from government forest areas is abysmally low (4% of total demand) compared to potential timber production from TOFs, which fulfil 45% of thetotal timber demand in India. Thus, TOFs have immense potential in meeting the growing timber demand;however, they have not been fully utilized due to discrepancies in state level TOFs' policies. The absence of an exclusive policy on timber production and inconsistent and unavailable data on production further poses challenges in establishing the causal relationship between forest policy and timber production in the country.

Although India strongly supports sustainable forest management, and is signatory to all conventions related to climate change and biodiversity, wood and wood products can be imported into India without verification of legality (certification) or quantitative restrictions, except when species attract CITES provisions. It has been reported that India is the third largest importer of the illegally logged timber in the world, and accounts for close to 10% of the global illegal wood trade (IUFRO, 2016). Timber trade is not regulated in India and forest and timber certification has yet to be widely implemented for safeguarding the interest of international EXIM laws and export revenue. Now an Indian, NCCF (Network for Certification and Conservation of Forest) Certification Scheme, endorsed by PEFC, is available for forest areas and the standards for ToFs certification by NCCF is in the pipeline.

There is no fixed domestic pricing pattern for timber available in the country. India is a net importer of timber and timber products. In terms of volume, the major import categories are wood logs, wood pulp and paper, while the major export categories are paper and furniture; furniture is the only category in which Indian exports exceed its imports. India's timber imports accounts to 19-26% of the total annual timber availability and have been growing at a rate of 9.3% since 2001. Imports of wood and wood products in India (2016-19) were for around Rs. 48100 crores, whereas export was less than around Rs. 16500 crores, with a huge gap of around Rs. 31600 crores for the period 2016-2019. There is no import/export data available for amount of certified and non-certified wood and wood products from India which may be assessed to formulate the timber policy and revised duty accordingly.

Availability of Timber from Government Forests is only around 3 million m^3 which is less than 4% of demand of 80 million m3; Agro-Forestry provides the major source (90%) of timber for industrial purposes; timber availability from Agro-Forestry is around 74.5 million m^3 whereas the requirement of timber for all industrial purposes is quantified to be only around 62 million m^3. Timber demand - supply analysis clearly showed the need for enhanced timber production on a sustainable basis through enabling policies and programmes to meet domestic demand and reduce the reliance of India on imports. The setting up of more Agro wood based industries could be promoted without hesitation, provided sincere and continued efforts to promote 'AgriWood' cultivation of the farmers is ensured with a view to gradually reduce the import of wood to the extent possible. As Agro-Forestry/ToFs being the major source (90%) of timber for all industrial purposes, suitable environment needs to be created for hassle free transportation, marketing and utilization of wood grown on agroforestry lands, as legal constraints exists in their trouble-free consumption, as they are still forest products and not agricultural products. It is, therefore, necessary to have further legal framework to promote the hassle-free utilization of wood cultivated trees from AF/ToFs. Indian Standards for CoC (Chain of Custody) Certification for timber is already with EPCH (Export Promotion Council for Handicrafts) under its VRIKSH Timber Legality and Certification Standard.

It is important to evolve a National Timber Policy to promote the important timber utilization sectors, in all possible ways to bridge the existing gap by augmenting supply of timber in the country with due consideration of following aspects/ guiding elements, as proposed by Singh (2021):

- Agro-forestry can play important role in bridging the gap between demand and supply of wood in the country provided a separate legal framework namely," Growing of Trees outside Forests (Promotion and Facilitation) Act", draft under consideration of MoEF&CC.
- National Working Plan Code 2014 mandates to set aside 10% of the area for plantation working circle. This would take care of the need of production forestry especially for long rotation timber species
- The state governments can decide how to manage the areas under plantation working circles to enhance productivity and production
- A tripartite agreement can be made by including Forest Department, local stakeholders and wood user company for forest areas mandated under plantation working circles
- The Forest Development Corporations (FDCs) of the concerned states should shift to long rotation indigenous species and may adopt this partnership model to ensure sustained certifiable wood raw material for the industries including wooden furniture sector
- E-marketing platform like TimberCart may be developed on all India basis so as to facilitate timely auction of Wood from Government Depots
- It is proposed that import of wood in the log form should be continued without any change in the present import duty
- There is need to launch Missions on augmenting supply of teak and pine timbers in the country since they form bulk of imported timber in the country
- The raw material from the species traditionally used by the wood industry might not be sufficient for

enhancing the production and there is requirement for introduction of new species having similar properties with wood modifications using modern techniques

- India should have its own Timber Certification Scheme for Forest Timber and Wood from Agro-Forestry
- Zero import duty on certified CARB*/European standard panel may hurt the domestic industry and may not be in the line with Make in India, *Aatma-Nirbhar Bharat* initiatives
- Strengthening "Certification Facilities" of wood-based panel board products as per the international standards necessary for export promotion.
- Due to increasing significance of USA as export market, R&D and testing infrastructure (including CARB) need to be established
- Need strong support of Government to Research & Training institute/bodies such as IPIRTI, IWST, NID, National Skill Development Council, ITI, Furniture and Fitting Skill Council, etc.
- Furniture Testing, Research and Training Centre should be established in newly planned Furniture Clusters in India
- New skill development training course relevant to industry may be designed in relevant institute with industry participation and government support
- Coherent custom duty to promote wood sector in India.

(California Air Resources Board (CARB) as a Third Party Certifier (TPC) under the Airborne Toxic Control Measure (ATCM), which aims to reduce formaldehyde emissions from composite wood product)*

The proposed establishment of the National Wood Council along with its State and District Councils along with the due constitution of the statutory frame work, 'Development Council for Timber Products Industries' under the Industries (Development & Regulation) Act 1951 by the DPIIT (Department for Promotion of Industry and Internal Trade) is expected to be of great help to handle the issues regarding the wood sector and WBIs for the future.

Chapter 2
Non-conventional / Alternative Timber Resources Sector

Rubber wood, coconut stem wood and bamboo forms the principal non-conventional/ alternative timber resources, the details of each are reviewed below:

1. RUBBER WOOD

In 1995, rubber trees were grown on an area of approximately 9.6 million hectares worldwide,in the tropical regions of Asia, Africa and America for latex production and its timber forms the most important non-conventional/ alternative timber resource. From being a perishablele waste-wood, rubber-wood became an important wood feedstock for the large wood products industry in the country after developing its processing techniques such as preservative treatment and seasoning. Nevertheless, it must be emphasized that the commercial success of rubber wood as a raw material of international repute is due to the intensive efforts by industrial players. In a survey reported by Ratnasingam and Scholz (2009), it was found that the averagecost of rubber wood biomass per hectare is US$ 2000, which approximates to about US$ 15 per m^3 of wood biomass. Although rubber wood saw logs can fetch up to US$ 60 per m^3, the small dimension residues average about US$ 20 per m^3. Inevitably, the cost of rubber wood fibber is lower than other wood fibre from the natural forests, suggesting the need for further government interventions if rubber wood production is to be expanded.

With more than seven lakh hectares is under rubber tree plantation in the country, India is now the third largest producer of natural rubber in the world. Rubber tree – Hevea brasilensis – is a major plantation crop in Kerala and North-Eastern states. At the age of 22 to 29 years, latex production becomes uneconomic and the trees are then cut and replanted. Thus rubber plantations are sustainable source of rubber as well as timber, contributing positively to the environment. In India rubber is predominantly a small holders' crop and over 87% of the rubber is from this sector. A rubber tree from small holdings will have about 0.57 m^3 (20 CFT) of timber and the per hactre (ha) yield is about 150 m^3 (5295 CFT). The stem wood has timber value of only 60%. Present total availability of rubber wood is estimated as 0.94 million m^3/yr. The same is estimated to be rising to 1.5 m^3/yr. by the end of the decade.It is valued for its dense grain, minimal shrinkage, attractive colour and acceptance of different finishes. It is also prized as an "environmentally friendly" wood, as it makes use of trees that have been cut down at the end of their latex producing cycle andis used in high-end furniture.As a member of the maple family, rubber wood has a dense grain character that is easily controlled in the kiln drying process. Rubber wood has very little shrinkage making it one of the more stable construction materials available for furniture manufacturing.Rubber wood is the most ecologically "friendly" lumber used in today's furniture industry. Unlike other woods that are cut down for the sole purpose of producing furniture, rubber wood is used only after it completes its latex producing cycle and dies. This wood is therefore eco-friendly in the sense that we are now using what was going as waste.

Conventionally, felled rubber wood is used for making packaging cases as it is of poor quality and deteriorates with fungal decay. Hence, it is not generally useful for other purposes like making furniture. New developments in wood science and technology like preservative treatment and finger jointing techniques for rubber wood have opened new avenues of utilization in furniture and panel board products. There

is a good response for rubber wood furniture in the market because of its good aesthetic look and low cost. The current (2021) price of rubber wood in Kerala, India is recorded as Rs. 3200-3300/- per tonne for logs of perimeter > 21 inches and length 9 feet.

A mature rubber tree is usually in the range of 20 to 30 m tall and its diameter can reach up to 30 cm. Tree trunk is generally free of branches until the height of 3 to 10 m. With a planting distance of 3 m by 7 m, the stocking density of rubber trees is usually in the range of 300 - 350 trees per hectare; more than 80% of total rubber plantation areas in the world are in Asia, with Malaysia, Indonesia and Thailand covering almost 70% of the total rubber cultivation. Increasing the value of rubber wood by expanding its applications to high value construction materials as well as fashion accessories may further boost the future of the material. The quantity of rubber wood available from Malaysia alone is forecasted to range between 5.3 to 6.1 million m^3 per annum over 2022.

Properties of Rubber wood:

Property	Value	Property	Value
Basic Density (kg/m^3)	550	Dynamic condition- Fibre stress at elastic limit (kg / cm^2)	820
Static Bending (N/mm^2) at 12% MC	66	Dynamic Modulus of Elasticity (x 1000 kg / cm^2)	118
Modulus of elasticity (Newton/mm^2)	9,700	Max height of drop of 25 kg hammer (Cm)	43
Static condition -Fibre stress at elastic limit (kg / cm^2)	368	Maximum Radial Shear Strength at 12% MC (kg / cm^2)	108
Modulus of Elasticity (x 1000 kg / cm^2)	82	Maximum Tangential Shear Strength at 12% MC (kg / cm^2)	120
Modulus of Rupture (kg / cm^2)	756	Maximum Average Shear Strength at 12% MC (kg / cm^2)	114
Compressive stress at Elastic limit Parallel to grain (kg/cm^2)	187	Radial Hardness (Indentation, in kg) (at 12% MC): Radial:	549
Max. Crushing Stress (kg/cm^2)	374	Tangential Hardness (Indentation, in kg) (at 12% MC):	526
Modulus of Elasticity in compression (x1000 kg/cm^2)	99	End Hardness (Indentation, in kg) (at 12% MC):	627
Perpendicular to grain - Compressive stress at Elastic limit (kg/cm^2)	101	Mean Hardness (Indentation, in kg) (at 12% MC):	567
Perpendicular to grain - Max. tensile stress, radial (kg/cm^2)	57	Hardness(in N)	4,350
Tangential Shrinkage (%)	5.7 - 6.5	Max. tensile stress, tangential (kg/cm^2)	63
Radial Shrinkage (%)	2.6 - 3.1	Tangential Shrinkage Coefficient (%)	1.2
Volumetric Shrinkage (%)	10 - 12	Radical Shrinkage Coefficient (%)	0.8
Longitudinal Shrinkage (%)	0.2 -0.9		
Standard Nail withdrawal resistance (Kg), Air dry	Radial: 126 Tangential: 116 End Surface: 113	Standard screw withdrawal resistance (kg), Air dry	Radial: 328 Tangential: 263 End Surface: 176

Hardness of the wood is very important for applications like flooring and decking where abrasion of surfaces is taking place. The table above gives the hardness value of rubber wood as measured by indentation of a steel ball (*Indentation is measured as load in kg required to embed a steel ball of diameter 1.28 cm to a depth equal to half its diameter*). It can be seen that dry rubber wood has better hardness than teak.

Sawing, Machining, Working and Finishing Properties:

Rubber wood is easy to work in sawing and machining. Clogging of saw with latex can easily be eliminated by dabbing of saw blade with fuel oil. For best results in sawing, narrow gauge saw blade with teeth having top clearance angle of 15o and front rake of 20o should be used. Short length of sawn planks can be overcome by finger jointing. Rubber wood has good machining and working qualities. A cutting angle of 30o gives very smooth surface on planning and stands well to further smoothening of the surface. It can be finished to a very glossy look on polishing and can be given ammonia fumigation cum bark extract -quenching treatment to obtain golden to dark brown hues and decorative figures. Rubber wood can be bent in steam or in ammonia to make curved items. It takes up stains well and being light in colour it can be stained to the shades of teak, rosewood, mahogany, beech, cherry etc.

Wood Working Properties:

Condition	Sawing	Planning	Boring	Turning				
	Re-sawing	Cross cutting	Ease of planning	Quality of Finish	Ease of Boring	Quality of Finish	Ease of Turning	Quality of Finish
Green	Slightly Difficult	Easy	Easy	Smooth	Easy	Rough		
Dry	Moderately Easy	Easy	Easy	Smooth	Easy	Rough	Easy	Rough
Overall Working Quality Performance Index							194	
Ease of Working							100	
Working Quality Index							131	
Comparative performance in turning							101	

Comparative Suitability Indices of Rubber Wood with respect to Teak as 100 are as given below:

Weight or Heaviness: 93; Retention of Shape: 77; Strength as a beam: 62; Stiffness as a beam: 77; Suitability as post: 52; Shock resisting ability: 75; Shear: 92; Surface hardness: 74; Splitting Coefficient: 75.

Processing of Rubber Wood

Processing of rubber wood essentially include sawing, preservative treatment, seasoning and wood working operations. As received from field the logs are about 270 cm long with girth ranging from 80 to 100cm. Due to the absence of heart wood - the durable and usable part of the wood - rubber wood is susceptible to the attack of fungi and insects.

Preservative Treatment: Immediately after felling, to improve the durability of the wood, preservative treatment with suitable preservative chemical is carried out. It is important to say that preservative treatment is meant only for improving the durability. It doesn't change the anatomical structure, strength, shape or any other property of wood. The structure of the vessels in rubber wood permits easy and effective preservative treatment. Rubber wood belongs to the treatability class 'b' and durability class III.

CCA (copper-chrome-arsenic) or CCB (copper-chrome boron) is suited for exterior use whereas Boric Acid treatment is suitable only for interior use. Due to its high leachability boric acid retains the natural colour of the wood whereas CCA gives an undesirable greenish yellow colour to the wood.The preservation is generally carried out by impregnation under vacuum and pressure in a vacuum in cylindrical chamber. In vacuum pressure process, the timber is subjected to an initial vacuum followed by pressure treatment and a final vacuum. In the oscillating pressure and vacuum method the cycle is repeated 10 to 15 times.

Considering the industrial importance of rubber wood, a unique specification for preservative treated and seasoned sawn timber from rubber wood was issued by the Bureau of Indian Standards as IS 14960: 2001 (Reaffirmed 2012) (BIS 2001).

Dry Salt Retention Requirements of Preservatives in Treated Rubber Wood:

Sl. No.	Service Condition Service Condition	CCA/CCB	Boric acid : Borax	Penetration
1	Interior protected from weather, painted	5 Kg/m^3	5-6.5 Kg/m3	Throughout
2	Interior intermittent wetting	8 Kg/m^3	na	na
3	Exposed to weather not in ground contact	12 Kg/m^3	na	na
4	In ground contact	16 Kg/m^3	na	na

The Kerala Forest Research Institute (KFRI) has done pioneering studies in the preservative treatment of rubber wood and developed energy saving economical schedules for its commercial scale vacuum-pressure impregnation treatment at different moisture levels and thicknesses for wood-based industries (Dhamodaran2008, 2020, Dhamodaran et al. 2020).

Seasoning of Rubber Wood: Rubberwood belongs to 'moderately refractory' class of timber, according to the Indian Standards IS: 1141-1993 (BIS 1993). Rubberwood can be seasoned free from surface and end cracking within reasonable short periods, given a little protection against rapid drying conditions. When freshly cut, moisture content of the timber will be above 60 %. For any use, the moisture content has to be reduced to the equilibrium moisture content (EMC); about 12%, for dimensional stability and for obtaining good machining and finishing properties. Rubberwood contains tension wood and hence seasoning is carried out with utmost care in controlled conditions of temperature & humidity so that the drying takes place uniformly throughout the entire charge with reduced drying defects. The final moisture content needs to be around 12-10%. The drying time is dependent on the timber thickness. Suggested schedule for dry-kilning is 'Schedule V' of the Indian Standards. Employing vacuum drying technique can save drying time wood with better colour and fewer defects can be achieved.

Applications/Uses

Processed Rubberwood is available commercially in: Rough sawn kiln dried(RSKD) timber form with up to 150 mm, thickness from 25 to 75 mm and length up to 2400 mm; Four Side Planed Sections (S4S) of width up to 125 mm, thickness from 25 to 50 mm and length up to 2400 mm; Finger Jointed Four Side Planed sections (FJS4S) of width from 30 to 100 mm, thickness from 20 to 65 mm and length up to 2400 mm or more depending upon specific requirement; Mouldings for furniture manufacture and interior work; Panelling and Flooring materials (tongue & groove, parquet etc.); Finger Jointed edge glued panels of thickness 15, 18, 24, 30, 36, 42 and 48 mm, length up to 2400 mm, and width up to 1200 mm; and other sizes on specific requirement. Rubber wood, with a furniture suitability coefficient value of 69 is classified as a Group II species, suitable for furniture and cabinets as per the Indian Standards 13622:1993 (BIS 1993). Suitability coefficient of rubber wood for making door and window shutters and frames is evaluated as 77, and classified as a Grade II timber by the Bureau of Indian Standards IS: 12896-1990 (Indian timbers for door and window shutters and frames- classification). Rubber wood is suitable for structural purpose and is coming under 'Group C Timber' according to its modulus of rupture and modulus of elasticity (BIS 1986); CPWD (Central Public Works Department, GoI) has approved it as one of the species for government construction work. As building components, rubberwood has been using for making doors, windows, steps, railings, balusters etc.

The attributes of processed Rubberwood are: Light colour, Attractive grain structure, Good strength properties, Good working, machining and finishing properties, Good staining properties, which make it a versatile wood. Processed rubberwood is used for the interiors – panelling, mouldings, beadings, skirting, edging, parquet and strip flooring; Furniture and Cabinet Making; Kitchen Wares, decorative and utility household items such as salad bowls, knife blocks, book shelves, trays, magazine racks etc.; compressed wooden shuttle blocks, wood carvings, bentwood articles, packing cases; laminated veneer lumber, veneer and plywood, block board and flush doors, fibre boards - Medium Density Fibre Board and Hard Boards.

With a suitability index of 89 for packing cases, rubberwood is classified as Grade II in IS: 6662-1993. (Timber species suitable for wooden packaging specification) and is widely used timber for making packing cases; to a certain extent a major share of the Indian wooden packing cases industry is handled by rubberwood.

Rubber wood has been widely used for making wood carvings, decorative and utility items like ornament boxes, utility boxes, lacquered items trays etc. in the wooden handicrafts sector. Rubber wood after being compressed to a density above 1000

Kg/m^3, is widely utilised for making compressed shuttle blocks and as compressed wood core in laminated shuttle blocks in the textile industry.

Rubber wood can easily be peeled into uniformly thick, smooth and tight veneers and is suitable for making commercial plywood. Rubber wood veneers after proper treatment with preservative is widely used as plywood core stock. It has also been widely used for making the core stock of block-board and flush-doors after proper preservative treatment. This species has been included in Grade I (Species suitable for core) in IS: 2202(part)-1999 (Wooden flush door shutters (solid core type)-specifications.

Rubber wood finds extensive usage in the manufacture of fibre boards in countries like Malaysia. Since it is relatively a new product in India and the manufacturing facilities are away from the rubber wood growing areas, this potential raw material has not been effectively utilised for making MDF so far. However rubber wood has been successfully utilizing for the manufacture of hard boards. Rubberwood is found application in making laminated veneer lumber (LVL), a new wood based panel product in India.

Rubber wood can also be used for making many suitable curved components for the production of furniture, doors and other fancy, ornamental and utility items. Bending wood by employing ammonia plasticisation technique for making bent wood articles like walking sticks, stairs, trays, peg tables, etc. is a very promising area for the better utilization of rubber wood.

Major rubber producing countries like Malaysia, Thailand and Indonesia are quite advanced in rubber wood processing and value addition. As an eco-friendly timber, it is well accepted in the world market. In India, rubber wood processing for value addition started in the '80s and still it is in the infancy, consuming only about 17% of the available stem wood. With a gap of about 11 million m3/ year between the supply and demand, the domestic market is also huge (Sarkar Plywood Pvt. Ltd. nd.). We are also yet to tap fully the export potential. The country is importing wood and wood products worth about Rs. 500 crores a year. Hence for the country, it is a foreign exchange saver and earner. Development of the rubber wood processing industry in the country will help to generate employment, strengthen national economy, make rubber cultivation sustainable and preserve the environment. This is quite relevant in the post-liberalisation period in which trade barriers are disappearing across the world.

The utility of rubberwood for pulping is limited due to the problem of interference of latex during production; mixing up of bamboo pulp with the pulp made of rubber wood for getting a superior quality paper is also suggested.

To improve the quality and acceptability of rubber wood and its products, a Laboratory has been set up in the Rubber Research Institute of India (RRII) at Kottayam, Kerala under the Rubber Board of India to make available testing facilities to the processors and consumers. It will also train processors in testing and quality control. Testing and certification with regards to species identification; physical properties – density, specific gravity, moisture content, swelling, and shrinkage; mechanical properties – bending, compression, shear, hardness, tension, nail/screw withdrawal resistance; durability tests on susceptibility to bio-deteriorating agencies like fungi, termites and borers; qualitative and quantitative estimation of chemicals in the treated wood; gluing properties and strength of glues joints; strength of joints – carpentry/finger joint; finishing properties- abrasion, quality and type of finish; tests on frames and shutters of doors and windows; tests on finish and abrasion for flooring; and tests in joints strength for furniture are possible to get done in the GoI's Rubberwood Testing Centre of RRII.

To improve technology and skills through demonstration and training, a state of the art model rubber wood factory has been set up at Kottayam with equity participation of the Kerala State Industrial Development Corporation Ltd. (KSIDC) and private sector. All these efforts on R & D and extension activities led to the introduction of a good number of rubberwood processing industries in the Kerala state, India, where the major rubber plantations of the country is concentrated.

Coconut Stem Wood

The whole Asia-Pacific region has an estimated number of senile coconut trees of about 371.3 million or 111.4 million cubic meters of sawn coconut wood, based on an average sawn lumber recovery of 0.3 cubic meter per tree. 20-22 Per cent of the total number of coconut palm trees in India is estimated to be senile and is due for felling and replanting. The possibility of utilizing the coconut palm wood on a commercial scale must be recognized as an impactful investment. The opportunity to look for non-forest or indigenous wood material and to conserve natural forests in countries where the coconut palm is grown, could led to a serious consideration of utilizing coconut stem wood furniture.

The huge number of old and senile palms in coconut growing countries, especially in Asia and the Pacific, as well as the wide-spread disease, root-wilt, along with serious natural disasters like hurricanes affecting coconut farms necessities urgent large-scale replanting. It has been widely recognized that the most effective way of disposing the felled trunks is to convert them to saleable wood products; as otherwise increasing the inoculum strength and environmental issues can adversely affect the agricultural sector. Coconut wood can thus be a promising material for the manufacture of furniture. It was reported that root-wilt disease did not have any significant effect on shrinkage, strength properties of wood, yield and quality of charcoal, etc. (Gnanaharan and Dhamodaran 1988).

The cylindrical trunk of coconut tree reaches a height of 20-25 meters or more with an average diameter of 30-40 cm, sometimes reaching up to 1 meter at the base. A tall variety of palm which contains timber of commercially utilizable value up to a height of about 3 m from the base and is estimated to contain at least 0.15m^3 of high density wood suitable for furniture. At a very conservative estimate, based on prevailing market rate, each palm would fetch a minimum of Rs. 7500/- from timber alone.

One of the components of the project for the promotion of coconut cultivation in the country by the Coconut Development Board of the Government of India is to replant the senile and unproductive disease affected palms in a phased manner with high yielding palms, has the estimation that around 16700 senile palms may be needed to cut and remove per year per districts. The wood of all the palms cut and removed all over the country needs to be to be effectively utilized; this could be a resource for alternative non-conventional furniture wood.

The oven-dry weight to green volume or basic density, the most important physical property of wood determining utilization potential of coconut stem wood decreases with increasing height of the stem and, at any given height, increases from the core to the cortex. In addition, the basic density at any particular height increases with the age of the palm. Overall, the basic density ranges from 100 kg/m3 at the top & core portion to 900 kg/m3 at bottom dermal portion of old coconut palms. The high density wood from the basal 3 m height is especially suitable for furniture manufacture along with other structural applications.

The dimensional stability of the wood is determined by its shrinkage or swelling which accompanies a decrease or increase in moisture content below fibre saturation point. Shrinkage and swelling cause drying defects such as checks and split. Unlike conventional wood where tangential shrinkage is almost twice the radial shrinkage, the tangential and radial shrinkage of coconut stem wood are not significantly different so as to affect its utilization value.

The mechanical properties of wood which define its end-use are positively correlated with the basic density. As a result, coconut stem wood has been classified according to three basic density groups; as high density (dermal) 600 kg/m^3 and above, medium density (sub-dermal) 400 - 600 kg/m^3, and low density (core) below 400 kg/m^3. All values of the strength properties decrease with decreasing basic density. The strength properties of high density coconut stem wood compare quite well with all other structural timbers. High density coconut wood almost exhibits superior strength properties over many conventional secondary timbers except modulus of elasticity (MOE) which shows lower strength values as far as compression parallel to grain is concerned.

Strength properties of Coconut stem wood in comparison with other conventional timbers

Species	Static Bending		Compression parallel to Grain
	Modulus of Rupture (MOR, N/mm^2)	Modulus of Elasticity (MOE, N/mm^2)	Maximum Compressive Stress (MCS, N/mm^2)
Albizia odoratissma (Safed seres)	144	14500	79
Artocarpus heterophyllus (Jackwood)	81	10100	50
Artocarpus hirsutus (Anjili)	97	12200	62
Tectona grandis (Teak)	96	12200	53
Terminalia paniculata (Laurel)	112	14300	64
Cocos nucifera (Coconut wood)	93	15900	57

(Source: Dhamodaran et al. 2020a)

Comparison of wood properties of Teak and Coconut wood

Property	Teak	Coconut Stem Wood
Basic Density (kg/m^3)	750	820
Hardness (N)	4740	8430
MOR (MPa.)	97	89
MOE (GPa.)	12	11
Crushing Strength (MPa.)	55	66
Shrinkage (%)		
Radial (R)	2.6	5.5
Tangential (T)	5.2	5.5
Volumetric (V)	7.2	9.2
T/R	2.0	1.0

(Source: Dhamodaran et al. 2020a)

Efficient processing and utilization of coconut trunks are aimed at solving technical and socio-economic problems especially when the coconut farmer decides to replant his senile palms. Being a monocotyledonous plant, its anatomical, physical, chemical and mechanical properties are different from the conventional woods. Hence, processing techniques and equipment including appropriate machinery have been developed, modified and improved to process coconut wood more efficiently and produce comparatively good quality products. The conveniently straight and branchless stems, and their nearly uniform volume and dimension allow the use of comparatively light and simple tools and equipments for felling and transportation. Logging operation in a coconut plantation is therefore easier and cheaper than logging under forestry conditions in mountainous steep terrains.

In sawing coconut logs, the most important factors in selecting the milling equipment are profitability and ability to be relocated if this is required; simplicity of design to avoid breakdowns which are difficult to repair in isolated situations; ease of operation as skills of operators will often be limited; an inexpensiveness as the industry is often situated in poorer and underdeveloped areas. Different types of mills have been tested at the Zamboanga Research Centre in the Philippines and the Timber Industry Training Centre in New Zealand and information gathered could provide a guide to the selection of mills for different conditions. These mills include the medium-size portable sawmill, a larger transportable sawmill,




light/general purpose portable sawmill, a mini mill, a breast bench with light weight carriages and a chainsaw with guide attachments. Problems of sawing coconut logs are similar to the ones encountered by saw millers when using high density species of tropical hardwoods.

It has been established that no importer is prepared to make a commitment to purchase large volumes of coconut wood unless both quality of material and reliability of supply are guaranteed. Uniform grading standards for coconut wood are therefore highly desirable. A system of grading coconut wood and the mechanics of its implementation and control should be established in the producing countries. The mechanism for quality

control should not restrict efficient management but should aim to protect and foster the interests of the country, the coconut wood industry, and its customers. Quality control of coconut wood starts during the logging operation. Coconut wood should be graded hard, intermediate or soft, corresponding to high, medium and low density: high density is above 600 kg/m^3; medium density between 400 - 600 kg/m^3; and low density less than 400 kg/m^3. Because of the widely varying density of material within each log, and the difficulty of differentiating these by superficial inspection after sawing, it is essential that a grading, sorting and identification system be established to track the wood from different parts of a log and from different logs along the length of a tree; this should start in the plantation at the time of felling. Systems of this sort have been designed and are implementable. The high density wood is recommended for furniture making as well as for other structural applications. Other portions of wood could find suitable end-use applications in an integrated approach.

Another important phase in coconut wood utilization is machining or the process of cutting and milling the wood into various shapes and patterns with the use of woodworking machines. Lumber production from coconut trunk has been commercialized in the Philippines since early 1970's. One of the most efficient processing techniques is the chainsaw-table saw lumbering system. Round coconut trunks are sawn into halves or smaller dimensions as in flitches using a 10HP chainsaw at the cutting site. The flitches are transported to the lumber yard for re-sawing into desired dimension using a table saw. The table saw may be stationary or mobile-type with 20 HP diesel engine. The saw blade is circular and the diameter is around 500 mm. The chainsaw-table saw lumbering system is designed for rural application. It involves relatively unskilled labour and the processing system may not be capital intensive. The preference of using chainsaw over mounted portable or stationary sawmills is its low investment cost and complete portability by a single operator. Mounted portable sawmills, although could be operated near the raw material source, require a number of personnel. The use of stationary sawmills or portable ones, although efficient in terms of lumber recovery, is as yet very limited because of prohibitive initial investment combined with the potential for irregularity of raw material supply.

Coconut is not naturally durable when used in situations favorable to attack by decay fungi and wood boring insects particularly in ground contact and exposed to the weather. The low natural durability can be overcome by the application of suitable preservative treatment, for which appropriate prescriptions and dose rates that have been developed. Choice of treatment depends on hazard

level and cost which can be borne. The treatment schedules of the different processes have been established for coconut wood through a series of laboratory experiments, field and service tests of treated materials (Gnanaharan and Dhamodaran 1989, Anoop et al. 20018). A review of the works done on the utilization potential of coconut stem wood at the Kerala Forest Research Institute (KFRI) is available with Dhamodaran et al. 2020b and Dhamodaran (2020).

Treated wood needs to undergo seasoning (drying) process to minimize if not completely avoid dimensional problems in its utilization. Dried wood with a moisture content of around 12 to 10% only are approved for furniture manufacture. The common drying methods include air drying wood under shed, forced-air drying, solar kilning, and dry kilning. Depending on weather conditions, 25- 50 mm coconut boards take 1-5 months to air dry to attain equilibrium moisture content of around 20%. Drying schedules have been worked out for kiln drying coconut wood to avoid the observed drying defects such as internal collapse, cupping, twisting, wrap, checks & splits, etc.

Good quality finish for coconut wood involves sanding the surface to remove the knife marks and produce a smooth surface. The use of mechanical sanders instead of manual sanding facilitates finishing the surface of the wood. Coating involves the sequence application of stain, filler, sealer and top coating materials such as lacquer, polyurethane, polyester and oil finish to enhance the natural beauty of the grain, colour and figure of coconut wood furniture. Usually two or more coats of finishes are applied to coconut wood to improve the appearance and quality of furniture.

Properly treated and seasoned coconut wood is an excellent and cheap raw material for furniture manufacture. The wood hard is with low shrinkage; with different shades of brown, with dark-brown veins has a characteristic texture and grain desirable for elegant furniture with attractive natural appearance. There is no distinguishable separation between the sapwood and heartwood. The older vascular bundles located on the outer perimeter of the tree trunk gives the palm good strength and elasticity. It has good resistance to indentation and abrasion. Coconut wood has a unique appearance and has a good decorative value. The timber will dry uniformly and without much cross-sectional distortion. The timber is thus suitable for modern (knock-down) & conventional designs. With effective product promotion, quality high-value furniture from coconut wood can have a potential share not only in the domestic but also in the world markets.

Apart from furniture, processed (preservative treated and seasoned coconut stem wood find application in load bearing structures such as: floor tiles or parquet, floor joists, door jambs, window frames, pillars, balustrades, purlins, trusses, scaffoldings, railings, girts, rafting, decking, etc. The medium density (400-600 kg/m^3) portion of the wood is suitable for good material for ceiling joists, horizontal studs, and walls. The whole trunk is sometimes used as poles in the power and telecommunication lines, after treatment.

Aside from the construction industry, other sectors, such as the tourism industry have also seen the economic potentials of the coconut wood; in Asia and the Pacific, for example, has found that the novelty items, handicrafts, and furniture made from coconut materials have an "exotic" appeal among foreign tourists. Because of this, the people in the region have since been exploring more ways to utilize the different parts of the coconut tree for commercial purposes.

Conclusions on Constraints & Remedies

Constraints	Remedies
Very high density wood at the periphery of trunk; saw gets out of the saw line. Fine substances similar to sand (silica) will rapidly blunt the blade	Tungsten carbide (TC) or Stellite tipped machineries & Tools
Difficult to nail; splits are common	Pre-drilling
Sawn Lumber – 25-50 mm thick sizes only. Trunk once formed does not increase in diameter with age	Glued Lamination of wood
Untreated freshly cut limber can be easily attacked by moulds and staining fungi. Dry wood could be attacked by insects/ termites	Grading, Preservative Treatment & Seasoning (air drying or Kiln drying)

Consumers and retailers are yet to be convinced about the quality and strength of coconut wood, which is comparable to conventional wood coming from natural forest or other plantation trees. With the world concern about environment and depleting forest resources, using senile palm wood as an alternative source to replace indigenous forest timber for furniture needs for modern day living is a logical move towards commercial venture. Furniture made from coconut wood is eco-friendly and possess unique natural appearance and color which can fetch premium prices in the niche market.

The Asian and Pacific Coconut Community (APCC) member countries occupy more than 10 million hectares of coconut in the world and an average 15 percent of the coconut palms are old and senile trees which could be a high potential source of supply for coconut wood. The tree usually continues to bear fruit until it reaches around 60 years of age after which the yield declines even when one applies fertilizers. The normal life span of coconut tree can be from 70 to 80 years. Thus, a coconut tree is ready for harvesting wood after 60 years and at this age, the wood is said to reach its highest quality. Nevertheless, the potential source of coconut wood depends very much on the level of maturity of coconut plantations and also government policies with regard to coconut area expansion and replanting programs. The availability of senile coconut palms in coconut producing countries can provide good indication on the supply side of the wood.

Other Miscellaneous Ligno-cellulosic Woody Resources: Coconut Shell

Coconut shell Charcoal & Activated Granular Shell Carbon for Industrial Use

Apart from the direct/ minor use for fuel, handicrafts and shell powder, the main commercial use of bulk quantity of coconut shell is for making high quality charcoal for industrial use. Coconut shell charcoal is the raw material for the further value-added industrial product, activated granular shell carbon, an important chemical adsorbent. The potential of commercial utilization of coconut shells were detailed by Dhamodaran (2009). Traditional shell charcoal production by the existing earth pit earth and drum methods is a highly air-polluting one due to ground level smoke

spread. Charcoal production in the cluster or community level offers an additional livelihood to coconut farmers and the rural poor. It was in this context, an investigation was conducted to develop an appropriate clean technology to produce charcoal at the cluster or community level. A pollution-free continuous vertical carbonization plant with an input capacity of 3 tones shell per day (in three shifts/day) which can produce about one tone charcoal (satisfying Indian Standards) per day was designed, fabricated, installed tested; optimized the process parameters for desired quality products, and assessed the quality of products for industrial use and commissioned.

Production of granular activated shell carbon is limited to large scale industries employing rotary kiln for physical activation using steam. This has very little scope for down-scaling appropriate to production in community based organizations (CBOs) level due to techno-economic considerations. It was in this context, fluidized bed reactor (FBR) system was identified as the appropriate technology

for small or community level production of granular active carbon from shell. An FBR activation plant with an input capacity 0.25 tone charcoal per day which can produce 0.125 tone of granular active carbon was successfully designed, fabricated, installed, trial runs were conducted, optimized the process parameters for desired quality products, and assessed the quality of products for industrial use. Both the plants are installed at the SUBICSHA Project site in Perambra, Kozhikode District of Kerala. The quality of charcoal and the granular shell active carbon produced were found conforming to Indian standards.

Further technical up-gradation of the FBR is suggested such as developing a Rotary FBR for still better quality activated shell carbon suitable for vapour phase applications (Dhamodaran 2009, Dhamodaran and Gnanaharan 2008a; Dhamodaran et al. 2009b; Dhamodaran and Babu 2011). As an economic analysis of the pilot plants developed showed that a minimum up-scaling of the plants to a level of a charcoal plant which can process 6 tons of shells per day is the financially viable proposition for self-sustenance (Dhamodaran and Gnanaharan 2008b), such a plant was developed (Dhamodaran 2019a) with further technical improvisation of incorporating a shell drier for pre-drying the raw material. The shell drier is designed for fitting above the carbonizer hood so that only dried shell will enter into the charcoal plant. This facilitates the use of slightly wet shells during the rainy season. The plant is successfully designed for a targeted charcoal yield of around 30 per cent.

The FBR activation plant developed was further up-scaled to a horizontal rotary fluidized bed reactor (RFBR) for taking the technical benefit of high quality product coupled with cost effectiveness and sustenance; the input capacity was up-scaled to 2 tons shell charcoal per day, targeted for the standard (50%) active carbon yield (Dhamodaran 2019a). Both the up-scaled plants for charcoal and activated carbon production are installed at the ICAR-CPCRI campus in Kasaragod, Kerala. The up-scaled and improved plants for charcoal and granular active shell carbon are found to yield products conforming Indian Standards and the technology is ready for commercialization (Dhamodaran 2014 & 2019a, Dhamodaran and Gnanaharan 2009).

Conclusion

With more than seven lakh hectares is under rubber tree plantation in the country, India is now the third largest producer of natural rubber in the world. The slaughter tapped trees at the age range of 25-20 years after clear felling the plantations, forms a non-conventional timber resource; Kerala accounts the major share of processed rubber wood in the country. With about 0.57 m3 (20CFT) of timber per tree and a per hectare yield of about 150 m^3 (5295 CFT) and with a total estimated availability 1.5 million m^3/yr. by the end of the decade, rubber wood forms an extremely precious resource among the non-conventional timbers. The timber being perishable needs preservative treatment; pressure treatment with eco-friendly boron compounds are prevalent among the rubber wood processing industries. Bureau of Indian Standards has the Indian Standard, IS 14960: 2001 (Reaffirmed 2012), for the treatment of rubber wood. Being a 'moderately refractory' class of timber containing tension wood, the timber needs to seasoned with care; however, it is easy to treat and dry; suggesting to employ schedule v of the Indian Standards IS: 1141-1993 for dry-kilning the timber.

Traditional use of rubber wood is for packing cases and pallets. Treated and seasoned rubber wood is under use for furniture and cabinets, panel products such as plywood and other reconstituted board products, door and window shutters and frames, with a minor share in other utilities like steps, railings, balusters, carvings and handicrafts, compressed shuttle blocks, etc. Rubber wood is easy to work in sawing and machining; dry rubber wood has better hardness and superior nail holding power than teak, suitable for flooring and decking, and furniture products. It can be bent in steam or in ammonia to make curved items; can be given ammonia fumigation cum bark extract -quenching treatment to obtain golden to dark brown hues and decorative figures. With excellent finishing quality, it takes up stains well and being light in colour it can be stained to the shades of teak, rosewood, mahogany, beech, cherry etc. Rubber wood is suitable for structural purpose and is coming under 'Group C Timber' according to its modulus of rupture and modulus of elasticity as per Indian Standards and has the CPWD (Central Public Works Department, GoI) approval for use in government construction works. Rubber wood also found potential in LVL manufacturing in India.

Coconut shell forms an excellent raw material for the value added product, shell charcoal, which further forms the raw material for the super value added product, active carbon, which is of great industrial use as an adsorbent. The limitations of smoke pollution problem arising while carbonizing shell to charcoal by the existing batch process earth pit or drum or choolas can overcome by employing the continuous industrial vertical carbonization technology developed. The techno-economic limitation of employing the industrially established rotary kiln technology for the physical (steam) activation of shell charcoal to granular activated shell carbon for the small to medium scale production by the community based organization (CBO) level manufacturing can overcome by employing the appropriate technology of continuous horizontal rotary fluidized bed reactor technology developed, proved successful for the production of water grade active shell carbon. Appropriate scales of capacity of operation can be decided by giving due care to cost-benefit analysis.

Chapter 3
Plantation Forestry

Forest plantations covered 187 million hectares across the globe in 2000, of which Asia accounted for 62%. The forest plantation area represents a significant increase from the 1995 estimate of 124 million hectares. The reported new annual planting rate is 4.5 million hectares globally, with Asia and South America accounting for 89 per cent (FAO 2000). About 3 million hectares are estimated to be successful. Globally, half the forest plantation estate is for industrial end-use, one-quarter for non-industrial end-use and one-quarter not specified. Globally, broadleaves make up 40% of forest plantation area with Eucalyptus the main fast-growing, short-rotation species principal genus) and *Acacia*; pines (31%) and other coniferous species are the main medium-rotation utility species, primarily in the temperate and boreal zones. Globally, Coniferous species make up 31% of which Pinus is the principal genus.

The potential for forest plantations to partially meet demand for wood and fibre for industrial uses is increasing. Although accounting for only 5% of the global forest cover, forest plantations were estimated in the year 2000 to supply about 35% of the global round wood. This figure is anticipated to increase to 44% by 2020. In some countries forest plantation production already contributes the majority of industrial wood supply. There is increasing interest in development of forest plantations as carbon sinks; however, failure to resolve international debates on legal instruments, mechanisms and monitoring remains a serious constraint. In developing countries about one-third of the total plantation estate was primarily grown for fuel wood in 1995 - although it should be noted that planted trees on farmland, in villages and homesteads and along roads and waterways contribute significantly to fuel wood supplies, enabling the demand to be met in most instances.

Climate and site have a very large impact on growth rates. The humid tropics and more fertile sites are more conducive to higher growth rates than locations with long dry seasons or infertile or degraded soil. Teak on many sites in India, for example, frequently has an MAI of 4 to 8 m^3 per hectare per year, partly because of drought combined with poor soils. Some species such as Gmelina arborea and some of the *Eucalyptus* species are very site sensitive. *Pinus* spp., in contrast, generally tolerates adverse conditions better and is more flexible with respect to site.

Both tree breeding and silviculture have improved growth rates. Good examples are *Eucalyptus grandis* and *E. urophylla* in Brazil and Pinus radiata in some countries of the Southern Hemisphere. Advanced silviculture typically includes improved nursery and establishment techniques such as good site preparation, weed control and judicious use of fertilizer. It has been suggested that growth of teak (*Tectona grandis*), for example, could be doubled in Kerala, India and Bangladesh, and increased six fold in Indonesia by adopting these practices. With coppice species productivity varies with rotation, the first and second coppice rotations usually being more productive than the seedling one.

The growth patterns vary among species. For example, very fast growing species such as *Gmelina* arborea can reach a peak MAI in less than 10 years, while *Pinus caribaea* var. *hondurensis* grown in Trinidad reaches maximum MAI at about 25 years and *P. radiata* at over 40 years. With *Cupressus lusitanica* in Costa Rica, the MAI maximum is reached at about 30 years (FAO 2001a). Rotation lengths can reflect both end-use and economics.

Many fast growing *Eucalyptus, Acacia* and *Casuarina* species and *Gmelina arborea* are grown on short rotations of under 15 years as they are used primarily for pulp or woodfuel. Usual rotations in Kenya for E. grandis are 6 years for domestic woodfuel, 7 to 8 years for telephone poles and 10 to 12 years for industrial woodfuel. In Brazil this species is largely grown for pulp or charcoal on 5 to 10 year rotations. Species being grown for high-value saw logs usually have longer rotations; teak (*Tectona grandis*) is grown on 50 to 70 year rotations and high-value conifers such as *Araucaria angustifolia* on 40 year rotations. Generally pines are grown on medium-length rotations of 20 to 30 years, unless grown solely for pulpwood, when shorter rotations may be adopted.

On average *Eucalyptus* and *Pinus* species, which dominate industrial plantations in developing countries, have similar MAIs of 10 to 20 m^3 per hectare per year. However, many of the popular species of both genera frequently achieve much faster growth rates. Thus *Eucalyptus grandis,* which is the most widely planted Eucalyptus species, can achieve 40 to 50 m^3 per hectare per year and in very exceptional conditions with advanced tree improvement 100 *equisetifolia, Casuarina junghuhniana, Tectona grandis* and *Dalbergia sissoo* have MAIs of less than 15 m^3 per hectare per year and frequently under 10 m^3 per hectare per year (FAO 2001). Average growth rates of frequently planted species are summarized in the Table given below:

Mean annual increments for selected species used in industrial forest plantations across the globe

Species	MAI(/ha/yr.)	Species	MAI(/ha/yr.)
Eucalyptus		**Pinus**	
E. deglupta	14-50	*P. caribaea var. Caribaea*	10-28
E. globulus	10-40	*P. caribaea var. Hondurensis*	20-50
E. grandis	15-50	*P. patula*	8-40
E. saligna	10-55	*P. radiata*	12-35
E. camaldulensis	15-30	*P. oocarpa*	10-40
E. urophylla	20-60	**Other species**	
E. robusta	10-40	*Casuarina junghuhniana*	7-11
Other species		*Cupressus lusitanica*	8-40
Araucaria angustifolia	8-24	*Cordia alliodora*	10-20
Araucaria cunninghamii	10-18	*Leucaena leucocephala*	30-55
Gmelina arborea	12-50	*Acacia auriculiformis*	6-20
Swietenia macrophylla	7-11	*Acacia mearnsii*	14-25
Tectona grandis	6-18	*Terminalia superba*	10-14
Casuarina equisetifolia	6-20	*Terminalia ivorensis*	8-17
		Dalbergia sissoo	5-8

(Source: Webb et al. 1984; Wadsworth 1997)

Hardwood Plantations

Long-rotation, slow-growing but valuable hardwood species have special technical properties, such as strength, natural durability, hardness and easy machining, and appearance (grain, figure, texture, colour and other aesthetic qualities) that make them suitable for high-value end-uses such as furniture. These high-grade hardwoods contrast with short-rotation, fast-growing, lesser-quality woods used for woodfuel, pulpwood or reconstituted products and less demanding building timbers. In tropical countries teak (*Tectona grandis*), mahogany (*Swietenia* spp.) and rosewood (*Dalbergia* spp.) are the main hardwood plantation species, while in temperate countries oak (*Quercus* spp.), ash (*Fraxinus* spp.), cherry (*Prunus* spp.), walnut (*Juglans* spp.), tulipwood (*Jacaranda* spp.) and hard maple (Acer spp.) predominate.

Because many valuable hardwood species are difficult to establish because of their ecological requirements or disease or insect susceptibility, focus has been on the easier species to grow, including teak (*Tectona grandis*), Indian rosewood (*Dalbergia sissoo*) and mahogany (*Swietenia macrophylla*). In 1995 the global areas of these species were 2 254 000, 626 000 and 151 000 ha, respectively. They accounted for about 10% of total hardwood plantations in the tropics. More than 90% of teak plantations were located in Asia, mainly in Indonesia, India, Thailand, Bangladesh, Myanmar and Sri Lanka. About 95% of rosewood plantations are located in India and Pakistan. The largest mahogany (Swietenia macrophylla) plantations are located in Indonesia and Fiji, which together make up about 80% of the established area (FAO 2001b).

The market preference for large piece sizes, slow growth and very long rotation lengths (e.g. 50 to 70 years for teak) combine to reduce the attractiveness

for commercial investment in these species. This is only partially counteracted by their value. The low return on capital investment, coupled with the long wait period for this return, has made it difficult to interest private investors without supportive, secure and stable government policies. A summary of the main characteristics of valuable hardwood species commonly grown in tropical areas is given in the following Table:

Characteristics of valuable hardwoods used in tropical areas

Use Categories	Desirable Wood Properties	Main End-Uses	Matching valuable hardwood species	Comments
Decorative timbers	Appearance, consistent quality, dimensional stability, durability; good machining, staining and finishing properties	Quality furniture and interior joinery	*Tieghemella* spp., *Entandophragma cylindricum*, *Chorophora* spp., *Aucoumea klaineana, Afrormosia* spp., *Entandophragma utile, Mansonia* spp., *Lovoa* spp., *Khaya* spp., *Swietenia* spp., *Dalbergia* spp., & *Aningeria* spp.	Highest value, competition from temperate hardwoods and MDF
High to very high-density timbers	Appearance, strength, high natural durability & availability in large sizes	Principally in construction	*Dipterocarpus spp., Lophira spp., Chlorophora spp., &Ocotea rodiaei*	Small share of total tropical timber use
Low to medium-density utility timbers	Appearance, clear grain, natural durability, good machining properties	External joinery, shop fittings, medium-priced furniture	*Shorea spp., Hevea brasiliensis, Terminalia spp., & Heritiera spp.*	Most commonly used, prone to competition from substitutes

(Source: Based on FAO 1991)

Fuel wood makes up about 80% of total wood use in developing countries and about 89% in Africa (FAO 2001c). Forest-based supply of fuel wood ranges from 13% in the Philippines to as high as 73% in Nepal. In many countries less than 50% of fuel wood is from forests.

Globally, non-industrial forest plantations estimated to be covering about 20 million hectares in 1995(FAO 2000b), was almost 17% of the world's total plantation area. A significant proportion of these plantations were planted for woodfuel, and 98% were in developing countries, about one-third of the total plantation estate was grown primarily for woodfuel. Three-quarters of these plantations were in Asia (excluding Japan), where they accounted for 60% of total plantation production. In Latin America more than half of plantation production went to woodfuel; in Africa and Oceania a larger proportion of plantation production was as industrial wood. However, plantations, in general, provided only a small proportion of total woodfuel used. (FAO 2001c). These plantation figures do not account for trees planted outside the forest on farms or in villages, etc., nor do they consider plantations that were considered agricultural plantations, such as Hevea or palm plantations.

Production of woodfuel from plantations currently makes only a small contribution to energy requirements, although it is very important in some localities and countries. Plantations currently supply 5% of wood fuel. Production from these non-industrial plantations is likely to double over the next 20 years, even with little expansion in area, because the age class distribution is heavily concentrated in young plantations. In an optimistic scenario where planting continues at the same rate as in the past ten years and then gradually declines, a 350% increase in wood fuel production would be anticipated by 2020. By-products from wood-using industries will also contribute to increased fuel wood supply. The situation is less positive in Africa, where for a few countries declines are projected in plantation-based

wood fuel production (FAO 2001c).

Plantations and Carbon Sequestration

Development of forest plantations as carbon offsets has evolved towards a market mechanism, although an organized market with carbon prices defined according to supply and demand forces is still a long way off. The adoption of the Kyoto Protocol in 1997 triggered a strong increase in investment in plantations as carbon sinks, although the legal and policy instruments and guidelines for management are still debated. A number of countries have already prepared themselves for the additional funding for the establishment of human-made forests. The 1997 Costa Rica National Programme was the first to establish tradable securities of carbon sinks that could be used to offset emissions and the first to utilize independent certification insurance.

To date, greenhouse gas mitigation funding covers about 4 million hectares of forest plantations worldwide (FAO 2001e). The recognition of afforestation and reforestation as the only eligible land use, land use change and forestry activities under the Clean Development Mechanism of the Kyoto Protocol, as agreed in Bonn during the second part of the Sixth CoPs (Conference of the Parties) to UNFCCC (United Nations Framework Convention on Climate Change) in July 2001, will lead to a steep increase in forest plantation establishment in developing countries. The sink decision of the Bonn Agreement is expected to funnel additional funds into forest activities in developing countries and thus to strengthen the international efforts in this field. However, it will also require a monitoring and verification system to ensure that these plantations will not be established at the expense of the local population or efforts to conserve biological diversity. Thus the decisions taken in Bonn to make the Kyoto Protocol ratifiable will also bear new challenges for forest plantation development.

New forest plantation areas are reported to be increasing globally at the rate of 4.5 million hectares per year. Asia and South America account for more new plantation development than other regions. The Asian region has the largest areas in forest plantations. Broadleaf species account for 40% of forest plantations, coniferous species 31% and unspecified species 29%. Industrial plantations account for 48% and non-industrial 26% of global forest plantations. Industrial plantation resources are dominated by China, India and the United States, while non-industrial plantation resources are dominated by China, India, Thailand and Indonesia. Forest plantation ownership in both industrial and non-industrial plantations is evenly balanced between public and private. Forest plantations can provide critical environmental, social and economic benefits. Sound forest plantation management, tree improvement and silviculture can sustain and/or enhance productivity of forest plantations. To do so, however, it is important that forest plantations be managed in accordance with a defined end-use objective.

Forest plantations in India now comprise some 19 million ha and represent a significant proportion of the total plantation resource of around 70 million ha in the Asia-Oceania region. Forest Plantations managed by the Government is the largest domestic source of timber in India. State Forest Development Corporations (SFDCs) set up by the State Forest Departments have established credible systems in harvesting, transporting and marketing of timber. The management of forests is the responsibility of State Forest Department and this is in accordance with the approved forest working plans prepared based on scientific forestry principles. However, the timber originated from forests, including agro forestry, farm forestry areas and trees outside forest areas often lack such management plans. To address this, the Indian industry, in particular paper and pulp sector provide technical and financial support to the farmers (most of them are small holders) to improve management of farm forestry / agro forestry areas in accordance with the best practices. The cooperative societies of these farmers play a significant role in implementing best forest management principles for such areas, including conservation of ecosystem services. National Forest Policy 1988 encouraged such partnerships to increase the supply of timber needed by the industry besides meeting the economic needs of the communities including fuel wood.

Nilambur Teak Plantations in Kerala and the 'Australian' Timber Plantations of the Nilgiri plateau are two of the largest and most famous timber plantations in British India during the second half of the nineteenth century.

Conclusion

Forest plantations in India, comprising some 19 million ha,the largest domestic source of timber with credible systems in harvesting, transporting and marketing in the country, provides critical environmental, social and economic benefits/eco-system services. There is increasing interest in development of forest plantations as carbon sinks; however, failure to resolve international debates on legal instruments, mechanisms and monitoring remains a serious constraint. Market preference for large piece sizes, slow growth and very long rotation lengths(e.g. 50 to 70 years for teak) combine to reduce the attractiveness for commercial investment in plantation forestry. The low return on capital investment, coupled with the long wait period for this return, has made it difficult to interest private investors without supportive, secure and stable government policies.

Projections for supplies of timber from existing valuable hardwood plantations indicate that because of the age class distribution and long rotations there will not be a significant increase in supply in the next 20 years. Future promotion of quality hardwood plantations needs to emphasize choice of species with versatile end-uses, market research and development to hold on to niche markets and maintained high standards from production to marketing. Careful site selection, use of high-quality planting materials of superior genetic origin and good silviculture are important. Planting programmes should be economically viable, environmentally appropriate and socially desirable. Incentives may also be necessary to stimulate private investment because of the long rotations. Even though valuable hardwood plantations have the potential to reduce the pressure on natural forests, they will not prevent deforestation resulting from agricultural encroachment. The supply of large quantities of high-value timber could perhaps undermine the value of natural forest stands and so lead to more rapid destruction. Hence it is advisable, where possible, to manage plantations and forest resources and forest products in a complementary manner.

As a result of the net effect of deforestation and removal of natural forests from wood production, some areas in the Asia and the Pacific region have wood deficits and roundwood harvesting is exceeding sustainable levels of cut. The worst affected areas are South Asia and insular Southeast Asia, with continental Southeast Asia also under strain. New Zealand is more than self-sufficient in wood production based on plantations. In Sri Lanka, India and elsewhere in the tropics, trees outside the forest are playing a critical role in roundwood and woodfuel supply. Actual plantation development as at present not sufficient to offset both growing consumption and declining harvest from natural forests (FAO 2001d).

Issues and solutions connected with utilization of plantation timbers:

- Low dimension timbers from short rotation plantations
- Reduced conversion recovery of planks/scantlings
- Poor physical and mechanical properties due to higher proportion of juvenile wood in short rotation timbers
- Poor durability due to limited heartwood formation
- Limitation with respect to aesthetic value

The solutions could be: Employ appropriate machineries for the conversion and processing of small dimension timbers – use of improved sawmilling machines and sawing techniques; spindleless lathes, etc; ensure the use of treated and seasoned wood; employ appropriate treatment chemicals and methods for ensuring desired dry salt retention of the preservative chemicals within the treated wood; conversion to re-constituted/engineered wooden panel board products (Plywood, particle board, fibre board, oriented strand board, laminated veneer lumber, cross laminated timber, glue laminated timber, etc.; and employing state of the art wood finishing techniques; however, these remain not the issues directly connected with the Plantation Forestry Sector, but are only corollary.

ASHOK AGARWAL

President
PLYWOOD MANUFACTURERS WELFARE ASSOCIATION-U.P.

National President
INDIAN INDUSTRIES ASSOCIATION

Amazing Quality & Features

Quatroo Press TECHNOLOGY

E-0 ZERO EMISSION

EXTRA LAYER

CALIBRATED

3 TIMES MONEY BACK

ANTI VIRUS
KILLS 99.9% VIRUSES & BACTERIA

www.ragnarply.com
info@kanchanply.com

RAGNAR™
TOUGHEST PLYWOOD
AS GOOD AS WOOD
QUALITY PRODUCT OF : **KANCHAN PLY**

Good Better Best

We **NEVER** let it rest,
until our **GOOD IS BETTER**
and our **BETTER IS BEST**

Better than The best panel for your interior furniture.

VIDYA PLY & BOARD PVT. LTD.

Delhi Office : B2/30 Ashok Vihar Phase 2, New Delhi-52, Vill-Lalpur,
Post-Dadraul, Jalalabad Road, Shahjahanpur, Uttar Pradesh-242001

Chapter 4
Agroforestry / Farm Forestry Sector

Trees planted on farms may be labelled *farm forestry, agroforestry or landcare planting*, depending on their main purpose. However, the distinction is often artificial, as the names have considerable overlap, especially where trees are managed for multiple purposes. A broad definition of *farm forestry* includes any trees on farm land which are managed to produce saleable products such as timber, oil, tannin, charcoal or carbon credits. The farm forestry label is now being used to include the commercial management of native forest on farms as well. The purpose of agroforestry is to incorporate trees and shrubs into farming systems to gain from their positive interactions with agriculture. Benefits gained from trees and shrubs may be direct (timber), indirect (shade, shelter and fodder), or a mixture of both. The terms agroforestry and farm forestry are often used interchangeably.

As defined by the International Centre for Research in Agro forestry (ICRAF), "Agroforestry is a collective name for all land use systems and practices where woody perennials are deliberately grown on the same land management unit as agricultural crops or animals in some form of spatial arrangement or temporal sequence". The Food and Agricultural Organisation (FAO) describes agroforestry as a dynamic, ecologically based, natural resource management system that, through the integration of trees on farms and in the agricultural landscape, diversifies and sustains production for increased social, economic and environmental benefits for land users at all levels. In terms of climate action, the introduction of trees to farms and landscapes for multiple productive purposes could play a key role in mitigating the impact of climate change by potentially contributing to more than 1.5 billion hectares of mosaic land restoration.

There is a huge domestic market for agroforestry products, especially timber products. Many states including Haryana, Maharashtra, Odisha, Jharkhand, Uttarakhand and Karnataka are actively implementing agroforestry practices.

Developing suitable agro forestry models with preferred timber, fodder, fuel and fruit tree species for different agro climatic zones is more economical, particularly on marginal lands. Observations taken in hot arid and semi-arid areas of Rajasthan indicated that marginal lands are incapable of sustaining stable and dynamic cultivation of agricultural crops. Silvipasture consisting of growing trees such as Prosopis, Albizia, Zizyphus and Acacia species may provide many times more returns per unit of land than agriculture under such conditions (Gupta and Mohan, 1982). Eucalyptus in agroforestry has been found to be more profitable than pure agriculture in Haryana. Populus deltoides increases the farm return by 50% in Tarai region of Uttar Pradesh (Chaturvedi, 1981).

International Union of Forest Research Organizations in 2016 reported that India is the third largest importer of illegally logged timber in the world. And it doesn't come cheap. Between 2010 and 2018, India imported Rs. 388 billion worth of wood and wood products from around the world. A World Bank study says this market is expected to grow at 20% every year for the next few years. Why do we want to import illegally logged timber when we can simply allow our farmers to grow them on their farms and buy from them? It will have a huge positive impact on the foreign exchange. These trees will act as insurance during exigencies for the farmer, reducing dependence on high-interest loans that he is unable to repay driving him into debt and death.

In February 2014, India became the world's first country to adopt a comprehensive National Agroforestry Policy (GoI 2014), with an objective to encourage and expand tree plantation in complementarity and integrated manner with crops and livestock to improve productivity, employment, income and livelihoods of rural households, especially the small holder farmers and to meet the raw material requirements of wood based industries and reduce import of wood and wood products to save foreign

exchange. The National Agroforestry Policy 2014 came in limelight to address the issues of quality planting material, tree insurance, restrictions on transit and harvesting, marketing of agroforestry produce, research and extension. The major highlights of the National Agroforestry Policy (NAP) are: establishment of institutional set-up at the national level to promote agroforestry under the mandate of the Ministry of Agriculture, GoI; simplify regulations related to harvesting, felling and transportation of trees grown on farmlands; ensuring security of land tenure and creating a sound base of land records and data for developing an market information system (MIS) for agroforestry; investing in research, extension and capacity building and related services; access to quality planting material; institutional credit and insurance cover to agroforestry practitioners; increased participation of industries dealing with agroforestry produce, and strengthening marketing information system for tree products. Initially 20 important multipurpose tree species have been identified at the national level to be exempted from all restrictions related to harvesting, transportation and marketing grown under agroforestry systems. Implementing this action plan in the Policy will encourage active participation of farmers and help in achieving 33% forest cover ensuring raw material to wood-based industries as well as environmental security. An overview of regulated and restricted tree species existing in different states is given in the following Table:

List of exempted and restricted tree species from the different states of India

S.N	Name of States/UTs	Status
1.	Andaman n Nicobar Islands	• Transit Permit is required for transit of forest produce in A & N Islands and no exemption for any sps. has been provided in the Regulation.
2.	Assam	• No Felling Permission (FP) is required for home grown bamboo. • No Transit Pass (TP) is required. Certificate from Gram Panchayat is required.
3.	Andhra Pradesh	• NO FP. All spp exempted. • NO TP, All spp exempted.
4.	Arunachal Pradesh	• No FP is for bonafide use except commercial use • No TP is required except commercial and other use
5.	Bihar	• Tree sps currently exempted from Transit Regulations (as on 27.02.2009) • Poplar, Eucalyptus, Kadamb, Gamhar, Mango, Litchi, Toddy palm, Khajur, Bamboo sps (Except Dandrocalamus strictus), Semul. • Some more sps are in process to be exempted.
6.	Chandigarh	• No interstate transit permit is being issued by Forest Department as no forest check posts have been established. • The permission for felling of trees on private /non forest land is given only in two cases, i.e either for any development work or trees are dangerous to human life or property. As such no tree sps. is exempted under this.
7.	Chhattisgarh	• Timber Sps that have been exempted from transit regulations are Poplar, Casuarina, Su-babul, Israili babul, Vilayati babul, Manzium , Nilgiri
8.	Delhi	• Since land is premium commodity in Delhi, farmers generally do not practice agroforestry here. Sps. likePoplar, Kikar and Eucalyptus have been proposed for exemption. So FP is requied • There is no transit rules in Delhi for transportation of timber.
9.	Goa	• No FP. Omitted Bamboo from the definition of tree. • NO TP. All types of bamboo grown in private areas (non forest areas) will not fall under the purview of forest produce and hence transit permit for bamboo felled from private areas are exempted
10.	Gujarat	• Nilgiri, Subabul, Saru, Champa, Laxmanfal , Ramfal, Sitafal, Asopalav, Pendula, Nagkesar,Nagchampha, Falsa, Ingorio/Angarea, Kamrakh, Kadhipatta, Limbu, Chikotru, Bijoru/Turanj, Narangi, Mausambi, Maharuk, Rukhdo, Motoarduso, Limdo,Neem, Bakan, Bakan, nim, Irani nim, Nimbara, Limbara, Mahanim, Mahogony, Bordi, Bor, Khati bor, Ghulbor, Liehi, Lilchi, Aritha, Aritha, Amba, Kadvo Saragavo, Saragavo , Agathin, Segto, Agastin, Desi Baval, Goras amlili, Gando baval, Ganda baval , Botlle Brush, Jamphal, Dadam, Chikoo, Boralli/Mursal/ Vakal/ Varasd/ Bakul, Saptaparni, Champo, Safed champo, Liar/ Nani/ Gundi/ Nagod, Nirgund/ Nargundi, Lingur Nirgudi, Ambla, Fanas, Pipli/papri, Shetur, Haredo, Harero, Poplar, Golden cane palm, Oilplam
11.	Himachal Pradesh	• Kala Siris/Ohi/Sriris, Kachnar/ Karial, Safeda, Kimu/ Chirmu, /Shahtoot/Tut/Mulberry, Poplar, Indian Willow/Biuns,Kuth, Kala Zira, Japanese Shehoot/paper mulberry, Paik, /Koi,/ Kosh/Kunis/ Kunish/Nyun, Khirk/ Khadki, Darark/Bakin, Fagoora/ Phagoora/Tiamble/timla/ tirmal/anjiri/cluster fig/goolar, Toon, Jamun, Teak/Sagun/Sagwan, Arjun, Semal, Shalmaltas, Bihul/ Beul/ Bhimal/ Bhiunal/Dhaman, Paza/ Padam, Kamala/ Raini/Rohan/Rohini/ Sinduri, Aam(Mango wild variety), Rishtak/Ritha/Dode

12.	Haryana	• Some sps are exempted from regulations under Punjab Land Preservation Act, 1900. These are Eucalyptas, Poplar, Alianthas , and Acacia tortilis. • There is no transit rules applied for timber sps.
13.	Jharkhand	• Eucalyptus (Safeda), Poplar, Casuarina, Maha Neem, Baken Kadmb, Subabool, Silver Oak, Israeli Babool Vilayati Babool, Babool, Plam, Ber, Munga, Mulberry Guava, Nimboo, Santra, Mussambi, Ashok,
14.	Jammu & Kashmir	• Kikar, Bel, Siris, Champ, Neem, Malugarh, Kakrad, Palas, Amaltus/ Karangal, Sisoo/Tali, Dhamman, Nili Gulmohar, Akhrot(khod), Kehbal jhingar, Baronkal, Bilati Kikar, Safeda, Poplar, Robin, Chitta banddha, Rondu banddha, Sagwan, Arjun, Beheda, Tun/Toon, Bana, Dhoi
15.	Karnataka	• Acacia hybrid, Acacia mangium, Tree of Heaven, Rain tree, All Cassias except Golden Rain tree, Cashew, Christmas tree, Arecanut, Casuarina, India Beef wood, Lemon, Ornage, Coconut, Coffee, Mayflower, Indian coral tree, Eucalyptus, Glyceridia/ Quick stick, Silver Oak, Rubber, Jacaranda, Sausage tree , Subabul, Umbrella tree, Sapota/Chikoo fruit, Melia, Indian Cork tree, Drumstick, Mulberry , Curry leaf tree, Peltoform, Purple bauhinia, Pagoda tree, False Ashoka, Guava, Sesbania, Hummingbrid tree, Paradise tree, African tulip , Tabebula, Trumpet tree
16.	Kerala	• SpeciesforPlywood: Vellappine,Kurangandi / Narivenga / Mundani, Karakily/Kalpine, Kulamavu/ Kulirmavu/Ooravu, Pali/Palendinjan, Thellipine/Undapine, Kulavu, Red Cedar, Poon/Punna/Punnappa, Vediplavu/Mullampali, Charu, Pothundi/Perunthondi, Cheeni, Nedunar, Vallabham/Varangu, Chorapine, Chemmaram, Champakam, Cherukonna, Mulliam, Neeramruthu, Peenary, Kumbil, Veembu, Gnavel, Kattunelli, Vakka, Thavala • Species for Matchwood :Aspin/Kanala/Nasakam, Elavu/Poola, Pala/Mukkampala, • Species for Bobbin wood : Vellakil, Manjakdambu, Species for pencil wood : Venkotta, Perumtholi/Poochakadmbu, Attuthekku/Cadambu, • Species for packing wood: Kara/ Bhadraksham, Amazham,Aval, Arayanjili, Kalaveppu/Malaveppu, Vatta/Uppathi, • Fire wood : Palvu(Jack),Parankimavu (cashew), Kattadi (Casuarina), Poovarasu (Poovarasu), Mavu (Mango tree),Puli(Tamarind tree), Nattupunna (Nattupunna), Aanjili(Aanjili), Vaka (Vaha- species), Poovam, (Poovam), Konna), Thanni (Thanni), Uthi (Uthi), Aal Jatikal (Ficus species), Matti (Matti), Murukku(Murukku), Elappu(Iloia) and Kodamuli(Koadampuli)
17	Lakshadweep	• NO FP. IFA or any Forest Act is not enforced in Lakshadweep. Also, Bamboo is not grown anywhere in Lakshadweep. Therefore amendment in IFA or any Forest Act does not arise in this state. • No TP
18.	Madhya Pradesh	• Neelgiri,Casuarina , Poplar, Subabul, Israili Babul, VilayatiBabul, Australian Babul, Babul, Khamer, Maharukh, Kadamb,Cassia Siamea,Gulmohar, Jacaranda, Silver oak, Plam, Ber, Mulberry , Katahal, Amrood, Nimbu, Santra, Mussambi, Munga, Molshri, Ashok, Putranjiva, Imli, Jamun, Mango, Saptparni, Kaitha, Jungle Jalebi, Petltaphorum, Neem, Bakain, Sissoo, Karanj, Palash, Safed Sirus, Pipal, Bargad, Gular, Rubber, Semal, Kapok, Chirol, Gliricidea, Rimjha , meithi Neem, Gurhal, , Jasoun, Conifers , imported Timber Species
19.	Maharashtra	• Nilgiri trees,Babhul, Subabhul , Prosopis,Ashok, Drumstick, Sindi, Orange, Chiku, Bhendi, Acacia, Poplar, Lac, Casuarina equisetifolia , Rubberwood
20.	Meghalaya	• Meghalaya being a Hilly state, there is no Agroforestry at all, since percentage of states land covered by agriculture is very small.If any blank inter- state movement of timber is permitted, state will lose meagre resource of forests under control of the State Government.
21.	Mizoram	• Kothal,Tung,Eucalyptusspp.,Mulberry,Neem, Rubbertree,Imli,SilverOak,Subabul,Mango, Guava, Coconut, Citrus, Areca nut
22.	Manipur .	• No Felling Permission (FP) is required • No Transit Pass (TP) is required for home grown within state. • TP is required outside state
23.	Nagaland	• Aam, Korei, Walnut, Neem, Alder, Manipur Sim, Kadam, Hollock , Khokan, Teak, Gamari
24.	Odisha	• Bada chakunda, Sana Chakunda, Jhaun, Sliver Oak, Patas/Nilgiri,Sunajhari/Acacia, Subabul, Kaitha, Ambada, Batapi, Oau, Sajana, Karamanga, Sahada, Plam tree, Debadaru, Bhersunga, Gohira, Giliricidia, Paladhua, Coconut
25.	Punjab	• "forest produce" shall specifically mean timber (converted or otherwise), firewood, charcoal, katha and resin, but shall not include Non Timber Forest Produces (NTFPs) like bamboos and agro-forestry species such as Populus spp., Eucalyptus spp., Melia azedarach (Drek), Morus alba (Mulberry), Leucaena leucocephala (Subabul), Casuarina spp., Grevillea robusta (Silver Oak), Acacia mangium, Melia dubia (Malabar Neem), Prosopis cineraria (Khejri), Salix alba (Indian willow), Gmelina arborea (Gamari) or any other species declared by the State/ authorised agency as agro-forestry species from time to time.
26.	Rajasthan	• Casuarina, Australian babul, Khamer, Caaia Siamea, Gulmohar, Jaccaranda, Silver oak, Plam, Ber, Mulberry, Katahal, Amrood, Sehjana, Molshri, Ashok, Putranjiva, Imli, Jamun, Saptarni, Kaitha, Jungle Jalebi , Petaphorum, Bakain, Karanj, Safed Sirus, Semal, Kapok , Churel, Mithi neem
27.	Sikkim	• No permission for felling of trees on any private or Forest land has been granted.If anyone wishes, he have to apply to Block Officer.
28.	TamilNadu	• Mesquite, Casuarina, Subabul, Palmyrah, Dadops, Umbrella thom, White Back Acacia/ Panicled Acacia, Maharuch, Maharukh/East India Walnut/Siris, Cashew, Kadam, Jack, Neem/Margosa, Red silk cotton/ Kapok, Sappan, Cassia, white silk cotton tree/kapok, Sissoo, Coral tree, Eucalyptus, Gamari, Rubber, Sea Hibiscus, Mohua, Mango, Persian Lilac, Malabar Neem, Morinda /Suranji, Manila/ Tamarind, Pongam/ Indian Beach, Rain tree, Mahogeny, Jamun/Indian cherry, Tamarind, Esperanaza, Indian Portia tree/Indian Tulip, Red Cedar/Toon, Silver Oak.

29.	Telagana	(i) Eucalyptus, Neelagiri,Jama oil (ii) Casurina, Sarugudu, Sarvi, Saru(iii) Poplar(iv) Subabul (v) Israeli Babool (vi) Seema,Thumma(vii) Australian babul(viii) Gummaadi teak (ix) Pddamanu (x) Kadamb, (xi) Seema/ Tangedu (xii) Jacaranda (xiii) Silver oak (xiv) Regu, Ber(xv) Mulberry (xvi) Jama, Guava (xvii) Orange and related species,(xviii) Munga (xix) Ashok/ Naramamidi (xx) Mahaputrajivi/Putrajeevi (xxi) Edakulapala (xxii) Turakavepa(xxiii) Kanuga (xxiv) Rubber/ Seemamarri (XXV)TellaTumma(xxvi) Gliricidea/Seema/Kanuga(xxvii) Tella Tumma (xxviii) Kaivepaku (xxix)Mandara (xxx) Conifers(chir, Kail, Deodar, Pine species) (xxxi) Tati, Tadi, Palmyrah (xxxii) Sapota (xxxiii)Coconut, Kobbari, Tenkai, (xxxiv) Cashew , Jeedimamidi (xxxv) Semma, Chinta, ((xxxvi) Raint ree, Nidragannreru, (xxxviii) Mango,Mamidi(xxix) Panasa, Jackfruit
30.	Tripura	• Tree species like Mango, Litchi, Drumstick, Guava, Rubber and bamboo are exempted from extraction from private land. Bamboo sps. have been exempted from transit permits both from Private and Forest land. Transport of Timber is also permitted .
31.	U.P.	• Aru, Casuarina, Jangal Jalebi, Poplar, Babool, Vilayati Babool, Rabania, Siris, Su-babool, Kathber, Jamun, Eucalyptus, Dhak Palas, Paper Mulberry, Ber, Sainjana, Shah toot, Mango (Desi, Tukhmi or Kalmi)
·	32.	• Uttarakhand27 tree species have been exempted from the provision of Tree protection Act, 1976. This includes fodder and small timber species that are being used in small scale industries, animal husbandry, agricultural implements and allied activity. Other 07 tree species like Walnut , Neem, Oak , Ficus (Peepal and Banyan) and Deodar have been placed in the restricted category and felling permission can be granted only in case of dead or dangerous trees.

Source; Ministry of Agriculture, Cooperation & Farmers Welfare, Govt. of India

NAP, 2014 also identified 20 most important tree species preferred by the farmers in different parts of the country to be relaxed in the first phase from such restrictions. It is understood from the Table that the status of the same species differs according to the states of occurrence as well as its need for conservation; species exempted in one state could be the species restricted in another state. Uniform guidelines for exemption of agroforestry tree species from restrictive regulatory regimes in all states are required with uniformity in tree and land tenure laws across the country. This is a difficult task and needs convergence of interests among multiple stakeholders. Currently, commercial agroforestry is gaining momentum due to large-scale demand from pulp and paper industries and is estimated to be practised over 5 million ha with tree species belonging to Eucalyptus, Populus, Casuarina, Leucaena, Ailanthus, Melia, Anthocephalus, Acacia, Bombax, etc. Of late, Melia dubia is on the rising trend in AF due to demands from panel and reconstituted board industries. The area under commercial agroforestry is as given below:

Area under traditional and commercial agroforestry in India

Types of AF System	State	Area (x 1000 Ha)	Species
Traditional AF			
Alder-cardamom	NE India	14	*Alnus nepaalensis*
Kamkayam-AF	Tamil Nadu	384	*Acacia leucophloea*
Home gardens	Kerala	1330	*Mix tree species*
Khejri-based AF	Rajasthan	1586	*Prosopis cineraria*
Commercial AF			
Pulpwood AF	Punjab, Haryana, UP, AP, Gujarat and MP	657	*Eucalyptus, Poplar,* Casuarina and Subabul
Timber-base AF (Furniture)	Kerala, Maharashtra, Tamil Nadu & MP	1700	*Tectona grandis*
Willow-based AF (Bat industry)	Jammu and Kashmir, HP, Uttarakhand & Punjab	137	*Salix spp.*

The AF practice is estimated to produce 100 million cubic metre timber/pulpwood for industrial and domestic use and 150 million tonnes firewood, add approximately 15 million tonnes organic matter through leaf fall, sequester 60 million tonnes carbon annually in tree components (excluding in soil and that locked in the wood products), and generate employment of 4000 million person days/ annum in nursery and plantation activities. The value of wood/pulpwood produced is estimated to be

around Rs. 10,000 billion and that of firewood as Rs. 30,000 million annually (Dhiman 2013). It is evident that private enterprises like pulpwood, match wood and other plywood industries are in huge demand for raw material supply which can be tied up through Public-Private Partnership (PPP) model or any new approaches that will be beneficial to the farmer also and will indirectly help in achieving forest cover.

In its Intended Nationally Determined Contributions (INDCs), India has committed to create an additional carbon sink of 2.5-3.0 billion tonnes of CO2 equivalent through additional forest and tree cover by 2030. Definitely, a major part of this objective will be shared by the Agroforestry sector which will be boost to industrial forestry to serve raw materials to the wood based industries of the country, as proposed in the draft national forestry policy (DNFP) 2018.

Conclusion

Tree growers under Agro-Forestry are generally small land holders in India; however they supply 92% of wood demand in India. There is no certification system suitable for wood produced from Agro-Forestry. Information technology based Certificate of Origin and Ownership (COO) system can be developed to certify Legality of Wood from Agro-Forestry. It can be used for - trading and transaction, insurance and collateral guarantee for banking and future trading. Digital tagging can be introduced at the farm level – used across supply chain and traced back for a chain-of-custody verification & certification.

The benefits of Agroforestry/ Farm Forestry, the incorporation of trees and shrubs into farming systems to gain from their positive interactions with agriculture, may be direct (timber), indirect (shade, shelter and fodder), or a mixture of both. Silvipasture consisting of growing trees is expected to provide many times more returns per unit of land than agriculture under conditions prevailing in the hot arid and semi-arid areas; such asProsopis, Albizia, Zizyphus and Acacia species in Rajasthan, Eucalyptus in Haryana; Populus deltoides in Tarai region of Uttar Pradesh. The social benefit of these farm forestry trees acting as insurance during exigencies for the farmer reducestheir dependence on high-interest loans. The National Agroforestry Policy 2014 safeguards the farmers in promoting growing trees in an integrated way linking the various sectors of agriculture and forestry. Twenty important multipurpose tree species preferred by the farmers in different parts of the country have been identified at the national level to be exempted from all restrictions related to harvesting, transportation and marketing grown under agroforestry systems. However, due to practical reasons, the status of the same species differs according to the states of occurrence as well as its need for conservation; species exempted in one state could be the species restricted in another state. Uniform guidelines for exemption of agroforestry tree species from restrictive regulatory regimes in all states are required with uniformity in tree and land tenure laws across the country, a difficult task needing convergence of interests among multiple stakeholders. Commercial agroforestry is geared to large-scale demand from pulp and paper industries; over 5 million ha is cultivated with tree species belonging to Eucalyptus, Populus, Casuarina, Leucaena, Ailanthus, Melia, Anthocephalus, Acacia, Bombax, etc. Of late, Melia dubia is on the rising trend in Agro Forestry (AF) due to demands from panel and reconstituted board industries. AF practice is estimated to produce 100 million cubic metre timber/pulpwood for industrial and domestic use and 150 million tonnes firewood, add approximately 15 million tonnes organic matter through leaf fall, sequester 60 million tonnes carbon annually in tree components and generate employment of 4000 million person days/ annum in nursery and plantation activities. The value of wood/pulpwood produced is estimated to be around Rs. 10,000 billion and that of firewood as Rs. 30,000 million annually.). Private enterprises like pulpwood, match wood and other plywood industries with huge demand for raw material are expected to bring tie ups through Public-Private Partnership (PPP) model or any new approaches that will be beneficial to the farmer also and will indirectly help in achieving forest cover.

KUMAR ENGINEERING CO
AN ISO 9001 : 2015 CERTIFIED COMPANY

marketing@kumarengineeringco.in
+91-9811119274 , +91-8222931414
Khatri Industrial Area, Sampla-Beri Road
Sampla-124501, Dist. Rohtak, Haryana, INDIA

Company Background:

KumarEngineeringCo. is a pioneer in India for making indigenous global standard machines being used in the wood working industries as Plywood, Laminate & Furniture, Founded in 1990 by Mr. Sunil Srivastava (M.D.) on Engineering graduate with breakthrough experience in advance automation with strong focus on research and development, our organization is recognized worldwide for technical excellence and development of innovative products. The numerous industry milestones, new products, technical upgradations and patents that have resulted from our work continue to provide long-term benefits to our clients.
We are ISO: 9001 2015 certified company located in NCR District Rohtak, Haryana, approximately 40 miles from the capital city of New Delhi and easily accessible from the airports.

Core Competencies:

- Double Head Wide Belt Top Sanding Machine
- Double Head Wide Belt Bottom Sanding Machine
- Heavy Duty Both Side Sanding Machine
- Triple Head Calibrating and Sanding Machine
- Heavy Duty Laminate Sanding Machine
- Heavy Duty Both Side Calibrating Machine
- Super Heavy Duty Both Side Calibrating Machine
- Single Combi Head Sanding Machine
- Single Head Calibrating Machine
- Double Head Both Side Brushing Machine
- Triple Head Both Side Brushing Machine
- Automatic Edge Cutting Machine (ServoControlled)
- Hardwood Calibrating & Sanding Machine.
- Sanding Machine with Cross Belt for UV/Lacquer.

Our Clients:

We have a diversified client base & enjoy strong patronage of 500+ national & international clients including leading Plywood, MDF, Laminate and other wood-based product manufacturers, research organizations and government agencies. Apart from pan-India presence our machines are being increasingly exported to Nepal and preparing for other neighboring countries.
We look forward to receiving your esteemed order and forging a strong relationship with you. Please feel free to contact us for more information

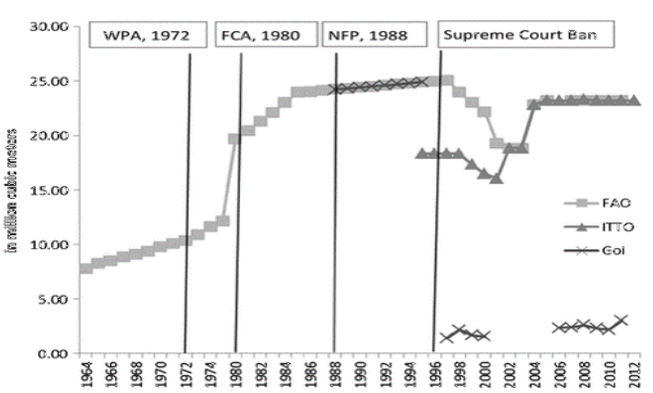
Chapter 5
Trees Outside Forests (TOFS) as Wood Based Industries' Timber Resource

Until the 20th century, forest policies across the globe focused primarily on effective forest utilization for timber production. Subsequent loss of forest land prompted many countries to review and amend such policies, in an attempt to incorporate the principles of conservation and sustainable forest management. One of the countries to implement such changes was India, which introduced new policies, acts and programmes to regulate forest conversion and degradation, beginning in the 1980s. These policies, acts, and programmes included the Wildlife Protection Act Forest Conservation Act (FCA) of 1980, the National Forest Policy (NFP) of 1988 and the Hon. Supreme Court Order of 1996. All of these regulations affected the timber supply from government forest areas, and created a huge gap in timber supply and demand (Fig. 1 & Table 1); industrial roundwood production declined from 24.4 million m^3 in 1990 to 1.5 million m^3 in 2000. Currently, this deficit is met through imports and trees outside forests (TOFs).

Globally, TOFs are defined as trees standing on land not designated as forest or other wooded land, covering an area of less than 0.5 ha, and found in agricultural lands, agroforestry systems, home gardens, orchards, urban-scapes – including along roads – and scattered in the landscape. In India, TOFs are defined as trees growing outside government 'recorded forest areas' (RFAs) (FSI, 2013), which include trees growing on community land, roadsides, farms, private land, and revenue land. However, the assessment and reporting of TOFs in India is done under two outputs, namely, 'tree cover' and 'growing stock' by the Forest Survey of India (FSI), and has been referenced in the biennial State of Forest Report (SFR) since 2001 through two specific assessments (TOFs rural inventory and TOFs urban inventory). India is the only country in the world that conducts a nationwide assessment of TOFs in rural areas. The term 'tree cover', as reported by the government, is defined as patches of TOFs in areas covering between 0.1 and 1 ha. Patches of TOFs that

are more than 1 ha are included in the assessment and reporting of 'forest cover', and therefore there is no exclusive and exact assessment for TOFs in India.

Timber production from government forest areas is abysmally low (3.35% of total demand) compared to potential timber production from TOFs, which fulfil 45% of the total timber demand in India. This implies that TOFs have immense potential in meeting the growing timber demand; however, they have not been fully utilized due to discrepancies in state level TOFs' policies (Ghosh and Sinha 2016).



Industrial round wood production in India
Source: INDIASTAT (2015), ITTO (2015) and FAO (2016).
Notes:
WPA 1972: Governs the constitution of protected areas where human occupation or resource exploitation is limited.
FCA 1980: Regulates the diversion of forest land for non-forest purposes.
NFP 1988: Ensures environmental stability and maintenance of ecological balance.
Hon. Supreme Court Ban 1996: Ban on green felling in RFAs without an approved working plan.
©. f.Ghosh and Sinha 2016)

Demand of wood by different industries in India (in Million m^3)

Industry	1998*	1999*	2000*	2005*	2010*	2015**	2020**
Paper & Paper Boards	4.5	4.5	4.5	9.0	15.4	26.2	35.8
Construction	13.6	14.6	15.9	19.4	22.1	26.3	28.5
Packaging	4.4	4.5	4.6	5.5	6.4	7.6	9.0
Furniture	2.3	2.4	2.5	3.4	4.6	5.9	7.5
Agricultural Implements	2.0	2.1	2.1	2.3	2.5	2.5	2.5
Plywood	10.1	10.5	11.0	14.0	18.0	22.9	29.2
Others	15.1	16.0	17.1	20.3	25.9	31.4	40.2
Total	**52.0**	**54.6**	**57.7**	**73.9**	**94.9**	**122.8**	**152.7**

*(Source: Ghosh and Sinha 2016. *Actual demand; **Projected demand)*

As is evident from Fig., Ghosh and Sinha (2016) observed in their review on the impact of forest policies on timber production in India, the data on timber production in India is reported to be not consistent; the data from FAO, ITTO and GoI differs from each other depending on the year. In India, there is no centralized data pool that maintains timber production records. Apart from the data on forest cover that is assessed by the FSI, the data for production and consumption of timber is not up-to-date. The inconsistency in data collection and reporting necessitates urgent intervention from the state and central governments, directing the concerned agencies/departments to collate such information at the state and national levels. This will help in guiding and formulating new policies/ mechanisms for overcoming the gap in supply and demand of timber in India. The FAO and the ITTO are primarily dependent on their corresponding country for data; however, India has been consistently lacking in the provision of reliable data. As a result, data on timber production from the FAO and the ITTO is mostly based on estimates made from assumed consumption patterns, and therefore this could include timber production from all sources, including TOFs. This also indicates that the government should attempt to record data on timber production from TOFs, so that comparisons with other sources can be made, and their related discrepancies can be addressed. Such observed inconsistencies and discrepancies in government records concerning timber production limit the scope of establishing the causality between policy and timber production. It is therefore suggested that there is a need for the effective monitoring of the implementation of any policies and/or acts through verifiable records.

The decline in timber production from government forests has been attributed to the growing emphasis on forest conservation (ICFRE, 2010) through policies, acts and regulations; however, this can be ascertained only when there is a robust record keeping of timber production from all sources within the country. The conversion of more and more forest land to protected areas for conservation could be corroborating evidence for the decline in timber production, as timber extraction is completely banned in the protected areas. Moreover, the Hon Supreme Court Order of 1996 paved the path to sustainable timber production through approved working plans, was not actively taken up by the states for timber logging. Further, the complete ban in the north-eastern states of India, initially a hub of timber and plywood, led to the cessation of all its forest activities, resulting in a gap in timber supply. Even today, these states have a low number of approved working plans; India has reported to be only 535 valid working plans out of 781 territorial divisions (ICFRE, 2011).Without an approved working plan, tree felling from any forest divisions is not permissible.

Trees outside forests (TOFs) became more important after the Hon. Supreme Court Order (1996) took effect, which regulated logging in government forests, and resulted in a sharp decline of timber production and a simultaneous increase in imports. India has the potential to increase production from farm forestry, private plantations and community forestry through private–public partnerships, in order to meet domestic timber demand. This is evident from the fact that wood-based paper mills, one of the fastest growing sectors in terms of demand, get 80% of their wood from agro farm forestry sources. Furthermore, the Indian paper

industry has planted and funded for about 0.7 million ha plantations on farmlands over the past two decades, which produce about 40 million tonnes of wood (Kulkarni, 2013). The potential to enhance timber production through TOFs is also recognised by the GoI, the National Forest Commission Reports, National Working Plan Codes by the Ministry of Environment, Forests, and Climate Change (MoEF&CC), the National Agroforestry Policy, etc. and emphasizes the need to simplify regulations related to the felling and transit of tree species. The FSI also reports on timber production from RFAs and potential timber production from TOFs. Since estimating actual timber production from TOFs is difficult due to different sets of felling and transit rules in different states and poor record keeping, the FSI uses an alternative approach to estimate the potential timber production from TOFs. Under this approach, species of TOFs are classified into two groups (timber and non-timber) for each state. The timber species are further reclassified into three groups based on their rotation period: short, medium and long.

Extent of TOF is estimated as the sum of extent of 'forest cover' outside the recorded forest areas (RFAs) and 'tree cover'. 'Forest cover' includes all areas outside the recorded forest areas, which are more than 1 ha in extent with a tree canopy density of 10% and more irrespective of the land use and legal status. Forest Cover outside the recorded forest area (RFA) is derived using boundaries of RFAs. 'Tree cover' is defined as all tree patches of size less than 1 ha occurring outside the RFAs. TOF refers to all trees growing outside RFA irrespective of patch size which could also be larger than 1 ha. Extent of TOF is estimated as the sum of extent of forest cover outside the RFAs and tree cover.

The total extent of TOF at the country level is 8.9 % of the total geographical area of the country. The Union Territory of Lakshadweep is having maximum extent of TOF (91.3 %). Among the States, Kerala (37.2 %) and Goa (36.1 %) have maximum TOF area, as percentage to their geographical area. In absolute terms Maharashtra (26.9%) has the maximum area under TOF, followed by Odisha (23.5%) and Karnataka (22.4%), Madhya Pradesh (21.1%), Jammu & Kashmir plus Ladakh (19.3%). The split up details of tree cover, forest cover outside the RFA, and the extent of ToFs for the various states and Union Territories, and the growing stock are given by FSI (2020) and the summary for the country as on 2019 is as shown below:

TGA (Km^2)	Tree cover (Km^2) (A)	Forest cover outside RFA (Km^2) (B)	Extent of TOF (Km^2) (A+B)	% of Geographical Area	Growing Stock (GS) of ToF (Million m^3)	GS/ha. in ToF Extent (Million m^3)	Potential Annual Yield (Million m^3/Yr.)	Total Carbon Stock in Forest cover outside RFA (Million Tonnes) (A)	Carbon Stock in Tree cover (Million Tonnes) (B)	Total Carbon Stock in ToF (Million Tonnes) (A+B)
3287469	95027	198813	293840	8.9	1642.3	55.9	85.2	1595.7	936.1	2531.8

The average growing stock per hectare of TOF extent for the country has been estimated 55.9 m^3. It is observed that Bihar is having the highest growing stock in TOF extent per hectare (89.1 m^3 /ha), followed by Telengana (85.9 m^3/ha) and Arunachal Pradesh (85.2 m^3 /ha). The top states in growing stock of ToF are; Maharashtra (177.1 million m^3), Jammu & Kashmir plus Ladakh (125.1 million m^3), Madhya Pradesh (106.4 million m^3), Karnataka (103.0 million m^3), and Chhattisgarh (99.9 million m^3). Maharashtra is having the highest potential yield of timber (10.6 m m^3/yr) in India followed by UP (7.5 m m^3/yr) and Karnataka (6.3 m m^3/yr). Odisha is having the highest carbon stock (151.5 million tonnes) in forests outside RFA, whereas, the same in tree cover is highest in the State of Maharashtra (106.0 million tonnes). The total carbon stock in ToFs is reported to be around 2532 million tonnes (FSI 2020); thus ToFs is having a dominant role in contributing the country's total carbon stock. The species-wise distribution of ToFs in the rural and urban areas is as given below:

Sl.No.	Species	Rural Area (Million m^3) % contribution Occurrence %	Estimated Volume	Urban Area (Million m^3) % contribution Occurrence %	Estimated Volume %
1	*Mangifera indica*	9.5	12.7	7.6	11.4
2	*Azadirachta indica*	8.1	8.1	6.4	8.9
3	*Acacia arabica*	4.0	3.4	--	--
4	*Acacia catechu*	--	--	8.3	--
5	*Acacia auriculiformis*	--	--	1.1	--
6	*Cocos nucifera*	3.4	3.2	17.2	14.0
7	*Butea monosperma*	3.3	2.9	--	--
8	*Tectona grandis*	3.0	2.0	3.1	2.5
9	*Zizyphus mauritiana*	2.7	1.4	--	--
10	*Eucalyptus species*	2.5	1.6	1.6	1.9
11	*Areca catechu*	2.4	--	8.3	--
12	*Hevea brasiliensis*	1.9	--	3.2	1.2
13	*Prosopis juliflora*	1.9	--	1.3	--
14	*Prosopis cineraria*	1.5	1.5	--	--
15	*Borassus flabelliformis*	1.8	3.9	1.0	1.6
16	*Grewia oppositifolia*	1.7	--	--	--
17	*Populus species*	1.5	--	--	--
18	*Leucaena leucocephala*	1.3	--	1.5	--
19	*Madhuca latifolia*	1.3	5.2	--	--
20	*Dalbergia sissoo*	1.3	1.6	--	1.3
21	*Terminalia tomentosa*	1.2	1.0	--	--
22	*Terminalia arjuna*	--	1.2		--
23	*Pinus excelsa*	1.2	--	--	--
24	*Pinus wallichiana*	--	2.8		--
25	*Artocarpus heterophyllus*	--	--	3.2	3.1
26	*Psidium guyava*	--	--	1.9	--
27	*Moringa spp.*	--	--	1.5	1.1
28	*Melia azdirachta*	--	--	1.2	--
29	*Swietenia mahagoni*	--	--	1.1	--
30	*Syzygium cumini*	--	1.5	1.1	1.6
31	*Anacardium occidentale*	--	--	1.1	--
32	*Morinda oleifera*	--	--	1.1	--
33	*Pongamia pinnata*	--	--	1.1	--
34	*Shorea robusta*	--	1.4	--	--
35	*Tamarindus indica*	--	2.6	--	2.1
36	*Ficus religiosa*	--	2.2	--	6.2
37	*Ficus bengalensis*	--	1.7	--	3.0
38	*Ficus racemosa*	--	--	--	1.0
39	*Ficus virene*	--	--	--	0.9
40	*Tecoma stans*	--	--	--	2.2
41	*Samanea saman*	--	--	--	1.7
42	*Bombax ceiba*	--	--	--	1.1
43	*Delonix regia*	--	--	--	1.0

(--No data available; Source: FSI 2020

The list of dominant ToF species recorded by the FSI (2020) in the rural and urban areas of India along with their quantitative data is given in the above Table. In the rural areas, mango tree (*Mangifera indica*) is the highest in number (9.5%) and volume contribution (12.7%) followed by neem (*Azadiracta indica*) (8.1% for both number and volume contribution respectively). Among, urban tree species, the number of Cocos nucifera (Coconut) (17.2 %) is maximum, followed by *Areca catechu* (arecanut palm) of count (8.3%). On the other hand, Cocos nucifera (Coconut) is having maximum volume contribution (13.9%), followed by *Mangifera indica* (11.4%) in the urban areas. Dominance of coconut trees is recorded in the coastal areas; whereas may be due to mango being a dominant tropical fruit with very high commercial value; is found as predominant in southern part of India.

The potential timber production from TOFs is much higher than that from government reported forest areas (RFAs). Trees outside forests (TOFs) contribute one-fourth of the total growing stock of the country, and have become a major source of timber in India. The higher growing stock per ha of TOFs in a few states indicates good management practices on the part of the states (Gujarat, Madhya Pradesh and Rajasthan), in the form of enabling policies for growing trees for commercial benefits to the growers.

Even though potential timber production from TOFs is significantly higher as compared to RFAs at the national level, there is significant variation among states in terms of timber production from TOFs. This is due to a difference in policies related to the harvest and transit of TOFs species. As a result, even though the states of Punjab and Haryana have a lower growing stock of TOFs, they have a greater potential for timber production from said TOFs as compared to states such as Odisha, West Bengal, Jammu and Kashmir and Arunachal Pradesh in spite of their higher growing stock of TOFs, due to simplified rules for the harvesting and transit of farm-grown species, as well as market forces (Ghosh and Sinha 2016). This implies that there is the potential to increase timber production from TOFs through a uniform national level policy.

The extent of TOF in the country has been presented for the first time in the ISFR- 2019 (FSI 2020). The extent of TOF in the country has been assessed 29.38 m ha which is 8.94% of the total geographical area of the country. *Mangifera indica, Azadirachta indica, Acacia Arabica* and *Cocos nucifera* are the major species found in TOF in rural areas which are contributing most to the total growing stock, whereas, *Cocos nucifera, Areca catechu, Mangifera indica* and *Azadirachta indica* are the major TOF species in the urban areas of the country. The scattered and block plantations contribute more than 90% of the TOF volume of the entire country.

Conclusion

With the change in the National Forest Policy, from production forestry to conservation forestry since 1980s and consequent to the Hon. Supreme Court Order of 1996 took effect to regulate logging in government forests,ToFs provides the major supply share to the industrial round wood. The data on timber production in India is reported to be not consistent; the data from FAO, ITTO and GoI differs from each other depending on the year. In India, there is no centralized data pool that maintains timber production records. Apart from the data on forest cover that is assessed by the FSI, the data for production and consumption of timber is not up-to-date. The inconsistency in data collection and reporting necessitates urgent intervention from the state and central governments, directing the concerned agencies/departments to collate such information at the state and national levels. This will help in guiding and formulating new policies/mechanisms for overcoming the gap in supply and demand of timber in India. The FAO and the ITTO are primarily dependent on their corresponding country for data; however, India has been consistently lacking in the provision of reliable data. As a result, data on timber production from the FAO and the ITTO is mostly based on estimates made from assumed consumption patterns, and therefore this could include timber production from all sources, including TOFs. This also indicates that the government should attempt to record data on timber production from TOFs, so that comparisons with other sources can be made, and their related discrepancies can be addressed. Such observed inconsistencies and discrepancies in government records concerning timber production limit the scope of establishing the causality between policy and timber production. It is therefore suggested that there is a need for the effective monitoring of the implementation of any policies and/or acts through verifiable records.

The need to simplify regulations related to the felling and transit of tree species is found to be the most essential step to promote growing trees under ToF activities. Enabling policies for growing trees for commercial benefits to the growers to facilitate ToFs activities is reported to be varying between states within the country.

The 2019 status of the extent of TOF in the country in has been assessed by FSI as 29.38 m ha which is 8.94% of the total geographical area of the country; the average growing stock per hectare of TOF extent for the country has been estimated 55.9 m3. The total carbon stock in ToFs is reported to be around 2532 million tonnes; having a

dominant role in contributing the country's total carbon stock. The potential timber production from TOFs is much higher than that from government reported forest areas (RFAs). Trees outside forests (TOFs) contribute one-fourth of the total growing stock of the country, and have become a major source of timber in India. There is the potential to increase timber production from TOFs through a uniform national level policy.The policies related to TOFs, which include farm forestry, private plantations and social forestry, needs to be revised with the aim to bridge the gap in supply and demand of timber. A synchronized nationwide policy or guideline could be developed, seeking insights from the leading states in TOFs (Haryana, Punjab, Andhra Pradesh, Uttar Pradesh) for market and industrial linkages. In the recent National Working Plan Code (2014), the MoEF & CC, GoI also has stressed the need for off-forest tree management. Further, there is a lack of reliability and consistency in some of the available data and information dealing with the growing stock, consumption and production of timber, which constrains the forecast of supply and demand projections. Strengthening and building capacities of the organizations and officials related to the monitoring and evaluation of forests and TOFs with respect to productivity is another key concern that the government needs to address.

Occupying nearly 9% of the geographical area of the country, TOF are significant natural, renewable resource which make vital contribution to the agro-ecology, socio-economy of the rural areas, environmental amelioration in the urban areas and feed wood based industries with the raw material and thus generate significant employment. TOF form a nearly 38% of the carbon sink in forest & tree cover of the country. TOF offers the path for achieving the national policy goal of 33% of forest & tree cover in the country. Through expansion of TOF, particularly in agro-forestry and on culturable waste lands, India can substantially increase its carbon sink to achieve its international commitments of NDCs (Nationally Determined Contributions) and LDN (Land Degradation Neutrality) by 2030 (FSI 2020).

TOF play a significant role in the socio-economic lives of people both in rural and urban areas of the country by enriching the people and society at large economically as well as ecologically. The management of TOF assumes high significance in the country for realising much higher potential which it offers in generating wood based economy and ecosystem services including carbon sequestration. TOF also act as an important source for timber and fuel wood to meet the demands of fast growing population of the country. There is a need to put focus on increasing the growing stock per hectare or yield of TOF by better management and planning. There is also a need for a separate policy on TOF to ensure its expansion and sustainable management for multiple ecological benefits, timber production, carbon sequestration and for obviating pressure from the natural forests.

Chapter 6
Regulated Timber: Forest and Timber Certification - Indian Scenario

The Sustainable Development Goals (SDGs) of the UN call for action by all countries to promote prosperity while protecting the planet. They recognize that ending poverty must go hand-in-hand with the strategies that build economic growth and address a range of social needs while tackling climate change and environmental protection.

Forest Certification: *"A voluntary process whereby an independent third party ("certifier") assesses **quality of forest management** and production against a set of requirements ("standards") predetermined by a public or private certification organization". **(FAO)***

Forests play a critical role in amelioration of the global environment, alleviating effects of climate change and natural disasters, are an integral part of water and carbon cycles, conserve biodiversity, provide food, medicine, wood and renewable raw materials for our diverse requirements. India is blessed with rich and varied wealth of forests and wildlife, which are being managed on scientific lines for the last more than 150 years. India ranks 10th in terms of forest area in the world as per Global Forest Resource Assessment (GFRA) 2020, accounting for 2% of total forest cover of the world. India has 16 major forest types and is one of the 17 mega-diverse countries with four global biodiversity hotspots. As per India State of Forest Report, 2019, the total forest cover of the country is 71.22 m. ha. (21.67% of the geographical area). The total forest and tree cover constitute 80.72 m. ha. (24.56% of the geographical area) which includes 2.89% (of the geographical area) as Trees outside Forests (ToF). Carbon stock in India's forests is 7124 million tonnes. The Protected Area Network includes 103 National Parks, 544 Wildlife Sanctuaries, 76 Conservation Reserves and 46 Community Reserves. There are around 1, 73,000 villages located in and around forests with an estimated dependent population of around 275 million.

The 1992 United Nations Conference on Environment and Development (UNCED), over 120 countries agreed, in the Forest Principles (which applies to all types of forests), that forest resources and forest lands should be maintained to meet the social, economic, ecological, cultural and spiritual needs of present and future generations and emphasized the need for sustainable management guidelines, criteria and indicators for the maintenance operations of the temperate, boreal and tropical forests alike.

Certification is an emerging global movement that supports sustainable development, economic growth, trade, livelihoods, value chains, consumer protection, while enhancing competitiveness, fostering technological development and fully meeting the requirements of health, safety, and environmental conservation.

Forest Certification is a tool, which is used to assess the quality and contemporariness of the management practices against the predefined norms of a Standard. Contemporariness is to be understood in terms of the environmental and social concerns of the governments, communities and consumers within and outside the country. Management practices across the sectors today, and increasingly in future, will be tested on the anvil of these common concerns, and also of course on the paradigm of economic sustainability. Forest Certification, as an instrument which is applied using a Standard to take care of the environmental, economic and social concerns of important stakeholders. A good Standard is the one, which is country specific, here

suited to India's forestry and management practices, but at the same time is internationally recognised. Certification is designed to allow participants to measure their forest management practices against standards and to demonstrate compliance with those standards. Certification of forest management covers forest inventory, management planning, silviculture, harvesting, road construction and other related activities, as well as the environmental, economic and social impacts of forest activities. Certification of forest management thus takes place in the country of origin.

In India, we need certification standards that promote sustainable management of forests as well as trees grown on non-forest lands, called trees outside forests (ToF). It must be mentioned that a forest or a plantation or a forest product that has undergone the process of certification commands a premium, i.e., brings in additional economic returns compared to a non-certified entity or product. Forest Certification is thus, the process whereby an independent third-party (called a Certifier or Certification Body) assesses the quality of forest management in relation to a set of pre-determined requirements, the Standard.

Timber Certification is a process which results in a written statement (a certificate) attesting to the origin of wood raw material and its status and/or qualifications, often following validation by an independent third party. Certification is designed to allow participants to measure their forest management practices against standards and to demonstrate compliance with those standards. Timber certification may also be used to validate any type of environmental claim made by a producer, or to provide objectively stated facts about the timber products and their forest of origin that are not normally disclosed by the producer or manufacturer. Timber certification typically includes two main components: certification of sustainability of forest management; and product certification. In product certification, round-wood and processed timber products are traced through the successive phases of the supply chain. Certification of forest management thus takes place in the country of origin; product certification covers the supply chain of domestic and export markets.

Thus, the objective of certification is to link the consumer who wishes to favour environmentally and/ or socially responsible products with the producers of these products and the raw materials from which they are made. This involves several assumptions, including:

- Consumer purchasing patterns can be influenced by differentiating similar products according to environmental and/or social attributes.
- Producer behaviour can be influenced by market signals based on environmental and/or social concerns.
- The premium generated through differentiation will provide sufficient economic incentive for producers to adopt improved management practices.
- Efficiency and competitiveness will increase by internalizing environmental and social concerns.

Certification schemes fall under one of two basic conceptual frameworks: an evaluation of a product or a practice against particular specifications; and the evaluation of the potential of a management system to produce a desired outcome. Management practices assumed to ensure sustainability are the evaluation's focus. The systems approach, on the other hand, is based on evaluation of "ability to manage in an environmentally sound and sustainable manner". Here the evaluation focuses on the operation's management structure and general condition of the forest resource. This approach is typified by efforts that are linked to the International Organization for Standardization (ISO) and its 14000 series standards relating to environmental management tools and systems to measure a company's practices.

In either case, a credible certification programme must evaluate the integrity of the producer's claim and the authenticity of product origin, and must be seen to be objective and impartial. Assessing integrity involves an evaluation of management practices judged against recognized standards, generally at the management unit level. Assessing the authenticity of the product's origin involves the identification and monitoring of its chain of custody, including log transport and processing, shipping, secondary manufacturing and, finally, retail distribution.

Chain of Custody (CoC) Certification provides independently verified assurance that certified wood contained in a product originates from sustainably managed forests. It traces the path of products from forests to markets through processing units and supply chain and ensures through tracing and labelling system that certified material is kept separate and is not mixed with uncertified material throughout the chain. The entire flow of wood material from forest to consumers must be monitored and documented to demonstrate its origin. It helps to minimize the risk of forest products/timber from illegal harvesting and sourcing and enables companies to demonstrate alignment with regulatory requirements (e.g., the European Union Timber Regulation - EUTR).

Potential costs and benefits of certification

The theoretical costs of certification can be divided into two general categories:

- The incremental cost of improving forest management over current practices at the management unit level to meet certification standards; and
- The cost of the certification itself, including an assessment or audit of management practice and the cost of identifying and monitoring the chain of custody.

The possible incremental costs of compliance at the management unit level are lower yields, higher opportunity costs and a different distribution of costs and benefits over time. Lower yields may be necessary to match harvest levels to the rate of annual growth, and to reduce the damage to residual timber and non-timber goods and services. Reduced timber output can be partially compensated by lower operating costs and increased recovery as a result of better planning, maintenance of a long-term supply base resulting from reduced impacts, and better protection of the increasingly economically valuable non-timber products and services.

The costs of reduced-impact logging (RIL)/ harvesting techniques suggest that better planning may reduce rather than increase operating costs. However, the income foregone with reduced yields can be a significant constraint. The costs of certification assessments have been estimated at between US $ 0.3 -1.0 per hectare per year in tropical countries using local specialists. The costs of identifying and tracing the chain of custody have been estimated to be up to 1 % of the border prices.

The potential benefits of certification can be divided into market benefits and nonmarket benefits. Market benefits of certification may include market share, a "green" price premium and the stabilization of forest economies associated with increased security of a supply base. The non-market benefits produced by forests, such as regulation of climate, genetic balance, soil, water and landscape values, are well documented (although poorly quantified) in the literature. The question is whether certification will, in fact, be an effective tool to improve forest management practices and, thereby, also these nonmarket benefits. A major difficulty is that the costs of conserving such non-market goods and services are difficult to quantify in monetary terms and usually fall on the forest owner or manager, while the benefits largely accrue to society at large.

Globally the two most well-known forest certification systems are the **PEFC (Programme for the Endorsement of Forest Certification)** and FSC (Forest Stewardship Council), both committed to the cause of Sustainable Forest Management (SFM). Together, PEFC and FSC have certified around 525 million hectares of forests across the world.

Major Certification Agencies

The **'Programme for the Endorsement of Forest Certification' (PEFC),** established in 1999, is an international non-profit, non-governmental organisation promoting SFM through third-party certification. It is an umbrella organization that works by endorsing nationally developed forest certification schemes, following the PEFC Benchmark Standards, under a mutual recognition system. PEFC is now a leading global alliance of 53 national members, with 46 endorsed national forest certification systems, accounting for around 325 million hectares of certified forests. The recently developed Indian Forest Certification Scheme has been endorsed by the PEFC.

PEFC Endorsement and Mutual Recognition helps national certification systems to gain international

recognition for the national forest management standard and sustainable management practices in that country's forests and provide the certified entities with market access through PEFC. The prime objective of PEFC Endorsement is to determine whether a national forest certification system meets PEFC Sustainability Benchmarks and conformance to PEFC requirements. PEFC Certification has mainly two kinds of certification programme; Forest Management (FM)Certification, and Chain of Custody (COC) Certification.

Forest Stewardship Council (FSC) is another international non-profit, multi-stakeholder organization established in 1993 to promote responsible management of the world's forests. It is an example of a market-based certification program used as a transnational environmental policy. FSC's mission is to "promote environmentally appropriate, socially beneficial and economically viable management of the world's forests", with the five goals of-

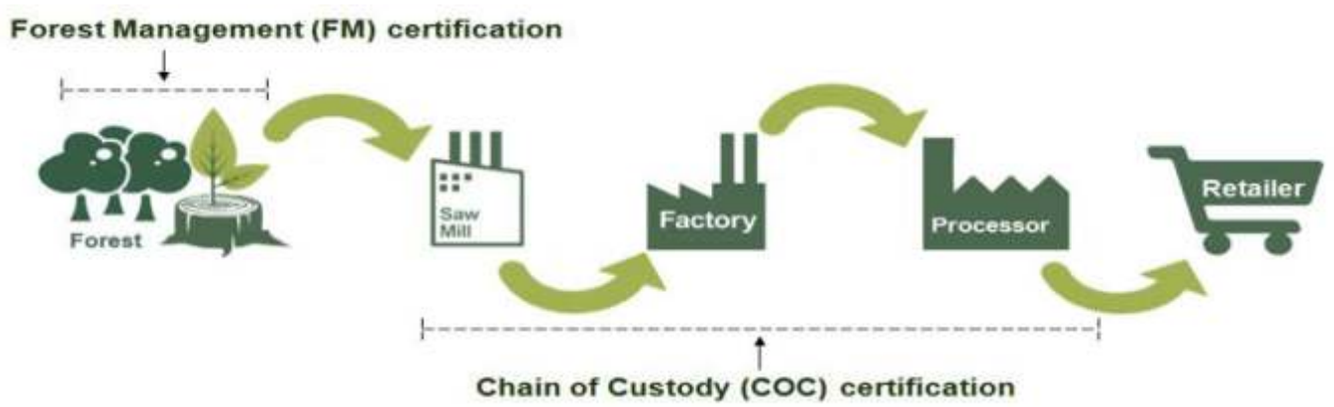
- Advancing globally responsible forest management
- Ensure equitable access to the benefits of FSC systems
- Ensure integrity, credibility and transparency of the FSC system
- Create business value for products from FSC certified forests
- Strengthen the global network to deliver the goals.

-which are supposedly promoted by activities which are managed and developed through the six program areas of Forests, Chain of Custody (CoC), Social Policy, Monitoring and Evaluation, Quality Assurance, and Ecosystem Services. Forests managed to its standards offer benefits to both local and wider communities and these are said to include cleaner air and water, and a contribution to mitigating the effects of climate change.

Directly or indirectly, FSC addresses issues such as illegal logging, deforestation and global warming and reports indicate positive effects on economic development, environmental conservation, poverty alleviation and social and political empowerment. Using the FSC logo supposedly signifies that the product comes from responsible sources—environmentally appropriate, socially beneficial and economically viable. The FSC label is used on a wide range of timber and non-timber products, from paper and furniture to medicine and jewellery, and aims to give consumers the option of supporting responsible forestry.

Emergence of the Indian Scheme of Forest Certification

Till recently, there had been no Indian scheme of Forest Management Certification. Our country has multiple forests types and a diversity of scientific and traditional forest management practices. A country specific certification system ensures required flexibility and adaptability in addressing sustainable management needs of such a diverse forests.



'Network for Certification and Conservation of Forests' (NCCF), a non-profit organisation of India came into existence as a Society in 2015, is actively engaged in diverse conservation activities including, development of globally benchmarked and India specific sustainability certification standards for various constituents of our natural resource base, viz., Forest Management (FM), Trees outside Forests (ToF), Non-Wood Forest Produce (NWFP), Protected Areas and Wetlands (PAW), Quality Planting Material (QPM), Ecotourism and Biomass & Biofuels, etc. They took up the work of developing the country specific and globally aligned certification standard for India through a multi-stakeholder group after following the UN norms of standard setting process. NCCF Forest Management Certification Standard is fully in conformity with the objectives of National Forest policy, National Working Plan Code 2014 of the Ministry of Environment and Forests, Bhopal India Process of the IIFM and international best practices in certification, duly reflected in its Themes, Principles, Criteria and Indicators, making it easier to implement and comply with, as per the international norms of certification. NCCF has been successful in obtaining the endorsement of its forest certification scheme from the 'Programme for the Endorsement of Forest Certification' (PEFC), the Geneva based leading International Forest Certification Organization. India now holds a globally recognised certification scheme by the NCCF specifically developed for the Indian forests, as on 27th February 2019. This scheme will allow the forest managers in various states of India to further strengthen their Working Plan based management practices as per the global standards and multilateral requirements.

Realising the importance of Forest certification, buying products made from certified wood only was called for promoting sustainable forest management, under the 'Green Good Deeds Movement' by the Government of India (GoI).

NCCF-SFM Certification Standard was developed through a multi-stakeholder Standard Development Group, represented by distinguished forestry professionals, representatives from government, central ministries, institutions, Quality Council of India, State Forest Departments, Forest Corporations, global conservation organisations such as IUCN and WWF, industry bodies like the CII, Indian Papers Manufacturers Association, ITC Ltd., certification bodies and many more. The SFM certification scheme involves the international best practices in forestry, the key elements of existing models in India such as the Bhopal India Process of the IIFM, the National Working Plan Code 2014 and provisions of the National Forest Policy.

NCCF-FM standard incorporates all internationally benchmarked sustainable management principles, criteria and indicators including the components of National Working Plan Code 2014. Thus, if a forest division is certified as per NCCF-FM standard, it improves its management and gives an independent, third party assurance that management systems are environmentally appropriate, socially beneficial and economically viable. It also ensures that related forest products will have a credible and internationally recognized label, to help access the global markets as well as gain preference from environmentally conscious consumers.

Forest-based industries in India, particularly those for paper, boards, plywood, medium density fibre board, furniture and handicrafts etc, have been pushing for forest certification to enhance their market accessibility to western markets including European Union and USA. The new scheme will address the need of augmenting the Indian forest management regimes and enhancing biodiversity conservation through the lens of forest certification and third party audit, monitoring and evaluation, with an endeavour to make the Indian wood and forest fibre-based industry competent globally by meeting their needs of certified products.

Post launch of the SFM certification standard, NCCF has been organising state level sensitisation workshops in collaboration with State Forest Departments and encouraging them to take up forest certification of few divisions on pilot basis. NCCF is also offering technical assistance in this regard. Till date workshops have been organised in 6 states of India viz., Assam, Sikkim, Karnataka, Madhya Pradesh, Punjab and Chhattisgarh; with many other planned in near future. Further, it is becoming an imperative for Indian forestry sector to tune itself to the growing sustainable forestry industry. It is also worth noting that recently notified Compensatory Afforestation Fund Rules 2018 permit utilisation of

the CAMPA funds for forest certification, development of certification standards and third-party monitoring.

Arrangements for conducting Certification Audit

Certification audit is conducted by independent third party, i.e., Conformity Assessment Body commonly referred to as Certification Bodies (CBs). The audit includes activities that cover document review, procedures, SOPs, meeting with top management, compliance with legal regulations, field inspections etc. following standard operating procedures.

NCCF has entered into a Memorandum of Understanding (MoU) with the National Board for Accreditation of Certification Bodies (NABCB), a constituent Board of the Quality Council of India (QCI) and a member of International Accreditation Forum (IAF), for accreditation of the CBs to conduct certification audit, thus facilitating international equivalence to India's certifications. Many CBs will now be available to conduct the certification of a large number of government forests and private plantations including farmers' trees. PEFC endorsed NCCF certification will be available to our industry at affordable cost, and will improve competitiveness of Indian industry and also promote wood-based exports such as furniture, handicrafts, pulp and paper, and packaging material, etc.

Certification: Current Status

A wide range of actions are currently under way concerning the certification of forest products. Certification schemes are being developed or studied at the international, regional and national levels and exist in both developed and developing countries. However, only a small number of schemes are operational at present and the volume of timber covered by them is minor. These include the Forest Conservation Program of Scientific Certification Systems and the Smart Wood Certification Program of Rainforest Alliance in the United States, and the Responsible Forestry Programme of the Soil Association and SGS Silviconsult Ltd. in the United Kingdom. Evaluating the sustainability of forest management practices is a key element in the process.

In many European countries there is an on-going process to develop national-level criteria for sustainable forestry within the so-called Helsinki Process. The work has been expanded to boreal and temperate forests outside Europe under the so called Montreal Process. The International Tropical Timber Organization (ITTO) has developed guidelines, criteria and indicators of sustainable forest management for tropical countries which are being further elaborated in some producing member countries. These international and national criteria and indicators are not being developed specifically for certification purposes but they can serve as a useful framework in this regard. It is noteworthy that the various processes are not necessarily developing criteria and indicators at the same level; some are working at the national or regional level, while others are concentrating on the management unit level.

Sustainable Forest Management (SFM) has been recognized as an integral part of sustainable development in Agenda 21 agreed at the UN Earth Summit in Rio (1992). SFM contributes towards all the three pillars of sustainability, viz., environmentally sound, economically viable and socio-culturally desirable. In Indian context, it is of critical importance due to the high dependence of people living in and around forests. Criteria and Indicators (C&I) have been accepted as the robust approach for assessment of forests for its progress towards sustainability over a period. The Bhopal-India Process (1999) was one of the nine global initiatives on Criteria and Indicators approach for developing Sustainable Forest Management and India developed its National set of 8 Criteria and 37 Indicators for the Sustainable Management of its Natural Forests. These processes have great influence on later development of the Forest Certification criteria and indicators.

In Brazil, however, certification criteria for plantation forests have been defined within the national Cerflor Certification system which is being launched under the leadership of the Brazilian Silvicultural Society (SBS). In Sweden, national-level criteria were recently proposed by the World Wide Fund for Nature-Sweden together with the Swedish Association of Nature Conservation (SNF). As far as the development of national systems is concerned,

Indonesia is probably one of the most advanced countries. A decision has been taken to establish a national timber eco-labelling institute and substantial work has been carried out to develop the criteria for assessment and tracking procedures. In the United Kingdom, the Woodmark system has recently been introduced by the private sector; however, this is more a certificate of origin than a certificate of the state of forest management. Such schemes have also been discussed in other countries (e.g., Switzerland).

In Canada, an industry-supported team involving the provincial governments is moving strongly on developing a certification system, intended to serve as a model on which a proposed ISO system could be built. In Germany, the main system is the private sector Initiative Tropenwald which, at present, is limited to tropical timber; in future it will be expanded to cover all timber. In the Netherlands, a process is under way to establish certification of imported timber, especially tropical timber; it will also include domestic timber in the future. In the Nordic countries, discussions are under way at various levels both within and among countries. In Norway, the private forestry sector, government and NGOs are discussing a form of certification. Sweden is developing a system which may be linked to the Forest Stewardship Council (FSC), but discussion is still on-going. The private sector in Sweden sees certification as a market tool and not a matter for Government regulation. In Switzerland, a system is being developed involving the private forestry sector, environmentalists and other interested groups. The issue is also under review by the European Union which has in the past focused mostly on support to member countries of the African Timber Organization (ATO). As for market pressures, the most visible phenomenon has been the WWF Target 1995 Group in the United Kingdom which was set up to phase out trade in 16 uncertified timber by associates of the group by 1995. This target date has proved to be impractical and now the objective has been redefined to increase the share of certified timber continuously in total purchases. There were approximately 50 associates in the WWF Target 1995 scheme in May 1995, including do-it-yourself supply stores, importers and merchants.

Among other Asian countries, Malaysian initiative MYTLAS incorporates all the relevant legislation throughout the supply chain from the forest to the export point to assure legality of timber exports. It is subjected to annual third party compliance auditing, internal control mechanisms by the implementing agencies and supported by an effective governance structure. The MYTLAS license fully meets the requirements for due diligence under the EUTR for exports of timber products to the EU. The Indonesian Initiative SVLK promotes legality of forest products through implementation of standard legality to consumers, suppliers, and producers. It demands law enforcement and good governance on forest products. It encourages private sectors (timber industries) to apply policies related with chain of custody or timber legality verification on supply of raw material.

Globally around 525 million ha (8%) forests are certified (325 million ha under PEFC and 200 million haunder FSC; 93 million ha having dual certification) and 47,810 CoC certificates have been issued. In India, so far 5, 21,510 ha of forest area is certified and aiming for raising this figure to 3 million hectares in the next three years. 670 Chain of Custody (CoC) certificates have been taken by various industries/ companies like the Pulp & Paper Industries, Wood and wood based industries (plywood, furniture, MDF, handicraft, etc.), Printings and Packaging industries, etc. The present figure of more than 400 companies possessing CoC is proposed to raise to around 600 in the coming 4 years, according to the FSC-India. Many State Forest Departments have initiated action for certification of a few forest divisions out of which the Uttar Pradesh Forest Corporation (UPFC) is in the forefront and has taken up the Forest Stewardship Council (FSC) & PEFC certification of its 13 Forest Divisions with an area of around 4 lakh hectares using NCCF Forest Management Certification Scheme and actions are pipeline for getting the FSC- Forest Management - Chain of Custody (FSC-FM-CoC) Certification of Forests under another 41 Forest Divisions of Uttar Pradesh Forest Department (UPFD), under various regions of UPFC. Tripura Forest Department has initiated the process of forest certification in West Tripura and Khowai Districts of Tripura and Karnataka Forest Department in Yellapur Division, Uttarkannada District, Karnataka, as per NCCF-Forest Management Certification Standard. Many

other states have identified the divisions for certification.

Examples of PEFC/FSC certified wood availability in India are: Among the government Organizations, Rubber wood from TFDPC LTD, Teak from MPRVVN, Bamboo from Bhamragargh Forest Division (all FSC) and Uttar Pradesh Forest Corporation - 41 Forest/Social Divisions: approximately 0.45 million ha area under PEFC; Among Private Land, Agro-Forestry crops for ITC Ltd, TN News Print, SARA in Karnataka, J&K Paper in Odisha, etc. (FSC).

The clients (State Forest Department, State Forest Department Corporation, Corporates, Companies, domestic and international Buyers etc.) have to bear the certification cost. Certification cost depends on area to be certified, type of forests, complexity of management systems etc. NCCF would be ready to help in working out cost estimation. Ministry of Environment, Forests and Climate Change (MoEF&CC) has been actively promoting certification. Forest Certification is an eligible activity for funding under the Compensatory Afforestation Fund Rules, 2018 (CAMPA). The Ministry has written to all State Forest Departments to initiate forest certification in some divisions, having reasonable economic activity, like extraction of timber, NWFP and bamboo etc. NCCF is providing professional support to the Ministry of Environment, Forests and Climate Change and State Forest Departments in taking up certification. NCCF has been actively providing professional assistance to the MoEF & CC, State Forest Departments and the stakeholders in certification matters through sensitization workshops, training programmes and advisory services.

Social Benefits of Forest Certification

I. Environmental Benefits:

Certification enables Forest Departments to manage forests while maintaining environmental safeguards including - use of permissible pesticides, safe collection and disposal of toxic wastes, controlling invasive species, minimising negative impact on soil and water resources, enhancing ecosystem services and identification and management of high conservation value forests.

ii. Economic Benefits:

Forest certification enables the forest managers and stakeholders to get premium price for their products and facilitates value addition and access to the new markets apart from brand recognition due to use of certification logo and international recognition of good management. Certification not only brings market access and financial returns but also brings benefit to the people. Certification is a way to use economic agency to reward responsible forest management.

iii. Monitoring Benefits:

Certification being Independent third-party evaluation adds value and credibility to the findings of periodic monitoring, and thus enables the forest departments to keep check on desired outcomes from their management interventions.

iv. Management Benefits:

It will bring the forest management at par with internationally benchmarked practices. Additionally, it strengthens regular capacity building of staff and workers, which catalyse efficiency in operations, emphasis on value addition, improved marketing with better markets, better product positioning and visibility.

v. Safeguards Social Attributes:

It contributes towards social and gender equity, enhancing livelihood opportunities for locals, health and safety for forest workers, respecting rights of tribal and local communities and active engagement with the stakeholders.

vi. Compliments Country's International Commitments:

Forest certification contributes to promoting SFM, REDD+, Sustainable Development Goals (SDGs), commitments under the Nationally Determined Contributions (NDCs) and in meeting the objectives of various international commitments under the UNFCCC, UNCCD and UNCBD, etc.

Forest certification acknowledges the country's dedication to responsible forest management and its efforts to maintain a sustainable supply of forest products and services from healthy, diverse, and productive ecosystems. NCCF's India specific, yet internationally benchmarked certification standard, being user friendly, will go a long way in conserving and enhancing our rich forests and biodiversity.

Trees Outside Forests (ToFs) Certification Scheme

The term ToF, refers to "all trees growing outside recorded forest areas". Forests and ToFs occupy about 24% of the geographic area of our country; majority of industrial demand of wood is met from ToF at present. ToF resources cater in a major way to meeting the requirements of wood fibre in India, especially from the pulp and paper, plywood and composite products and the handicrafts and furniture industry. However, due to the small scale and unorganized nature of the ToF practitioners, these tend to remain on the fringes of the certification universe.

Globally, the wood fibre based industries are moving towards sustainability and certification, and keeping the ToF outside the certification ambit is impacting the uptake of these resources by the industry, as well as denying them the benefits of certification. It is keeping these issues in mind that NCCF has also developed a certification scheme for Tress outside Forest (ToF), the first of its kind not only in India but anywhere in the world, that is intended to cover certification of agroforestry plantations, urban trees and forests, scattered trees in farmland and homesteads, trees along roads, canals, railway lines and in orchards and gardens, through a multi stakeholder Standard Development Group (SDG). This Standard has been developed in consultation with diverse stakeholders including the Ministry of Agriculture and Farmers Welfare. The scheme will bring much-needed recognition to the wood and timber produced by farmers on their lands, ensure better markets and price premium for their produce and augment availability of certified wood and wood based raw materials to the industries. Large scale adoption of the certification will certainly contribute to the government's resolve to double the farmers' income.

NCCF is also developing standards for non-wood forest produce, protected areas and wetlands, quality planting material, ecotourism, biomass & biofuels and land degradation neutrality along with the Carbon Registry-India (CR-I), which is an India centric carbon offset market mechanism comprising of greenhouse gas (GHG) emissions reduction and removal enhancement projects and associated methodologies. CR-I is intended to provide a platform for listing, registration and verification of projects, issuance of net emissions reduction units, trading and tracking of carbon credits and approval of new methodologies.

Illegal logging and deforestation cause severe environmental damage, including a loss of biodiversity and impacts on climate change. The livelihoods of the local communities who depend on forests, including indigenous people are affected. Legitimate operators who are trying to manage forests sustainably find it hard to compete with illegally produced timber. Where forest governance is strengthened, policies to conserve and sustainably manage forests and reduce deforestation become much more effective. Illegal logging is a global problem with significant negative economic, environmental and social impact. In economic terms illegal logging results in loss of revenues and other foregone benefits. In environmental terms illegal logging is associated with deforestation, climate change and a loss of biodiversity.

Responding to public concerns on the above issue, in 2003, the European Commission adopted a European Union (EU) Action Plan for Forest Law Enforcement Governance and Trade (FLEGT). The key regions and countries targeted, which together contain nearly 60% of the world's forest and supply a large proportion of internationally traded timber, are Central Africa, Russia, Tropical South America and Southeast Asia. Though the ultimate goal of the Action Plan is to encourage sustainable management of forests, ensuring legality of forest operations is considered a vital first step. The FLEGT Plan focuses on governance reforms and capacity building, to ensure timber exported to the EU comes only from legal sources. It includes ideas for action in areas such as public procurement and the private sector. A key element of the Action Plan is a voluntary scheme to ensure that only legally harvested timber is imported into the EU from countries agreeing to take part in this scheme. The Council adopted a Regulation in December 2005, allowing for the control of the entry of timber to the EU from countries entering into bilateral FLEGT Voluntary Partnership Agreements (VPA)with the EU. Once agreed, the VPAs will include commitments and action from both parties to halt trade in illegal timber, notably with a license scheme to verify the legality of timber. The agreements will also promote better enforcement of

forest law and promote an inclusive approach involving civil society and the private sector. Increasing number of EU Member States are adopting green public procurement policies requiring timber and timber products to be from legal and sustainable sources. Countries implementing such policies include Belgium, Denmark, France, Germany and the UK. These policies are expected to have an important influence on the EU market; in many of them FLEGT licenses will be accepted as reliable proof of legality. A number of EU private sector timber trade federations have made commitments through Codes of Conduct to eliminate illegally harvested timber from their supply chains. Examples of such Codes can be found in Finland, France, Netherlands, Spain, UK, EU, ACE, and CEPI. Several major banks have put in place policies to ensure clients are not associated with illegal logging activities (e.g., ABN-AMRO and HSBC).

Stakeholders in Europe have raised questions about the effectiveness of the FLEGT VPA approach. FLEGT VPAs focus on bilateral agreements with specific countries and coverage would therefore not be universal. In addition, efforts of countries under FLEGT VPAs could also potentially be circumvented. Producer countries which may not join the scheme could therefore provide a route through which illegally produced timber from VPA countries could enter the EU.

India is not an EU FLEGT VPA country. India does not plan to sign VPA since it has banned the export of unprocessed logs. It is however a priority country for the EU FLEGT Asia Regional Support Programme (FLEGT Asia).

The Lacey Amendment Act of 2008 is a conservation law in the United States that prohibits trade in wildlife, fish, plants and plant products such as timber and paper that have been illegally taken, possessed, transported, or sold. This landmark legislation is the world's first ban on trade in illegally sourced wood products. The Lacey Act is a fact-based statute with strict liability, which means that only actual legality counts (no third-party certification or verification schemes can be used to "prove" legality under the Act) and those violators of the law can face criminal and civil sanctions even if they did not know that they were dealing with an illegally harvested product. Penalties for violating the Lacey Act vary in severity based on the violator's level of knowledge about the product: penalties are higher for those who knew they were trading in illegally harvested materials. For those who did not know, penalties vary based on whether the individual or company in question did everything possible to determine that the product was legal. In the U.S. system, this is called "due care," and is a legal concept designed to encourage flexibility in the marketplace.

Manufacturers, Formulator of chemical substances or import them from outside the European Union have the registration obligations under the REACH regulation. REACH stands for the regulation concerning the '**R**egistration, **E**valuation, **A**uthorisation and Restriction of **C**hemicals (EC) No 1907/2006 (REACH). It came into force on 1st June 2007 and replaced a number of European directives and regulations with a single system. **REACH Certificate** of **Compliance** is a document certifying that a product is **compliant** with the EU REACH regulation (EC) No 1907/2006. It can be a testing report or statement issued by a third-party testing organization, or a self-declaration. REACH applies to all chemical substances, not only those used in chemical processes but also for end-consumer use – even if not hazardous -, for example in paints, as well as in articles such as clothes and furniture. Therefore, the regulation has a wide impact on the compliance of most companies that deal with products for the EU-market.

Forest product **chain-of-custody (CoC) certification** or simply **timber certification** as far the wooden furniture industry is concerned, enables to demonstrate that the wood used for making the furniture comes from well-managed certified forests or other controlled sources. From logs to lumber to furniture, it is becoming more important to know exactly whether the materials have come from certified resources. Chain of custody certification is having a growing influence in the marketplace for forest products. It refers to the generic process of tracking materials from forest to market. Its growth has been promulgated by increasing channel and/or market concerns related to sourcing wood products manufactured with raw materials from environmentally certified sources. Timber

Certification is a process which results in a written statement (a certificate) attesting to the origin of wood raw material and its status and/or qualifications, often following validation by an independent third party. Certification is designed to allow participants to measure their forest management practices against standards and to demonstrate compliance with those standards. Timber certification may also be used to validate any type of environmental claim made by a producer, or to provide objectively stated facts about the timber products and their forest of origin that are not normally disclosed by the producer or manufacturer. Timber certification typically includes two main components: certification of sustainability of forest management; and product certification. In product certification, round-wood and processed timber products are traced through the successive phases of the supply chain. Certification of forest management thus takes place in the country of origin; product certification covers the supply chain of domestic and export markets.

Thus, the objective of certification is to link the consumer who wishes to favour environmentally and/ or socially responsible products with the producers of these products and the raw materials from which they are made. This involves several assumptions, including:

• Consumer purchasing patterns can be influenced by differentiating similar products according to environmental and/or social attributes.

• Producer behaviour can be influenced by market signals based on environmental and/or social concerns.

• The premium generated through differentiation will provide sufficient economic incentive for producers to adopt improved management practices.

• Efficiency and competitiveness will increase by internalizing environmental and social concerns.

Certification schemes fall under one of two basic conceptual frameworks: an evaluation of a product or a practice against particular specifications; and the evaluation of the potential of a management system to produce a desired outcome. Management practices assumed to ensure sustainability are the evaluation's focus. The systems approach, on the other hand, is based on evaluation of "ability to manage in an environmentally sound and sustainable manner". Here the evaluation focuses on the operation's management structure and general condition of the forest resource. This approach is typified by efforts that are linked to the International Organization for Standardization (ISO) and its 14000 series standards relating to environmental management tools and systems to measure a company's practices.

In either case, a credible certification programme must evaluate the integrity of the producer's claim and the authenticity of product origin, and must be seen to be objective and impartial. Assessing integrity involves an evaluation of management practices judged against recognized standards, generally at the management unit level. Assessing the authenticity of the product's origin involves the identification and monitoring of its chain of custody, including log transport and processing, shipping, secondary manufacturing and, finally, retail distribution.

Chain of Custody (CoC) Certification provides independently verified assurance that certified wood contained in a product originates from sustainably managed forests. It traces the path of products from forests to markets through processing units and supply chain and ensures through tracing and labelling system that certified material is kept separate and is not mixed with uncertified material throughout the chain. The entire flow of wood material from forest to consumers must be monitored and documented to demonstrate its origin. It helps to minimize the risk of forest products/timber from illegal harvesting and sourcing and enables companies to demonstrate alignment with regulatory requirements (e.g., the European Union Timber Regulation - EUTR).

Globally the two most well-known forest and CoC certification systems are the **PEFC (Programme for the Endorsement of Forest Certification)** and **FSC (Forest Stewardship Council),** both committed to the cause of Sustainable Forest Management (SFM). Together, PEFC and FSC have certified around 525 million hectares of forests across the world.

Chain of Custody PEFC ST 2002 Standard lays out the requirements for chain of custody

certification for forest and tree based products – the conditions a company must meet in order to achieve PEFC certification (PEFC, nd). During the certification process, the certification body will assess the company against the requirements set out in this document. If the company complies, they will receive their PEFC chain of custody certificate. More than 300 million hectares of forest are certified to PEFC's internationally recognized Sustainability Benchmarks, supplying more than 18,000 Chain of Custody certified companies with responsibly sourced timber and wood-based products. PEFC certification enables furniture manufacturers to source responsibly and to communicate to customers and consumers alike that the wood using for products comes from sustainably managed forests (PEFC 2017).

The benefits of using wood; its adaptability, aesthetics and environmental credentials all speak for themselves. Leading retailers are demanding PEFC-certified products as part of their corporate social responsibility commitments and are developing responsible procurement policies for many forest products. With PEFC certification, business will be well placed to meet these requirements.PEFC certification assists in meeting regulatory requirements such as the **European Union Timber Regulation** (EUTR) and the **US Lacey** Act. By gaining PEFC certification and selling PEFC-certified products, it can be ensured that both the company/producer and its customers can maintain access to these environmentally conscious and demanding markets. 2/3rd of the world's certified forest area is PEFC-certified; that's more than 300 million hectares. This means that specifying PEFC-certified material for furniture will give the access to an extremely wide range of PEFC-certified fibre and timber.

PEFC Chain of Custody certification provides independently verified assurance that the certified wood in a product originates from well-managed forests. To earn PEFC Chain of Custody certification, the company must develop and implement procedures to account for the purchasing, tracking, manufacturing, sale and recordkeeping of certified materials.

The PEFC Due Diligence System (PEFC DDS) is an integral part of PEFC Chain of Custody certification. The PEFC DDS minimizes the risk that timber comes from illegal harvesting. It also enables companies to demonstrate alignment with regulatory requirements such as the EUTR. PEFC Chain of Custody certification complements PEFC sustainable forest management certification, which provides assurance that forests are managed in line with challenging environmental, social and economic requirements.

PEFC Chain of Custody certification is available to all companies that manufacture, process, trade or sell timber or timber-based products, and it is available globally. The exact steps necessary, as well as the costs involved, depend on multiple factors, such as size and complexity of business operations. But essentially, one needs to set up a management system in compliance with PEFC's Chain of Custody requirements. This can be integrated into existing systems the company may have already implemented, such as ISO 9001 or ISO 14001. Once the management system is in place, and additional requirements implemented, the company needs to be audited by an independent certification body. After compliance is verified, the company will become PEFC Chain of Custody certified.

Once the company have achieved PEFC certification, they are entitled to use the PEFC label. The certified company need to ensure that they are procuring PEFC-certified timber – this means that the suppliers must be PEFC-certified as well.

In October 2010, the European Union (EU) adopted a new Timber Regulation (EUTR) to combat trade in illegally harvested timber, as a corollary of the 2003 EU Action Plan on Forest Law Enforcement Governance and Trade (FLEGT). Similarly other international regulations came into action focusing on combating trade in illegally harvested timber Like Lacey Act, Australian Legality Act, Saint Petersburg Declaration for Russia, Belgium Legality Act, etc. to help stamp out illegal logging.

The Main obligations of the International Regulations are:

- To prohibit the placing in the International Market of the illegally harvested timber and products derived from such timber.
- To require the traders who are placing their products for the first time in the international market to exercise "Due Diligence" or "Due Care".
- To keep the records of their suppliers.

The three key elements of the "Due Diligence" or "Due Care" are:

Information: In this the operator must have access to information describing the timber and timber products, country of harvest, quantity, details of the supplier and information on compliance with national legislation.

Risk Assessment: The Operator should have assess the risk of illegal timber in his supply chain based on the information identified above and taking into account criteria set out in the regulation.

Risk Mitigation: When the assessment shows that there is a risk of illegal timber in the supply chain that risk can be mitigated by requiring additional information and verification of the supplier.

Of late, FLEGT (EU Forest Law Enforcement, Governance and Trade), Lacey Act, FSC (Forestry Stewardship Council), REACH (regulation concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (EC) No 1907/2006) compliance and CODE are certificates are used to be demanded by various governments for the Indian wood based handicrafts and furniture.

Once the International regulations came into existence, buyers started losing confidence in the Indian wood fibre. No current full proof internationally acceptable mechanism to prove and validate the legality of wood appropriate to the Indian situations was available within the country; lack of an acceptable standard system puts a question mark in the international market on the wood origin, authenticity of documentation and validity and veracity of timber legality documents presently in acceptance. Handicraft industry was the first to feel the heat; small artisans may lose their livelihood if clarity not brought about regarding wood legality issues which are beyond their capabilities. Till recently, there were no approved mechanisms that can comprehensively establish timber legality for EUTR/Lacey Act requirements for handicrafts industry. Handicraft Industry Felt the Need for a timber legality assessment scheme to address these concerns of industry, artisans, buyers and international market. There was a need for quick action before India's competitive advantage is lost out. In 2013 May, **Export Promotion Council for Handicrafts** (EPCH) has been nominated as the nodal agency for issuing certificate on due diligence adopted by the exporters in procuring wood from legal sources for manufacture of Handicraft articles. EPCH has developed the **'VRIKSH Timber Legality Assessment and Verification Scheme – India'** (EPCH 2018).

EPCH's VRIKSH CoC Certification is to promote the responsible and legal use of wood in the handicrafts and home décor industry, keeping in mind the social and environmental obligations; to provide a viable solution to help the handicrafts exporters and to effectively deal with International timber regulation requirements. The EPCH "VRIKSH" Timber Legality Assessment and Verification Standard – India is intended for entities who want to accurately track and make claims about the legal origin and transport of their products. VRIKSH covers wood originating from Government Forests, Agro forestry, Farm Forestry, Imported wood, and Private Forests.

This standard has been designed to allow organizations to avoid trading in illegally harvested wood, for verification of legality and legal origin of wood and wood products is intended for organizations who want to accurately track and make claims about the legal origin and transport of their products. Compliance with this standard allows organizations to demonstrate that they are implementing best efforts to avoid the trade in illegally harvested timber, in support of international Forest Law Enforcement, Governance and Trade

(FLEGT) Programme, The European Union Timber Regulations (EUTR), the us Lacey Amendment Act of 2008, the Australian Illegal Logging Prohibition Act 2012 and other such Global Timber Legality Verification Programmes. It allows companies to start implementing their own responsible sourcing policies. The four aspects of legality to be covered under the ambit of VRIKSH standard are:

- Legal right to harvest and trade within legally gazetted boundaries
- Compliance with legislation related to forest management, environment, labour and welfare, health and safety
- Compliance with legislation related to taxes and royalties
- Compliance with requirements for trade and export procedures.

Advantages of VRIKSH Certification

- Supports compliance with EUTR and other International Timber Regulations
- Well documented process
- Legality verification of diverse wood origin sources
- Ensures traceability of material through delegated system Suppliers' Benefits
- Increased confidence of buyers
- Increased market access due to ability to put certified products on market
- World-wide presence through web based registry
- Competitive advantage by product differentiation
- Reinforce your brand image with on-product, third party certification labelling.

An organisation needs to prepare the following documents and present them to the Auditor at the time of VRIKSH Audit:

1) Organisational VRIKSH manual. 2) Organisational Policy. 3) Sales Invoice. 4) Training records. 5) Suppliers' list. 6) Material balance records. 7) Annual Volume summary. 8) Company registration documents. 9) Tax registration documents. 10) IE Code. 11) Latest payment receipt (Sales tax/Income tax). 12) Risk Assessment. 13) All applicable Government requirements. 14) Document verifying legal origin of material such as TP, Forest Pass, Sales Invoice of Farmers, and Govt. Auction Records. 15) Batch Accounting 16) Outsourcing Agreement.

In this the organization should be able demonstrate that it approvals (permits/ licenses and transportation/export documents) were properly obtained, and contain up to date information and accurate. All approvals/ licenses and permits shall be valid at the date of assessment. The assessments are carried out on an annual basis.

An Organisation purchasing wood and wood products need to classify them as being low/high/unspecified risk. This can be done in accordance with the following criteria for classification:

Low Risk	**High Risk**	**Unspecified Risk**
Wood purchased from government auctions and tenders	Wood purchased from non-credible sources	Indirect purchases from government auction
All FSC, PEFC certified wood, FSC Controlled wood, VRIKSH, CITES licensed wood, FLEGT licensed wood	Any wood source or supply line that cannot be supported by documentation	All other wood sources and supplies

Importance of VRIKSH

- VRIKSH will go to create heavy market for the certified wood.
- Buyers requirement for due diligence will be fulfilled, so it will become easier for them to place their products in the international market.
- VRIKSH make sure that no illegal material enters the supply chain.
- VRIKSH will going to bring international recognition , as it will be fulfilling all the requirements of the international market , Buyers also will going to gain confidence on Indian wood .
- Web registry will be provided in which all the names of the Organization which are VRIKSH certified will be present,
- Buyers can always check the Database and can get the information related to VRIKSH certified organizations.

The Network for Certification and Conservation of Forests (NCCF), a non-profit organization of India came into existence as a Society in 2015, actively engaged in diverse conservation activities including, development of globally benchmarked and India specific sustainability certification standards for various constituents of our natural resource base, viz., Forest Management (FM), Trees outside Forests (ToF), Non-Wood Forest Produce (NWFP), Protected Areas and Wetlands (PAW), Quality Planting Material (QPM), Ecotourism and Biomass & Biofuels, etc., launched the internationally benchmarked

National Forest Management Certification in January 2018. The standard was developed following the standard setting process - a rigorous 3- year multi-stakeholder consultation initiated in 2015 after following the UN norms of standard setting process. The NCCF Forest Management Certification Scheme has been endorsed by the PEFC International, a Global Forest Certification Alliance, in 2019. Since then, NCCF has certified about 450408 ha area under this scheme. NCCF has also developed the world's first of a kind Trees Outside Forest (ToF) Certification Scheme in August 2019.

NCCF Forest Management Certification Standard is fully in conformity with the objectives of National Forest policy, National Working Plan Code 2014 of the Ministry of Environment and Forests, Bhopal India Process of the IIFM and international best practices in certification, duly reflected in its Themes, Principles, Criteria and Indicators, making it easier to implement and comply with, as per the international norms of certification. NCCF has been successful in obtaining the endorsement of its forest certification scheme from the 'Programme for the Endorsement of Forest Certification' (PEFC), the Geneva based leading International Forest Certification Organization. India now holds a globally recognised certification scheme by the NCCF specifically developed for the Indian forests, as on 27th February 2019. This scheme will allow the forest managers in various states of India to further strengthen their Working Plan based management practices as per the global standards and multilateral requirements. NCCF has adopted PEFC Chain of Custody Certification as part of its certification schemes for forests and trees outside forests. It is available worldwide and is open to all companies that manufacture, process, trade or sell forest-based products (NCCF, nd).

The FSC-India is also reported to be in the process of developing a National Forest Stewardship Standard, the draft of which is expected to release shortly to the public domain for discussions at a wider level.

Many of the countries that now supply India with timber suffer from high levels of illegal logging and associated trade. The International Union of Forest Research Organizations (IUFRO) estimates that India was the third-largest importer of illegally logged timber in the world in 2016, after China and Vietnam. While the government regulates the tax and phytosanitary regimes of the timber imports, as well as Convention on International Trade in Endangered Species (CITES) of the International Union for Conservation of Nature (IUCN), India has not instituted any robust regulation to exclude the import of wood products harvested and traded in violation of the laws and regulations in the source country. Certification systems that could verify legality and/or sustainability are also not used widely. Without such systems, there is no guarantee

that India's exports of manufactured timber products are verified as legal. Yet more than three-quarters of India's timber product exports require such verification by law in the importing nation– a figure that rises to 90% for furniture alone.

The United States and the European Union are India's largest markets for timber products. Both now have laws in place to restrict the import of illegal wood and forest products and require verification of legal harvest. Australia, Japan, the Republic of Korea and Indonesia also have similar laws in place, to be followed soon by Vietnam, and Thailand. Buyers in all these markets risk fines, penalties and/or prosecution if they cannot comply. Indian suppliers risk losing these markets to other countries that can provide the legal assurances requested. Given that India's timber product exports are already vulnerable in regulated markets, and many furniture and handicraft artisans are likely to see increasing demands to verify that the timber they use is legal, it was recommended that Government of India to develop a robust import regulation specifically designed to exclude the import of wood products that are harvested and traded in violation of the laws and regulations in the source country (Norman and Canby 2020). It was also recommended to the governments in countries with laws regulating the import of illegal wood that the report by Norman and Canby (2020) found that the majority of the potentially high risk species were listed in products exported under HS code 4421, which is outside the scope of many timber import regulations including the EU Timber Regulation, the Australian Illegal Logging Prohibition Act and the Japanese Clean Wood Act. In the case of the Republic of Korea, all wooden furniture products and HS codes as well as "other articles of wood" under HS code 4421, are currently outside the scope of products covered by the Korean Revised Act on the Sustainable Use of Timbers. They also reported that traceability and legality verification of Indian-manufactured furniture and handicraft products is a challenge. While there are a number of certification systems designed to verify forest management and chain of custody (CoC) systems, only a few furniture factories or artisans use them. Verification of imported timber legality is weak even for certified products.

The key documents based on the applicable legislation and are considered to play a key role in demonstrating legal origin are: the Forest Working Plan a per the National Working Plan Code (NWPC) with the Legal Authority of MoEF&CC, Harvesting Permit, and Transit Pass FROM THE State Forest Division (SFD), EXIM License, Sales Records, Bill of Lading, etc.

During the past years, the use of international certification systems, particularly the Forest Stewardship Council (FSC) Certification, has increased, partly because of the response towards FLEGT among buyers in the EU (Forest Legality Alliance). Currently, there are 8 valid FSC-FM Certificates, with a joint area of 522486 ha, as per the FSC Facts & Figures, Feb. 2020.

Conclusions on Problems and Constraints of Timber Certification

The problems and constraints related to timber certification lie mainly in the lack of generally accepted international principles and criteria to assess forest management sustainability; the lack of a widely accepted accreditation process for certifiers; and the emergence of many parallel systems. As has been discussed above, much effort at both the national and the international levels is currently being invested to determine the principles, criteria and indicators of sustainable forest management. However, this work continues to be fragmented, overlapping and even conflicting at times. Certification also suffers from another important weakness; it is not always clear who is providing the information or what standards are being used to assess the claim. As early as 1990, calls echoed from various interest groups for the establishment of an accreditor for certifying organizations to ensure the creditability of market claims. The Forest Stewardship Council (FSC) is the leader in work towards the evaluation of certifiers for the purpose of accreditation.

Currently, the certification picture is clouded by the development of many competing and even conflicting systems. There is a real risk that timber suppliers may be called on to acquire more than on certificate for the same product in order to satisfy different groups of customers, each with its own allegiance to a given certification scheme. Beyond

these practical challenges, there is a larger philosophical question concerning the potential for certification schemes actually to do what they set out to do, i.e. provide a positive impact on the management of forest resources. There often seems to be a general feeling that certification is "inevitable" but that there is scant evidence of the real potential of this type of approach in contributing to sustainable forest management.

The awareness of the need for sustainable forest management is worldwide but agreement on the potential role of timber certification in achieving this goal is by no means equally widespread. Any viable timber certification scheme will need to be seen to be credible, objective with measurable criteria, reliable and independent and, most important, covering all types of timber. Participation must be voluntary, non-discriminatory in nature and adaptable to local conditions, cost effective, practical and transparent. So far, timber certification has not been applied on a wide enough basis to prove its practicality in application, its effect on the market or its contribution to good stewardship of the forest. The issue remains highly political in nature and will no doubt continue to be a subject of active international and inter-governmental debate for some time before a solution is found.

Limited availability of certified wood is a major challenge in the wood sector of the country to meet the industrial requirements and hence efforts to explore developing a timber policy to boost locally produced solid wood to get certified is of prime concern in the timber certification sector of the country. Forest/wood certification in India recognized by international agencies; a social forestry timber policy and certification of wood from TOF should be the immediate priorities.

Voluntary international certifications such as Forest Steward Council (FSC) and Programme for the Endorsement of Forest Certification (PEFC) are developed for forests management regime. Globally, the total area certified under PEFC and FSC is 325 million ha and 200 million ha respectively with 93 million ha having dual certification. Current voluntary certification schemes of FSC, PEFC, SFI etc., are being adopted in India based on market demand. There is no certification system suitable for wood produced from Agro-Forestry (AF) in the country. Information Technology (IT) based Certificate of Origin and Ownership (COO) system can be developed to certify Legality of Wood from Agro-Forestry which can be used for .trading and transaction, insurance and collateral guarantee for banking and future trading. Digital Tagging can also be introduced at the farm level which can be used across supply chain and traced back for a chain-of-custody verification & certification.

As regards supply of timber from forests in the country is concerned, the country has already committed to Sustainable Forest Management Principles under the Bhopal India Process and the same is incorporated in the National Working Plan Code 2014; the same can be further extended to a National Forest Certification Scheme (NFCS) as suggested by Dr. Maharaj Mutthoo Committee and IIFM in 2010. NFCS can be endorsed by international bodies and exporting countries; ICFRE may function as Auditors for the IIFM developed certifying system.

CRAFTING SKILLS FOR THE NEW AGE WOOD

Association of Indian Panel Board (AIPM) along with illustrious organisations such as IPIRTI, IWST, FFSC are working hand in hand to train & promote skilled and unskilled carpenters / trainees to understand & handle the optimum usage of the New age wood(Medium density Fibreboards).

Teams of various professionals are invited to association's organized workshops where the trainees are given opportunities to upgrade their skill, learning, analytics and accountability aspects where the carpenters are given formal training to be able to use the tools and the technology that goes in to the fitting of a Medium Density Fibreboard. It is consequential that the Carpenters know how to function with a Medium Density Fibreboard and this has certainly added more quality to their lives and has brought upon a higher finesse and professionalism out in the domain.

COST-EFFECTIVE | DESIGNER | SUSTAINABLE | DURABLE & ENVIRONMENT FRIENDLY | MOULDED INTO SHAPES

Address: 2nd floor, Rushil House, Near Neelkanth Green Bunglow, Off. Sindhu Bhavan Road, Shilaj, Ahmedabad - 380058, Gujarat, INDIA.

Tele. No.: +91-79-61400400 | FAX No.: +91-79-61400401

E-mail: jt@aipm.in | Website: www.aipm.in

AIPM

ASSOCIATION OF INDIAN PANEL BOARD MANUFACTURERS

Chapter 7
Timber Harvesting, Logging, Sorting/grading & Transportation Sector

Most logging operations in India are done manually through contracting system, although efforts have been made from time to time to introduce mechanized logging. Mechanized logging has not been extensively favoured, in part, because labour is comparatively cheap and more easily available. However, acute shortage of labour is reported in some areas, particularly for forest operations.The assortments are usually divided into three main groups: commercial timbers, industrial wood and fuel wood.

Commercial Timbers

For building construction: Mainly from *Deodar, Sal, Pine, Chir-pine, Teak, Acacia, Dipterocarps* and *Terminalia.* In the mountains, for transport reasons, the length of logs is limited to 10 or 12 feet (3 to 3.5 meters). This coincides with the length of railroad sleepers. In the plains the logs vary in length from 6 to about 20 feet (1.8 to 6 meters). The top diameter for building construction timbers is about 70 cms.

The sawmills, of which there are several thousand, are small units with a consumption varying from 800 to 3,000 cubic meters per unit per year.

For sleepers: Mainly from *deodar, sal, chir pin*e and *Pterocarpus species.* The basic lengths are 9 feet 2 inches (2.8 meters) with trim allowance, 6 feet 2 inches (1.9 meters) and 5 feet 2 inches (1.6 meters)

For poles: Mainly from sal, deodar and teak. Lengths from 10 feet (3 meters) to 35 feet (10.5 meters) with minimum top diameters of about 15cms

For fence posts: Mainly from sal, *Acacia, deodar* and *Pterocarpus* species

Industrial Wood

Boards: manufactured from various waste material from the sawmills
Veneers: mainly from teak, rosewood, sissoo and laurel
Furniture: mainly from teak, sissoo, walnut and Pterocarpus species
Packing cases: mainly from chir pine, salai, mango and fir

Raw material for pulp: At present the main raw materials used by the paper industry are bamboo and, to a lesser extent, sabai grass and coniferous woods (mainly chir pine). Some of the mills have started using miscellaneous hardwoods. The total amount of bamboo potentially available annually has been estimated at 4 million tons. There are about 50 paper mills, with an average production per unit of about 12,000 tons/year.

The limited amount of coniferous pulpwood is logged as second assortment after the logging of commercial timbers. It is also logged from twisted grained chir pine which is not suitable for sawn wood. The length of the pulpwood is usually 3 feet (1 meter).

Fuel wood

Of the total volume of fuel wood, only 3 per cent is softwood, the balance - about 10.5 million cubic meters (370 million cubic feet) - being hardwood. The length is mostly about 1 meter (3 feet).

Logging techniques differ considerably in the mountains and in the plains of India, due mainly to the extreme topographical variation and to the different dimensions of the trees; in the mountains the trees are generally very big. Major improvements introduced in logging include the introduction of saws for felling and conversion. The dimensions of the trees marked for logging vary between 18 and 90 cm dbh. The biggest trees are found in the Himalayan Mountains, upper Assam, some parts of the west coast and the Andaman Islands.

Transportation in the mountains is, as usual, more complicated and expensive, and for this reason - despite the fact that the annual cut in the really mountainous areas is only about 10 per cent of the total cut; much greater attention is paid to logging in this region than in the plains. Means of transport of logs includes semi-mechanized and mechanized systems such as gravity ropeways, forest tramways and railways, and motor trucks.

Felling, Crosscutting, Debarking

Throughout the major part of the difficult to work nature forests felling is done by axe, but the use of axe and saw (now-a- days portable Diesel operated chain saws also) combined is also practiced widely. The felling axe is usually made locally, the weight of the head -varying from 0.7 to 1.8 kilograms. The handle is nearly always straight and round and is usually fashioned from any wood available locally. Felling is carried out by a team of two or more workers. Stumps are very often high - up to 60 cm - for ease of working; however, due to the precious nature of wood material, basal cut at ground level is also common.

The saws used for felling and crosscutting are two-man manual crosscut saws with peg teeth or the portable chain saws now days. Raker-teeth saws are used to a limited extent. The saw blade is imported but the teeth are cut in the country. Bow-saws and one-man crosscut saws are practically not used. Limbing is done with a trimming axe or with the felling axe itself. The former has a broader blade than the latter. The trimming axe is also used for the rough squaring of timber, for which the axe has to be especially heavy. No spuds or any other special implements are used for debarking logs, the usual method being to beat the surface with the reverse end of the axe head, thereby loosening the bark from the log, after -which it can be peeled off.

Bamboos and small poles are at some places felled by billhooks; a great variety of shapes being found from locality to locality.

The season for logging operations is mainly determined by climatic conditions. It usually starts in October and continues up to March or April.

Conversion

The production of sawn timber from logs - conversion - is traditionally done manually in the difficult to work forests; conversion is usually done at the stump site itself. The logs are generally rough-squared by axe before being sawn by manual crosscut saws. In the plains, conversion at the stump site is also the general practice, although in areas with adequate transport facilities logs are often transported for conversion to the sawmills. The trend is definitely toward the transport of material in log form from the forests to the sawmill.

Log Transportation

Short-distance transportation:Short-distance transportation is mostly effected by non-mechanized means. Various methods of transportation are in vogue, depending upon such factors as the terrain, the size and character of timber, economic considerations, availability of labour or supply of draft animals, climatic factors, etc. The following methods are generally employed:

Dragging by means of animals:The draft animals used are elephants, buffalo and bullocks. Rough earth roadsare made for dragging. In some cases dragging is facilitated by placing round billets in front of the log to act as rollers.

Chains and sometimes fibre ropes are generally employed for dragging. They are fastened to the logs through drag holes cut into the latter - an expensive method. Other methods for fastening the chain are also used. The front end of the log is slightly rounded off (snouting) to prevent it from ploughing into the ground.

Transportation by means of carts:Carts driven by bullocks or buffalo are extensively used for the

carriage of sawn timber and logs in the plains. Carts are taken right up to the stump site for loading whenever possible. Sometimes one end of the log rests on the cart and the other trails behind on the ground.

Rolling carriage:Logs are rolled in flat country or on gentle slopes over rolling roads made by clearing away all obstructions along the alignment: they are rolled by elephants or by men using stout wooden levers. Every precaution has to be taken to control the speed of the logs, and only one log at a time must be moved.

Carriage by men and pack animals:Pack animals such as camels, buffalo, mules ponies and donkeys are often used for the transport of timber. In the Himalayas, scantlings are usually carried by men on their backs from the stump site to the launching or other depots. This method is costly but is often the only method possible in the circumstances.

Transport by aerial ropeways:A system of aerial ropeways based on traction by gravity, the Donald's gravity ropeway, has come into wide rise in the Himalayas for the extraction of scantlings from inaccessible areas. It can be used on slopes from 17 to 45 degrees. The best spans and gradients for speed and economy are 750 to 1,050 meters at 22 to 35 degrees between top and bottom stations. A safe working load is about 225 kilograms.

Slides:Various types of timber slides used in the mountain forests are described below:

Wet slides or flumes are the chief method used for extracting scantlings from the Himalayan forest. They consist of rectangular troughs constructed from scantlings.

The components of these troughs are also removed when the slides are no longer needed. Success of this method depends on the maintenance of a sufficient and continuous flow of water down the Slides. Wet slides can work at as low a gradient as 0.5 degrees provided a good supply of water is available. The earth slide or chute consists merely of a trough scooped out down the hillside. The logs have to be slid carefully to avoid smashing them into rocks or into one -mother. Where the gradient is steep, the speed of the logs is checked by the construction of check walls.

Dry wooden slides are -used when the route lays across the slope or in localities where the terrain is too difficult or rocky for an earth slide, or where it crosses over or is situated at the edge of cultivated fields. Dry slides -work well on gradients of between 15 and 25 degrees.

Long-distance Transportation - Rail and Trucks:In the plains, long-distance transportation of timber by land is mainly effected by railroads or motor trucks whenever good permanent lines exist. The network of railroads is quite extensive and railroad lines have been constructed mainly for timber traffic through many forest areas. Motor-truck traffic has increased to a great extent since the Second World War and has largely replaced rail traffic over comparatively short distances. Motor trucks are of the common type used for general transport purposes and special logging trucks or trailers are seldom used. In the plains, if possible, the truck is taken right up to the stump site. The use of forest tram roads is on the decline. Out of several systems introduced in the past, very few are still in use.

Floating and rafting:The transport of timber by water is the oldest method followed in India. Although the cheapest, this method is being superseded by rail and road transport because the vehicles can frequently be brought right up to the felling areas, there is less damage and loss in transit and transport is quicker than by water. For this reason water transport has all but disappeared, except in the Himalayas and other hilly regions, and in some of the coastal areas. Water transport includes two different operations floating and rafting. Floating is practiced in the upper reaches of rivers where the streams are too narrow, shallow, or rocky or where the current is too swift for the management of rafts, while rafting is practiced in the lower reaches where conditions are favourable for this operation.

In the coastal waters of the Andaman Islands, rafts are towed along the creeks by power launches. In the open sea, the rafts may get broken and so the timber is transported in small powered vessels.

Mechanized Logging

Forest roads/ tram roads, hauling logs from tree

stumps to the railway line employing caterpillar/ tractor, winches for skidding use of sawmills, some portable sawmills, etc. forms the integral part of mechanized logging. At present, skyline cranes, caterpillar tractors for skidding, power operated chain saws, and portable sawmills are employed for mechanical logging. Elephant tram roads have been largely replaced by diesel locomotive tram roads.

As far as the forest labour is concerned, manual equipments are usually owned by the workers themselves, but in some cases it is provided by the employer. The position as regards safety precautions is rather unsatisfactory.

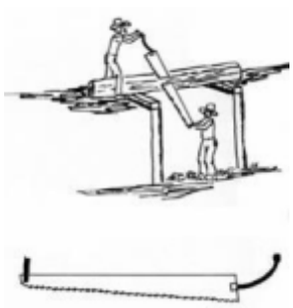
As a result of the work of the FAO expert, A. Koroleff, in 1955, a Logging Branch was established at the Forest Research Institute, Debra Dun, in 1957. This Logging Branch acts as a co-ordinating agency for the State Forest Departments and as a general clearinghouse for information on logging, as well as collecting statistics on the economics of various logging tools and practices and conducting research on the efficiency of various equipment and methods involved in logging. An essential activity of the Logging Branch is the publication of pamphlets, research notes, etc., and the study of foreign equipment and techniques with reference to Indian conditions. This was followed by the establishment of some Logging Training Centres by the Government to train the employees.

As on today many brands of capital intensive reduced impact logging machines of various brands are available all of which are capital intensive, the photographs of a few are given below:

Logging and Log transportation by road, rail and waterways

Chapter 8
Sawmilling Sector: Primary and Secondary Conversions and Downstream Processing

Log Sorting & Grading: Logs are sorted and graded as per species, diameter, length and end-use; to ensure maximum recovery, to predict the proportion of high-quality lumber that will be produced from that log, and to help buyers and sellers to settle on a fair price. Sophisticated modern mills make use of ultrasound, X-rays etc. capable of detecting internal defects in the logs for grading them.



Sawmilling sector is responsible for the primary conversion or 'breaking down' of the logged timber, which means rough sawing. Sawmill essentially comprises the facility where logs are cut into lumber. Modern sawmills uses power operated motorized saws to cut logs lengthwise to make long pieces, and crosswise to length depending on standard or custom sizes. Sawmilling is the process of operating the sawmill. **Portable sawmills** are another option for the convenience of bringing the sawmill to the logs and milling lumber in remote locations; however, Indian Forest Rules were not promoting portable sawmilling. The pattern of sawing is determined by the dimension and condition of the log, as well as the market requirements for the widths and thicknesses of the lumber.

Head saws are used to turn logs into cants (sawn log that is sent to another machine for additional/ secondary/down-stream processing or sold as a large slab to be used as a building log). Saws are basically cutting tools with toothed edges. They may be reciprocating (it includes various hand operated and machine operated blades which cut in one stroke or both strokes i.e., backward and forward), revolving or traveling types. The various types of essential head saws for the primary conversion of the logged timber includes one or more numbers of band saws of the horizontal and vertical types (at least one in each type) and circular saw, along with portable chain saws. Usually, sawmills are provided with re-saws and other basic wood working machines for the secondary conversion or downstream processing to products. Some of the primary conversion sawmilling devices such as the heavy duty portable chain saw for crosscutting the logs, horizontal and vertical as well as circular saws are shown below:

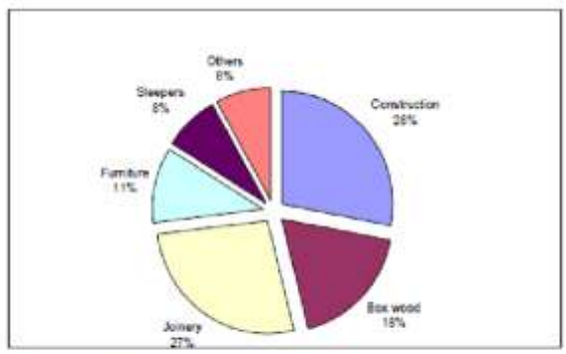
Technology has changed sawmill operations significantly in recent years, emphasizing increasing profits through waste minimization and increased energy efficiency as well as improving operator safety. Sawdust and other mill waste are now processed into particleboard and related products, or used to heat wood-drying kilns. Co-generation facilities will produce power for the operation and may also feed superfluous energy onto the grid. While the bark may be ground for landscaping bark dust, it may also be burned for heating boilers. Sawdust may make particle board or be pressed into wood pellets for pellet stoves. The larger pieces of wood that won't make lumber are chipped into wood chips and provide a source of supply for paper mills. Wood by-products of the mills will also make oriented strand board (OSB) panelling for building construction, a cheaper alternative to plywood for panelling. Pulverizing wood waste for wood-polymer composite manufacturing is also another practice.

India is the second-largest importer of tropical logs in the world. At any given time, around 30% of all tropical logs in trade are destined for India. Import of logs represents over 74% of the total imports of forest products in the country. Among the reasons for importing logs into India are the simple and cost-effective 23,000-odd saw mills in the country, 98% of which are small units in the unorganized sector, with an annual log intake of only 3,000 cubic metres, accounting for 82% of the sawn timber produced in the country (Saigal and Bose 2003). The total production capacity is estimated at around 27 million cubic metres per annum (GoI 1999, AHEC 2016); but capacity utilisation is estimated to be between 50-64% (Tewari 1995, GoI 1999). The survey conducted in the late 1970s indicated that about 1.4 lakh workers were employed in the sawmilling industry at the time. It is estimated that small sawmills account for 82% of the total sawn timber in the country (Tewari 1995)

Different types of sawing patterns

The most common methods are the Plain/ Flat/ Live sawing; Quarter sawing; Radial/ Rift sawing; and Tangential sawing

Plain/Flat/Flich/Ordinary sawing: This is the most common



Source: GoI 1999

Figure 1: Main uses of sawn wood produced by sawmills

Main uses of sawn wood produced by sawmills
(Source: GoI 1999; c. f. Saigal & Bose2003)

and widely used method of sawing. Plain sawn lumber is produced by making the first cut on a tangent to the circumference of the log. Each additional cut is then made parallel to one before. This method produces thee widest possible boards with the least amount of log waste.

Flat sawn is the most commonly found sawing pattern. It comes from taking boards from the outside of the log. This gives the wood a cathedral grain pattern. When looking at the end grain of a board, you will notice that the annual growth rings are either smiling (cupped) or frowning (crowned) at you. Flat sawn lumber tends to produce wider boards and fewer knots. It is also the most economical because it's very quick to produce and little waste associated with it. This is the method or action of sawing timber tangential to the growth rings, so that the rings make angles of less than 45° with the faces of the boards produced. This method is widely used and comprises a greater proportion to the output of sawmill. Plane sawing yields more and operations are easier. In this around sawing method, log is turned around and cuts are made after two or more planes.

Live sawing: Place the straight or nearly straight log on the carriage with the best face toward the saw. Use full taper set-out. Cut 4/4 boards till you reach the centre of the log. Then turn the log 180 degrees and continue sawing the rest of the log through and

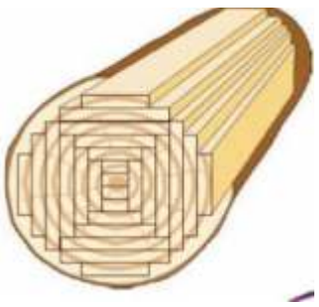
through. Live sawing, also known as slab sawing or through and through sawing, is when a log is sawn about halfway through on the opening face and then turned once to the opposite face for sawing until the log is finished; successive cuts are made on the same plane.

Live Sawn is a European approach to cutting lumber. Plain sawn is the modern way of sawing lumber, in which the log is turned till the Sawyer can cut off the clearest board. In live sawn; the logs are sliced directly through without turning the log.Live sawing is more wasteful than around sawing, but around sawing is more time and labour consuming.

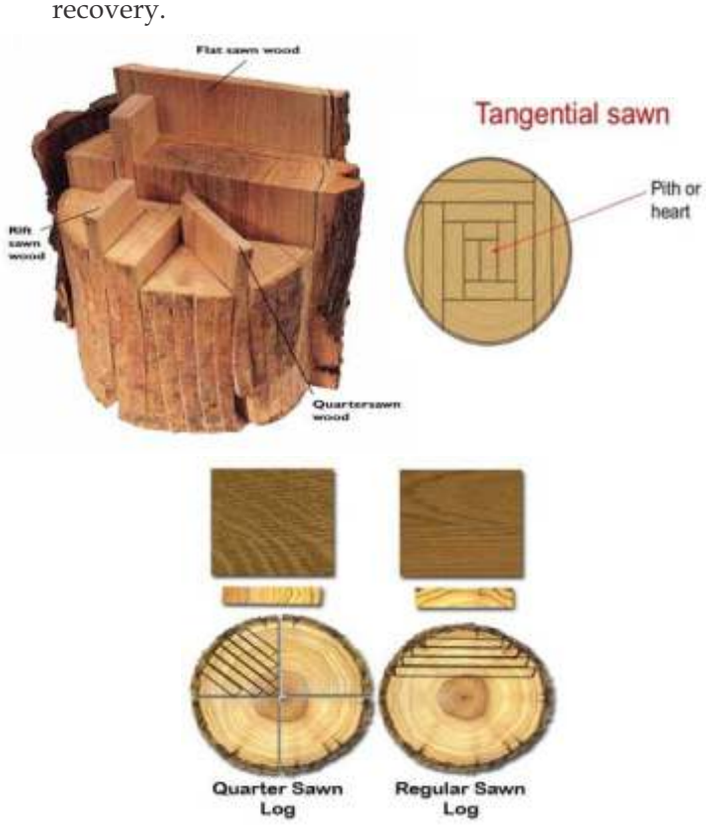
Quarter sawing: Quarter sawing gets its name from the fact that the log is first quartered lengthwise, resulting in wedges with a right angle ending at approximately the center of the original log. Each quarter is then cut separately by tipping it up on its point and sawing boards successively along the axis. Quarter Sawing involves sawing in a plane which is to be more or less perpendicular to ray and perpendicular to the growth ring of the tree; used for decoration piles and for surface cracked wood. This method produces the most stable and desirable grain patterns.

Radial/ Rift sawing: This is an innovative sawmilling process specifically designed to maximise the recovery of wood from smaller logs. Conventional sawmilling cuts logs into square sections, often creating stress in the wood produced. As a result, the wood is more prone to bending, cupping or splitting. Radial sawing, in contrast, cuts the logs into wedges first, in line with the natural way a log would split on drying. This removes many of the internal stresses that exist in the wood, resulting in more stable products, less waste and more even grain in the wood.A cut through the center so the rings are at right angles to the face of the board is termed a radial cut or radial section. In a radial section the annual rings are parallel. The center boards in this log are close to radial sections because the rings are nearly at right angles to the face of the boards. A summary of the main environmental and technical benefits of radial sawing include: more timber out of each log, higher value products from younger trees, timber products with consistent growth rings, and more stable wood, less likely to move after processing.

Tangential sawing: to saw (a log) lengthwise by parallel cuts in regular succession — *compare quarter sawn*. Tangential cutting occurs when the saw cut glances on the outside of growth cylinder in the wood. The resulting pattern on the board's surface is called cathedral or crown grain, having pronounced figure as shown in the photos to the left.



In brief, the Flat/Plane/Tangential Sawing yields maximum recovery, with more aesthetic and faster to produce boards with the disadvantage of more shrinkage and swelling whereas the Radial/Quarter Sawing yields in dimensional more stable, less likely to cup, twist & warp boards with the disadvantage of labor and time intensivecostly process with less recovery.



A study on the sawmilling sector in Kerala, India, conducted by KFRI (Muraleedharan and Bhat 1989) reported a capacity utilisation is of the order of 53% only because of the shortage of raw material. As size increases the capacity utilisation also increases, since large size mi1 is have better stock of raw material. The average out turn in a sawmill accounts for only 50%. Modernisation of the sawmill and protecting the logs from cracking, end splitting and biological degradation are suggested for improved capacity utilization. Sawmill maintenance is not just a matter of repairing or maintaining machinery but also of organization and method whereby maximum production of sawn timber can be achieved to the financial gain of all involved. Various FAO publications (FAO 1985, 1990) shows light into the need for establishing strong saw doctoring facilities in sawmills. Saws used in timber mills are very large and expensive. They need careful maintenance for safe operation. Repair of damaged saws requires a high degree of skill. It takes many years of full-time saw filing to become proficient in the trade.

Saw Doctoring

The saw filer/saw doctor inspects the saw for needed repairs then gums, fits and benches the saw as necessary.

Gumming involves grinding the gullets of the saw teeth to a particular shape. The saw filer uses a semi or fully automatic grinding machine for this. Saw bands operate under high stress and heat and in the presence of wood chips. Carbon migrates into the steel from the wood. Gumming prevents case hardening and fatigue cracking of the saw band gullets. A precise profile of the tooth (including gullet area, hook angle and top clearance angle) must be maintained for proper saw operation and wood chip removal. Ease of cutting greatly depends on this. The shape is determined by the type of wood and cutting conditions. A saw filer will maintain the gullet shape by manually shaping the grinding wheel with a dressing stone, and the set-up of his grinding machine. Variations include face angle, face length, back angle, gullet width and depth, and a frost notch (if necessary). Typical band saw tooth dimensions are 1-3/4" tooth space x 3/4" gullet depth x 3/4" gullet width (grinding wheel width) x 30deg face angle x 16deg back angle.

Fitting means tooth dressing and involves swaging, shaping, gauging, and grinding. The tip of the saw tooth is swaged to a flare, and then the sides are compressed in slightly with a shaper tool to an exact kerf(the amount of wood material removed during cutting/the width of the wood material that is removed by a cutting process). Then a final grinding pass is made. The same grinding machinery used for gumming is used for fitting. The saw kerf is usually made this way from the base saw metal. Sometimes, however, the kerf is made with stellite or carbide tips for the sawing of timber with high hardness/silica content), in which case swaging and shaping isn't needed, although gumming is still required. The kerf may also be 'set' with a punch and hammer, with the teeth bent left, right, left... Set teeth are rarely used.

Benching is the levelling and tensioning of the saw. When a saw band is run on a mill it is stretched with thousands of pounds of force, and during operation the cutting edge heats up. These forces and temperatures cause the saw to deform. Benching deforms an un-mounted saw in a way that counteracts the operating stresses, and allows the saw to pull flat and cut straight when in use. It takes months to learn benching. Benching is done in a dark room with a stretcher-roller machine and flat anvil. A single light at the Benchman's work station, along with ground gauges, allows the saw filer to measure level and tension.

Levelling is done with a cross-face hammer and stretcher-roller adjustments. Cross face hammers are available in left and right hand versions. Each filer has his own hammer which he carefully dresses.

Tensioning is done with the stretcher-roll. This machine has hardened rollers above and below the saw. They rotate slowly (one is powered, while one runs free) and pinch the saw when a lever is cranked, rolling a thin strip through the length of the saw, stretching the metal where it was rolled. Careful placement and force of the rolls deform the metal in a way that counteracts the forces the saw sees during operation. More rolls are placed in the midsection of the saw. Re-saws have the back pulled to counteract the uneven heating of the cutting edge. This is done by rolling the back (non-cutting edge) of the saw. The back is measured with a three pin gauge, and is usually around .003" per three feet curved.

Benching involves the simultaneous solution of multiple deformations introduced to the saw to counteract the predicted stresses of the saw in operation. Benchman can easily recognize variations in steel batches.

Other band saw duties include welding broken teeth, fixing cracks, and trouble-shooting operating problems. Of late, CNC equipments have evolved to the point of being able to do significant benching and fitting tasks. Saw filers have the same maintenance duties with circular saws as they do with band saws, with a few exceptions:

- Levelling is done mostly with specialized hammers of which there are 3 main types Dog head (side on profile resembles a dogs snout), twist face (A double sided hammer in which the faces are in a 45 degree alignment) and cross face (faces are at 90 degrees to one another) and anvils (there are 2 main type of anvils dead (for levelling the saw) and live(for both levelling and tensioning the saw), although stretcher-roller machines are also used for levelling and tensioning.
- Circular saws can be solid tooth (straight saw steel which is bent to give clearance of the saw blade) or can have carbide, Stellite or insert teeth that don't need swaging.
- Fatigue cracking of the tooth gullet is not as common as in band saws, as in the majority of cases it is a heavier plate gauge and is not bent around band wheels multiple thousands of times per run.

Hence, the important equipments for saw-doctoring are the Levelling and Tensioning Machines, Band Saw and Circular Saw Sharpening Machines, Stellite Tipping Machines, Tungsten Carbide Tipping and Grinding Machine, Cutter Grinding Saw doctoring Machines, MIG Welding Machine, Brazing Equipment, Grinders for other knives, etc.

High quality tool maintenance means gains in raw material yield, increased productivity and products of improved quality which will command higher prices. High quality tool maintenance, whether saws or knives, requires good equipment installed in a saw shop large enough with all the lighting and other facilities necessary for it to be used to full advantage. Above all these requirements however, it requires skilled personnel prepared to use the equipment to its full potential. Under these circumstances economic advantages much greater than the tooling costs will also arise. The information given is based on experience of proven techniques in various countries where processing of softwoods and hardwoods is carried out. It must be emphasized however, that the full theoretical knowledge of all the above subjects will not yield satisfactory results without the requisite skills necessary to put them into practice. The need for all key personnel engaged in wood processing industries to be properly trained, and to acquire the practical ability and experience necessary to achieve and maintain maximum efficiency from the various equipment with which they are working is therefore paramount. Without this experience, the best equipment available will not produce satisfactory results and the natural forest resources of any country will not be used to full advantage. Hence, training and skill development opportunities and skilled manpower is most important in sawmilling. As usual, the risk-safety and the consequent legality and costs associated with this are imperative in this sector. In the Indian situation, forest conservation being the prime objective of the MOEFCC, existing sawmills are always under close watch of the government and clearing licenses for new sawmills are under very strict legal grips. Issuing new licenses for sawmilling is very rare now days.

Secondary Conversion – Resawing

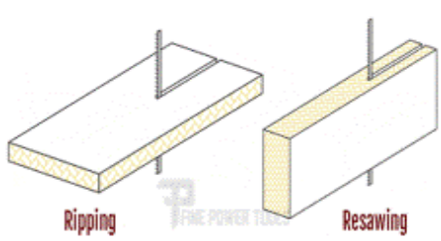
Lumber (also known as timber), wood that has been processed into beams and planks, a stage in the process of wood production, is mainly used for structural purposes but has many other uses as well. Cants or slabs of wood/lumber needs further processing at resaws so as to suit for the production of 'dimensional lumber' (lumber that is cut to standardized width and depth) for the various uses in framing wooden buildings, joineries and fixtures (doors and windows – frames & shutters, furniture) and in the manufacture of many other utility products. The second stage of conversion is called 're-sawing' and refers to more precise cutting to the required sizes, followed by preservative treatment and drying (seasoning) and then the downstream mechanical processing for product manufacturing which includes activities such as such as planning (surface and thickness), moulding, routing, turning/carving, joinery work (tenoning and mortising, boring/drilling, etc. followed by product fabrication and finishing activities such as sanding and polishing. As usual, the finally finished quality checked product will be packed, stored, and transported for marketing. This entire process for the wooden product manufacturing is termed as the 'secondary conversion – resawing – downstream processing'.

Resawing Operations

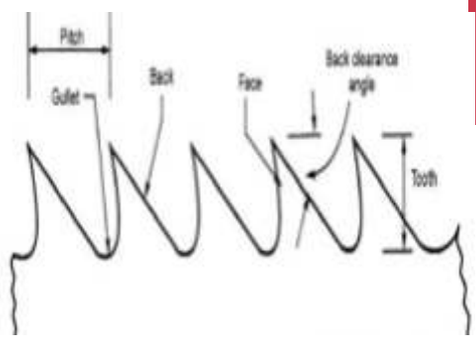
Secondary Conversion is the further breakdown of slabs, flitches and cants into planks boards. Resawing is the process of cutting the wood across the thickness and along the length to produce two thinner slabs of wood. Resaws relieve the primary saw of additional cuts, aiding material flow within the mill. Primary cuts reduce logs into slabs of wood, secondary cuts produce boards. The ends of each log is trimmed to ensure they are straight and cut into boards. Large circular saws are then used to further-process the boards, removing the curved edges. Each processed piece of wood now looks like a board. Boards incorporating natural defects such as knots (branch abscissions) are inferior to clear boards. The aim of the sawmill is to cut logs to produce boards of greatest value. However, when logs are pruned, knots are only exposed after primary cutting. This complicates the conversion problem. To effectively convert logs into boards the interrelated effects of the cutting phases must be recognized. The objective function can be modified to maximise either total value of boards (incorporating quality) or total volume. Results from simulations indicate that significant increases in value are possible when quality is considered (Todoroki and Rönnqvist 1999).

Band saw is the best choice to do resaw, for reasons of the thin kerf possible and bandsaws can resaw much wider boards. A resaw is a large band saw optimized for cutting timber along the grain to reduce larger sections into smaller sections or veneers. Resawing veneers requires a wide blade – commonly 2 to 3 inches (52–78 mm) – with a small kerf to minimize waste. Resaw blades of up to 1 inch (26 mm) may be fitted to a standard band saw. Many small and medium-sized sawmills use 1- 1.5 inch band saw blades. Timber mills use larger resaws to rip large planks into smaller sizes. A typical mill sized resaw blade is eight inches wide and made with 16 gauge steel. Resaw blades can be identified by their straight back, as opposed to headsaws and double cut blades, which have notched or toothed backs.

The resawing basics consist of the craft skill of an expert wood worker in the following steps: *Installing the proper blade:* a 3- or 4-TPI (teeth per inch) blade with a 5° to 10° positive hook tooth configuration. Its deep gullets clear sawdust from a wide ripcut, while the hooked teeth make for an aggressive cut. Choose a wide blade–typically 1⁄2" to 3⁄4" for a 14" saw with thickness ranging 0.022" to 0.035" for bandsaws 17" and less. To set up the resaw: first adjust the blade tension, then adjust the height of the guide post, & guide; Square the table to the blade, and do the resawing milling.



Both ripping and resawing are cutting the wood along the grain direction. However, in ripping you are cutting across the width whereas resawing refers to the cutting across thickness. In short, rip-cut splits the wider board into two smaller width boards whereas resawing slices the lumber into two thinner boards



Resawing operations

The re-sawn dimensional lumber needs to subjected to preservative treatment (optional, for durable species only), followed by season (drying) (mandatory for all species of timber).

Some of the latest technologies like Laser Cut is has the advantages of freedom of cutting from point of interest, minimum wastage (as the kerf is less), and less energy consumption, but with the disadvantages of difficult to cut thick section, and charred/black surface with smoke production issues.

Preservative Treatment for imparting enhanced durability to less durable /perishable timbers and wood containing sapwood could be done by the simple **dip diffusion treatment** which does not requiring any operational skill, plant and machineries or equipments. This method essentially involves dipping the wood in the specific preservative solution of the required concentration for the desired time duration (depending upon the thickness of sizes) followed by storing the treated material under cover for the desired diffusion storage in order to facilitate the through and through or possible maximum penetration and uniform distribution of the preservative chemical within the treated wood by preventing the immediate drying of timber by exposing it to the open dry atmosphere. This method had the disadvantage of taking more time and handling difficulties; only less quantity of material could be treated within a specific time. This is ideally suitable for rural woodworking artisans/treatment at the village level for the treatment of small quantity of material. Only green wood can be treated by this method.

For the industrial-scale/commercial treatment of mass quantity of material within short time, use of vacuum – pressure impregnation (VPI) treatment plants (requiring high establishment cost and technical skill to operate) are necessary. Effective penetration and distribution of the preservative chemical can be ensured in the treated material by the application of an initial vacuum (to remove some moisture and air) on the wood placed in a treatment cylinder (connected with the solution storage tank with a vacuum pump and a pressure pump) and then to impregnate the material with the preservative solution of required concentration under the application of a specified pressure for desired time duration, followed by the withdrawal of the treatment solution from the treatment cylinder where the wood is placed for treatment and the application of a final vacuum for a very limited time duration for preventing the immediate bleeding of preservative from the treated wood when once it is removed from the treatment cylinder. Care should be taken to ensure that the Indian Standards for preservative treatment of wood (BIS 2001) are strictly followed. Use of the preservative chemical withadequate concentration is of prime importance to achieve the required dry salt retention suggested in the standards. Boron formulations of boric acid and borax in the ratio 1: 1.5 wt/wt. is the most eco-friendly preservative chemicals used for protection of perishable timbers for indoor use; commercial formulation of copper-chrome-boron (CCB) preservative is employed for the protection of wood for use in exposed conduction, such as for

construction. Use of CCA is getting de-promoted in the country due to environmental reasons. Use of other types of preservatives such as the organic solvent based and new generation preservative chemicals are rare in the industrial sector mainly due to cost factor. Similar is the case with the application of nonconventional preservation methods such as the chemical and thermal modification of wood. Even though the use of acetylation and furfurylation techniques for the non-toxic **chemical modification of wood** (bulking the cellulose hydroxyl groups so as to make it unrecognizable as food source to the enzyme molecule secreting by the attacking fungi in the chemical modification treatment) were theoretically developed in the country, commercialization is awaited for want of pilot scale testing and validation. Similar is the case with method developed within the country for the thermal modification (heating slowly in a nitrogen atmosphere with less than 2% oxygen at a temperature range of 160 to 240°C) of wood where even the use of chemicals can be avoided for wood protection; as the method being energy intensive due the cost of heat sources and equipments related, for want of commercial pilot scale testing and validation facilities limits the transfer of technology within the country.

Timber Seasoning/Drying is a must for ensuring the dimensional stability (thereby marketability and price too) of the products and to certain extent durability. The main reasons for drying timber include:

To prevent unacceptable shrinkage after installation; To maximize strength, as mechanical properties of timber generally increase as it dries below 25%-30% moisture content; To reduce susceptibility to fungal decay, timber maintained at < 20% MC is unlikely to be attacked by sap stain and decay fungi; To make processed timber easier to handle, as seasoned timber is not as heavy as green timber; For effectively glue, paint, stain, fill and polishing; and to prevent the corrosion of metal fixings.

Natural drying using solar heat is the most cost effective method of drying timber, for which the method involves drying properly stacked timber under shade or air-drying sheds of proper design and ensuring intermittent inspection to avoid the development of casual drying defects (which is likely to be more in air drying as humidity – temperature controls are difficult to manage here). Timber needs to be dried so as to reach a moisture content of 12-10% for the product making and use in the Indian climatic conditions. Moisture content can be checked in wood with a calibrated moisture meter or by the use of a heating oven and weighing balance. Even though the method is cost effective, air-drying is time consuming (3-6-12 months) and handling difficulties are more; much material cannot be dried within short time. As atmospheric temperature and relative humidity cannot be controlled in air drying process, losses through cracking, splitting, warping can be considerably minimized by paying proper attention to stacking, protection of stacks against direct sun heat, dry winds, and sanitary conditions. Air seasoning technique consists mainly in making a good stack of sawn timber with the help of crossers on raised foundation.

For the industrial/commercial scale drying of timber within short time (2-4 weeks), higher throughput and better control of moisture content, artificial drying employing **dry kilns** can be followed; artificial source of heat being always expensive (use of fuel wood/thermic fluids, electricity) and this system requiring a spacious well-insulated drying chamber (with adequately controllable air and steam vents) where the timber can be properly stacked (to prevent/control the development of drying defects in timber) and

temperature and humidity inside the kiln can be controlled. Proper kiln drying schedules available needs to be followed; care should be given to ensure following the Indian Standards for seasoning (drying) timber (BIS 1993).

Alternative to dry kilns, use of **solar timber drying** kiln (employing black body radiation) as a pre-dryer and then employing a dry kiln can save the energy expenditure for drying considerably. For drying wood for specialty purposes, use of cutting edge technologies such as **vacuum drying** or **radio frequency drying** could be employed. Except air-drying, all other drying systems are capital intensive (high establishment and operation costs) and drying cost will be increasing with the increasing high-tech nature of the drying technology employed.

Dehumidifier kilns are **especially suitable** for drying timber on a small scale; advantages include low capital, low running costs, and low levels of degrade. Dehumidification chamber uses a heat pump to condense moisture from air using cold side of refrigeration process. Heat gathered is sent to hot side of refrigeration process to re-heat the air and returns this dryer and warmer air. These kilns traditionally operate from 35°C to 75°C and use about half the energy of a conventional kiln and takes around 12-18 days for a batch of wood to get dried.

Energy efficiency of conventional dry kilning being maximum around 50%, while by introducing the Dehumidification drying the same can be improved up to a maximum of around 75%.

Vacuum Dry Kilns with control over chamber pressure, heating and humidity of the drying process, drying within still shorter period, 5-7% MC in 10-12 days with minimal checking is possible with less discoloration, being the drying in vacuum, oxidation discoloration possibility is less. Temperature control is provided by a heating system

for precise vapour pressure control. Process leaves the wood incredibly stress free with no need for conditioning.

Microwave Drying is a good technique to dry wood in a hurry; drying can be completed within hours. Microwave oven works by vibrating the molecules within the material which creates heat. The microwaves penetrate deep into wood. Molecules in sap are easier to vibrate than those in wood. Heating/expansion moves the liquid out from the centre, dry outer surface drawing the moisture out from the centre.

Downstream Processing

According to the selection of machineries as per their nature, number, specifications, brand, etc., depending on nature of raw material wood, processing required, the nature of products to be made and their finishing requirements, waste utilization requirements, pollution control aspects, etc. the machinery costs will vary. For a specific purpose, there could be locally made low cost ones to very high quality machines of varying brands and cost. Machineries need to be finalized after ascertaining the production line flow charts.

Downstream Processing for product manufacturing mainly employs mechanical processing of the dimensional timber with the use of machineries.

Conclusion: Machineries Suggested for Wood Processing Units

Al list of machineries commonly suggested for a wooden product manufacturing enterprise essentially involves the following:

Sawing Machines	Routers	Blade Grinders
Portable Chain Saws, heavy duty	Pneumatic high speed Router	Band saw blade Grinder
Horizontal Band Saw	CNC Router automatic	Planner Blade Grinder,
Vertical Band Saw	Preservative Treatment Tool Grinder	Profile Grinder/ Universal
Table Band saw	Dip Treatment Tanks	Moulders
Resaws	Vacuum – Pressure Treatment Plant, with automatic door, trolley line, trolleys, and all accessories	Spindle Moulder
Cross Cut Circular Saw	Wood Seasoning	Four side Moulder, 6 Head
Radial Arm Saw	Dry Kilns, with Boiler, steam lines, chimney; with trolley line, Trolleys, and other accessories	Laths & Copying Machines
Tilt Arbor Saw	Planners automatic	Copy Shaper, Heavy Duty,
Jig Saw	Surface Planner	CNC Lath, Automatic
Pneumatic cut-off-saw	Thickness Planner Machines	Tenoning & Mortising
Precision sliding table saw	Boring/Drilling Machines machine	Double end Tenoning
Panel Saw	Drilling Machine, standing type	Rectangular Tenoner
Panel Beam Saw	Three Head Multiple Boring Machine	Oscillating Mortiser
Guillotine Jointer Machine	Panel Board Making Machines	Sanding Machines
Dust Collectors	Finger Jointing – Finger Cutter, Gluer, Glue-setting, etc.	Sander Planner
Diesel Generator, heavy duty	Clamp Carrier, Hydraulic Sander, Auto Planner	Two Head Wide Belt
Crane	Veneer Splicer Machine /Finishing	Polishing/Painting
Fork lift	Hot Press, Hydraulic	Spray Paint Booth
Computers & Peripherals – Design Studio, Software, etc.	Edge Banding Machine	Air Compressors
CC TVs	Motors	Portable Machines

Chapter 9
Wooden Furniture Sector

Wooden Furniture Sector, for practical purposes includes furniture & fixtures along with cabinets, doors and windows frames and shutters, etc. and the sector overlaps slightly with the wooden handicrafts as well as building sectors, as carved and turned wood many times become parts of wooden furniture and fixtures and buildings.

Furniture is one of the most important components of any household. Furniture makes a person's space more suitable and comfortable for living and working. The concept of furniture developed as early as 3100-2500 B.C. Dressers, cupboards and beds were among the first forms of furniture. Over the years, the concept of functional furniture in household has exploded while keeping the artwork aspect displayed in the olden times. This has made way for furniture in our culture that is both functional in our everyday lives but also a form of artwork that are pleasant to look at. Indian furniture history is a blend of European furniture styles and Indian materials and techniques. In early India, most people didn't have furniture; but with European colonization, furniture was developed using Indian craftsmen to make furniture with Indian materials like hardwoods of teak, ebony and shisham. The basic design of most furniture has remained the same for most part though material and stability has become stronger and longer lasting with more focus on comfort and luxury in our modern lives. Chairs have become designed as more than just a place to sit, but as a place to relax with items such as recliners and rocking features. The design change in furniture, in a way, shows the evolution of our society from mere survival to live of luxury and privilege. The furniture industry relies extensively on wood and wood-based materials as it excels in performance, manufacturing, appearance characteristics, and ease of assembly of wood pieces with other materials and it can be readily available with varnishes and paints. Wooden furniture is the most common consumer choice cause of its innate stability and reliability, pleasant appearance, sustainability and good economic value over the long term. The unique and vibrant traditional furniture art reflecting customs and culture has created a niche for Indian furniture in the global competitive market. It is also influenced by availability of natural resources, terrain and topography, climate and socio-economic factors. These attributes aligned with sustainable management practices and sensitized consumer market would lead India as the potential global leader in the sector (Mishra and Sunder raj, 2020).

The story of wooden furniture in the country may starts from primitive unfinished wooden coat – cum – chair to the princely peacock thorn to the modern-day's elegant cushioned design furniture. Maple, oak, cherry, pine and cedars are generally considered as the best furniture timbers over the globe; while the popular wood types used in India include walnut, sandalwood, teak, sheesham, rosewood, deodar, ebony, redwood, red cedar, white cedar, satin wood, mahogany and sal are considered to be some of the best common furniture wood in India. Sandalwood and ebony are also used very rarely due to cost and availability factors. Pine may be the cheapest wood easily available for furniture making and is considered to be of a higher quality compared to most softwoods. Additionally, it also blends with other types of woods hence complement each other easily, making it one of the best choices for softwood furniture.

Different wooden furniture items are available with different designs for the homes, offices, service sectors such as hospitals, airports, railway stations, etc. in the Indian furniture market. Apart from indigenous timbers available in India, wherever domestic supply is inadequate, import of wood is also practiced.

Teak accounts for almost 50 per cent of the total wooden furniture produced; sal and deodar account for about 20 per cent and the balance includes mahogany, cedar and other tree types. Plywood, Bamboo Material Boards (BMB) and Veneered Panels are also becoming popular in the Indian wood

furniture market for manufacturing furniture. The abundant rubber wood supply from the southern state of Kerala (producing 95 per cent of the total supply of rubber wood in India) is also making use for furniture sector after due preservative processing for enhanced durability. Natural rubber plantations cover 520,000 hectares with an additional 6,000 hectares being replanted almost every year since 1994.

Although furniture making as an activity is spread across the length and breadth of India, a few centres have become famous for their exquisite carving, inlaying, turning and lacquering. Indian states well known for woodwork include Gujarat, Jammu & Kashmir, Punjab, Uttar Pradesh and Kerala. India is one of the largest consumers of wood in South East Asia. The country has sufficient availability of tropical wood, however, in recent years, growing concerns about the environment and the need for conservation of forests have led to reduction in the supply of wood. India imports wood from various countries like Malaysia, Indonesia, Myanmar, and Ivory Coast, etc. MDF boards are imported from Europe, soft and hard wood are imported from Russia and other South East Asian countries. Veneered panels are becoming increasingly popular in India and are imported from the European Union and USA. This situation called for rigorous awareness on the quality of furniture wood. The Indian and imported timber species mostly used for furniture works in the country includes:

Tectonagrandis (Teak), *Dalbergia latifolia* (Rose wood),*Dalbergia sissoo*(Sheesham), *Chloroxylon swietenia* (Satinwood), *Swietenia macrophylla* & *S.mahagoni* (Mahogany), *Shorea robusta* (Sal), *Cedrus deodara*(Deodar), *Artocarpus heterophyllus* (Jack), *Melia azederach* (Marandi /white cedar), *Morus alba* (Mulberry), *Juglans nigra* (Walnut), *Acer saccharum* (Hard Maple), *Betula alleghaniensis* (Birch), *Quercus* spp. (Oak), Prunus spp. (Cherry), Pinus spp. (Pine), *Castanea* spp. (Chestnut), *Robinia pseudoacacia* (Black locust), *Thuja* spp. (Cedar).

The furniture industry is increasing by leaps and bounds worldwide and sustainability has become one of the most important features of the furniture industry. Wooden furniture has been growing in demand because of its luxurious appearance, longevity and sustainability, as wood locks carbon. India imports Rs. 2.5 lakhs crore worth furniture from abroad; even though China is the dominant exporter; due to national interests, import from China is getting discouraged. On the Atmanirbhar call by the Honorable Prime Minister, even though some webinars on wooden furniture were organized by DPIIT and FICCI, attention was distracted on large-scale investors like IKEA only.

The Covid pandemic has slowed down the growth of furniture industry and needs proper examination of the present and future scenario, the problems need to be identified and unique solution should be devised to promote the growth of wooden furniture. Promoting Trees Outside Forests (ToFs) could be the potential solution for the future raw material availability.

Current Situation of the Wooden Furniture Industry

The demand of the furniture could be classified into residential furniture, commercial furniture, and hotel and other furniture. In India, the furniture manufacturing for residential purposes is done by the local carpenters with available tool and locally available timber. Whereas for commercial use, mostly re-constituted/engineered wood or pre-fabricated and imported wood panels are used; similar is the situation with the manufacture of hotel furniture too. For furniture for schools and government establishments, only a very small extent is made of wood; major quantity is mostly made from metals. The demand for artistic wooden furniture is low because of cost factor; scarcity of skilled craftsmen/carpentry workers causing price escalation of the products. Since the cost factor is one of the major considerations in the market, imported furniture is filling the market demand as it is more artistic many times and considerably cheaper than local furniture. Hardwoods are preferred more over softwoods because the higher density wood has superior manufacturing characteristics such as better machining and finishing, and higher strength.

Additionally, hardwoods have a more interesting colour and appearance. Solid Wood is widely preferred in furniture manufacturing owing to its durability and resistance characteristics in the longer term.

The Wood Furniture Market in India is growing at a CAGR (Compound Annual Growth Rate) of >11% over the next 5 years. Wood accounts for nearly 65% of all furniture made in India. This includes several types of indigenous wood, as well as imported wood. India imports wood from various Southeast Asian countries, such as Indonesia, Myanmar, and Malaysia. The popularity of traditional furniture has strengthened the demand for wood in the manufacturing of furniture in India. Over the past few years, the utilization of wooden goods at the home has increased as people have started using wood for furnishing cupboards, decorating, and for other purposes. Wood Furniture Market in India is segmented by type (hardwood & softwood), material (plywood, laminates, MDF, and other materials), product (bedroom, seating, kitchen, and other products), and by application (residential & commercial). The wooden furniture industry uses both indigenous wood and imported wood. The furniture market in India is moving from the unorganized sector to the organized industry to adapt to fast changes in the furniture market. The demand for wooden furniture in the Indian market is mainly driven by the residential sector. The contribution of the residential sector for the demand for wooden furniture is high as compared to the commercial sector. This is mainly because people are utilizing wooden furniture in homes for many purposes such as cupboards, decorating, and other purposes. This is augmenting the need for wooden furniture such as sofa sets, dining sets, beds, chairs which are further expected to witness prolific growth in the upcoming years as well. The residential real estate market is also witnessing prolific growth in the last couple of years, owing to the increasing population and growing demand for affordable housing accommodation, which is likely to further add to demand in wooden furniture in the market. The critical states for the wood furniture market in India are Kerala, Punjab, Andhra Pradesh, West Bengal, Uttar Pradesh, and West Bengal. Engineered wood furniture goods are also gaining popularity in Indian cities. The leading cause of this is a rise in demand for ready to assemble furniture in towns. Urbanization and growth in the number of nuclear families in India are further adding to the demand for wooden furniture products. Changing lifestyles, tastes, and preferences for different kinds of wood furniture is escalating the growth in the wooden furniture industry.

The wood furniture market in India is competitive due to the presence of a large number of small and local manufacturers in the market, accounting for a larger share in production. Southern and Northern India has a high demand for furniture products, but it is in the South where most manufacturers and distribution networks exist. The Indian wooden furniture market has enormous opportunities for manufacturers to innovate and deal with growing demand in the wood furniture market. Local manufactures are partnering with foreign manufacturers to improve their quality and designs in the market. The need for modular furniture provides immense opportunities for wooden furniture and hardware owners in the market. Furniture manufacturers are considering several factors while designing furniture, such as the furniture's functionality, look, feel, and value while designing furniture.

Style, Design and Versatility of Indian Wooden Furniture: Historical Influences on Indian Wooden Furniture

Style and Design are reflections of ideas and culture which have been improvising over the time. It unites function, fantasy, tradition and sustainability. Designs are considered intuitive but are never devoid of personality and experience. Today, furniture is made using modern techniques and designs adapted from around the world. It is important to equip our designs based on the natural settings that we live in and it should tell a tale of local cultures and experiences. When tradition blends with this ecological material, there is extensive potential for design innovation to create an alluring piece of furniture.

Ancient Indian Furniture: India has the most diversified culture and heritage that have brought a unique blend of styles and influences to Indian Wood Furniture. Despite the rich and diverse history of culture, there was a lack of emphasis on household furniture. People practiced sleeping on the floor and enjoying meals while seated on the floor; later developed to the humble charpai (Indian cot bed). Therefore, homes usually consisted of cushions for seating or the low height stools.

Furniture making has been practiced in India since 1336 AD during the Vijayanagar Empire. Furniture making was considered more of an art and trade. Craftsmen were held in high esteem by the royalty because they were able to preserve legends and folklore in wood. The conventional and standard furniture items can be found in ancient temples and modern buildings. But it was mostly ceremonial, like the throne and other wooden carved lavish pieces.

The Mughal Style: The major Indo-Islamic influence on furniture of northern India was seen during Mughal reign. The Mughal style exhibited tables and writing desks amongst household furniture made from dark hardwoods like ebony and decorated with inlaid bone or ivory.

European Influence: India around 15th century was invaded by the European countries and the migration and settlements of the Europeans influenced furniture styles and materials. Consequently, Indian furniture styles and design are a blend of those from the East and West which is often termed as Indo-European/Anglo-Indian furniture majorly depicting the Portuguese and Dutch influence. Chairs with the most intricate wooden jaali work, tables with detailed in lay and four poster beds are typical examples found among the ancient Goan furniture.

It is only when in the beginning of the 1500's Portuguese invaded India, India got the big influence of different furniture kind, the Indo- Portuguese style. As the settlers wanted to have pieces like they had back home, Indian craftsmen and material came into practice to make the Indo-Portuguese style furniture which is a crossover of Mughal and Portuguese style. This style has intricate inlaid and incised geometric decorations on furniture and the most symbolic furniture of this style are chested drawers and screen separators. Goan furniture majorly exhibits the Portuguese influence.

Indo-Dutch Style: Indo-Dutch style of furniture included light-colored hardwoods with incised and inlaid decorations and furniture made from dark woods and elaborate floral carvings.

Traditional English Styles: The 18th century was marked by the British invasion and brought a predominant change in lifestyle and style of furniture. The furniture was made with Indian wood materials and decoration styles. 'Charpoy' or locally called 'charpai' influenced the English style of furniture because of its versatile utility. The British upgraded their diwan style furniture with bolsters and cushioning which was influenced by Indian culture. Diwan is one of the core components of Indian household furniture in present time.

Locations known for excellence in wooden furniture woodwork in India – Styles & Ethnicity

Although, furniture is manufactured in many different parts of the country, a few centres have become well known for their exquisite carving, inlaying, turning and lacquering for furniture. These are:

Kashmir: Famous for walnut wood carving as an ornamental and delicate craft process that is unique to Kashmir due to the concentration of walnut trees in this region. The hard, durable, black/dark close grained wood with even texture from the root and trunk of the walnut tree facilitates fine and detailed craftwork. It also presents visually interesting effects with mere plain polished surfaces. They make walnut furniture carved with intricate recurrent patterns of lotus, rose, iris, bunches of grapes, pears and chinar leaves and flowers, and dragon motifs, or lattice works. They adopt a semi-carving technique that allows the grain of the wood to be displayed along with the craftsmen's skill. Multi-layer undercut curving (**Khokerdar)** three-dimensional depiction of various motifs or scenes of jungle with layers of flora, intertwined, rabbits hopping from bushes, birds flying, etc.; open or lattice work (**Jalidhar**) of carved screens employing beautiful see-through Jali works, chinar leaf motifs and Mogul jali patterns, etc; **Deep carving** (**Vaboraveth**) as raised carving comprising dragons or lotus motifs with up to up to 5 inches. Depth; Semi carving (**Padri**) comprises thin panels along the rim of the surface with a central motif; and Shallow carving (**Sadikaam**) with motifs or scenes merely chased along the lines in pencil giving them a little depth, are the principal styles of the Kashmiri wooden work. The Kashmiri specialty of wood carving is the '**Khatam-band**' which has geometrical patterns beautifully done on the wood. The designs are either carved along the borders or filling the entire surface. The intricately carved floral patterns or geometrical motifs create beautiful pieces of art. A single piece can take from 2 days to 6 months depending on the intricacy of the pattern. Walnut wood has an inherit sheen which surfaces on its own when polished with wax or lacquer. **Jaali Designs:** Jaali or 'net' designs are commonly found in Indian furniture across the regions. The wooden frame of the furniture is fitted with Fabrics or materials of netted design. The Jaali design can be simple or have patterns such as ornate leaves and creepers or geometric flowers.

Saharanpur (Uttar Pradesh): This is the most flourishing commercial centre for woodcarving in the country. Sheesham and teak are extensively used for the small-scale manufacturing of traditional, as well as modern furniture products. Influenced by Kashmiri designs, with many of the craft-persons having descended from Kashmiri immigrants, these influences continue to reflect in contemporary products like the finely chiselled screens and *jaali* work and the *anguri* or vine leaf pattern found in many Saharanpur furniture products. The history of wood carving in Saharanpur dates back to the 15th century with the settlement of Afghani artisans in the outskirts of Saharanpur. Carved wooden furniture of Saharanpur can be found anywhere from different regions of IndIA to Bahrain's kingdom. The furniture is known for its intricate carved patterns on the wood that requires utmost precision and skills; the indigenous design and quality have exhibited their furniture as world-class and have been in demand internationally. The export of Saharanpur heritage furniture art has flourished the industry but the local artisans need a reform to uplift their economies and create a better and safer work environment. This furniture has created a niche for itself in the international market owing to its luxurious appearance, durability and ethnic designs and is now projected on e-commerce platform.

Gujarat: Besides carved chests and almirahs, Gujarat is synonymous with the wooden swing and the **Sankheda style.** Different varieties of swings are made using a range of wood from unvarnished hewn wood to rich lacquer. *Sankheda village,* in Gujarat, has a unique tradition of engraving indigenously developed silver, gold and bronze colours on wood; fragile and durable teakwood furniture treated with lacquer and painted in traditional colours of maroon and gold. To promote the furniture art form, a training institute for Sankheda furniture has been established in Ahmedabad.

Surat has a tradition of parquetry/marquetry (inlaid work made from small pieces of coloured wood or other materials, used for the decoration of furniture) work, locally called ***Sadeli.*** Sadeli is a form of the art of decorating the surface of wooden articles with delicate pieces of wood and other materials in precisely cut geometrical shapes.

Jodhpur Shekhawati or Rohida style is one of the most prominent styles of Rajasthan wood furniture. It is mainly made using Marwar teak (Tecomella undulata), traditionally. This style requires high craftsmen skill for the neat carving of geometry and patterns. This furniture uses wood of Rosewood, Shisham, Mango and Acacia. The finesse of the product renders a luxurious appearance. Rajasthan is synonymous with wooden furniture art at its core and the huge scale of wooden furniture industries. The furniture is recognized for its artistic representation of fauna and folk designs; the pompous royal appearance makes it a higher-end product in both the domestic and international market.

Hoshiarpur (Punjab): Wood workers here specialise in inlaying ivory, now more or lessreplaced by plastic due to its low cost. Intricate designs have received royal patronage some generations ago. Wooden furniture, trays and mirror frames repeat certain basic motifs and ornamentation derived from nature.

Chettinad Furniture: Chettinad furniture f Tamil Nadu is a blend of South Indian culture and the European style of design. The furniture is made mainly from teakwood and embellished withmarble. Chettinad is one of the most distinctive Indian furniture art while the patterns of grids and flora keep it on par with contemporary architecture.

Andhra Pradesh is known for its colourful red sander furniture.

West Bengal has its own tradition of strong folk carving. Carved figures, furniture, cabinets, jewellery boxes, chests and lamp stands produced in Bihar, are noted for their elegant designs.

Kerala: Woodcrafts in the state of Kerala, 'God's Own Country,' vary from household furniture to animal figures, which is a major economic and cultural activity. Carvings from Kerala represent its tradition and borrow strongly from spiritual values and thoughts.

Odisha excels in making beautiful dowry chests of painted wood, in addition to carved figures of Lord Jagannath and the temple at Puri.

Northeast States- Bamboo and Cane Furniture: Cane and bamboo weaving techniques are extensively used in Northeast Indian states and also in Himachal Pradesh. This style of furniture has been used since colonial times and continues to be one of the preferred choices of furniture for casual interior design and a perfect addition to an outdoor setting.










Cane Furniture




Bamboo Furniture



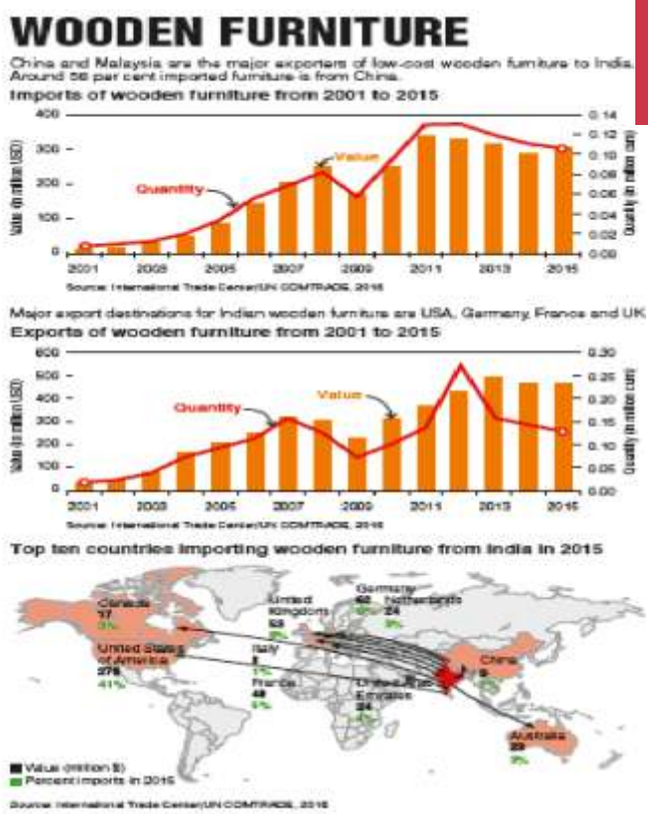


Availability of Raw Material and Labour - Issues

Almost 50% of the entire furniture made in the country is with teak and out of the remaining, around 30% accounts for timbers like mahogany, cedar, sheesham, mango, etc. and 20% with sal and deodar. Wooden furniture market in India during 2019-'20 is estimated to fetch Rs. 936 crores with a projected CAGR (Compound Annual Growth Rate) of around 15%. The future of the furniture industry of India is bright, with a huge growth in demand, but poor business models within the unorganized sector discourage competiveness. The procurement of raw material presents its own set of The major commercial timbers are getting scarce and costly, as forest resources cannot be depended upon any more for the future wood requirement for furniture industry. The preservative treatment technology used to make secondary timbers durable and usable is yet to be widely made use of in the local furniture sector. It is the durable local timbers that are available from agroforestry ('Agro Wood') or Trees Outside Forests (TOFs) are meeting the small timber requirements. The total forest cover of the country is 7, 12,249 km2 which is around 21.7% of the geographical area of the country. The Total growing stock of wood in the country is estimated to be about 5,915.8 million cubic meters comprising 4,273.5 million cubic meters inside forest areas and 1,642.3 million cubic meters outside the forest, from TOF, as per the report of the Forest Survey of India (FSI). The cost of extraction of the wood raw material available within the country is also high. Due to various reasons, skilled workers are not available to the extent of requirement. The cost of labour in the country is high when compared to prominent furniture making of the South-East Asian countries. The avenues for skill up-gradation are also less. The youths' aspiration to enter this sector is low and existing workforce is looking for other sectors for better wages and facilities. The furniture sector could not offer competitive wages compared to other employment options. This further develops discontent among the labour force.

Future Scenario

The demand for furniture in India is increasing annually at the rate of around 15%. Wooden



furniture is the only category in which Indian wooden products exports exceed its imports. The market is moving more towards organized sector, as the present customer preference is towards high-end readymade and branded low maintenance, quickly installable wooden furniture products. Simple designs are the preferred trend compared to traditional artistic furniture. Furniture made from regulated wood had high scope for export.

Desirable Wood Quality Parameters for Furniture and Fixtures

Wood to be used for furniture and fixtures should be strong and hard, it should be durable (resistant to rot/fungi, borer etc.), dimensionally stable (low in shrinkage and swelling, water resistant) and aesthetically appealing. For decorative and ornamental furniture, grain orientation, texture, colour and figure are important requirements.

Requirements of timber for different types of furniture and cabinets are different. Moisture content, density (weight), shrinkage (retention of shape); static

and impact bending, compressive and tensile strengths of the wood species are required to be evaluated as per Indian standards (BIS, 1986) to compute the strength coefficients and other parameters. Considerable amount of data on different anatomical, physical, mechanical and chemical properties of various wood species had been already generated by FRI (FRI 1970, 1972, Rajput et al. 1996).

Moisture content: The amount of moisture present in wood sample is expressed as a percentage based on its oven dry (OD) weight. For the determination of moisture content in wood working places, a calibrated moisture meter can be used for quick operation of large number of samples on a regular basis. Wood is a hygroscopic material that absorbs moisture in a humid environment and loses moisture in a dry environment. As a result, moisture content of wood varies as a function of atmospheric conditions; it depends on the relative humidity and temperature of the surrounding atmosphere. Under constant temperature and humidity conditions, wood reaches the state of equilibrium moisture content (EMC) level at which it is neither gaining nor losing moisture. EMC represents a balance point where the wood is in equilibrium with its surrounding environment. The EMC of wood is invariably controlled by relative humidity and temperature conditions of ambient air. In an uncontrolled environment, EMC of wood will be fluctuating depending on the seasonal climatic conditions and locations. Under normal conditions, average EMC value of wood is expected to vary in the range of 10-14% (12±2%). The equilibrium points are generally found to vary throughout the country, from the dry desert areas to moist coastal areas along the sea. In addition, a wide range of relative humidity can be experienced between individual job sites within the same location. For example, a property located oceanfront will have a higher EMC than a home away in mainland. Different heating/air conditioning systems can also dramatically alter on site relative humidity thereby changing EMC of the wood (BIS 1991).

Wood Density: Density of wood is one of the most important physical properties; most of the other physical and mechanical properties of wood are closely correlated to density; in general, denser wood exhibits greater mechanical properties such as strength, stiffness and hardness. Density is determined as the ratio of its weight to the volume; the oven-dry weight to green volume based density (wood basic density) is usually used for comparison purposes. Density (colloquially 'weight' or 'heaviness') is inversely related to the porosity (or proportion of void volume) of wood. Timber for any product making is to be dried near to 12% and subsequently the strength values is used to be adjusted to 12% for the purpose of comparison.

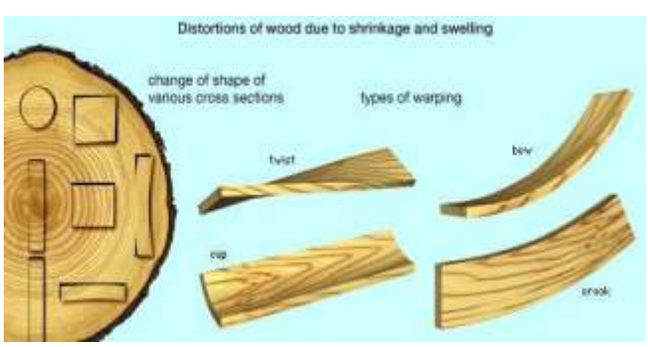
Shrinkage is the reduction of the dimensions or the volume of a wood piece due to changes in its moisture content from higher to lower values. Factors affecting shrinkage and swelling are moisture, density, chemical composition, and mechanical stresses in wood. Wood shrinks when bound water is lost from the cell wall and swells after water absorption. The dimensions of wood block reduce when moisture content decreases below Fibre Saturation Point (FSP) (Moisture content 25-30%) and the extent of shrinkage is proportional to moisture loos. Changes in moisture content above FSP have no significant effect on dimensions or volume of wood sample. Shrinkage or swelling should occur evenly across timber for it to retain its dimensional stability. As such, amount or extent of shrinkage/swelling will be different in three principal directions in wood. Specifically, change of dimensions is least in longitudinal direction (along the fibre direction), much greater in the radial direction (from pith to periphery) and still greater in a direction tangential to growth rings. The following Table presents the range of values of the radial (SR), tangential (ST), longitudinal (SL) and volumetric (SV) in wood:

Shrinkage	Range of values
Radial (SR)	2 – 6%
Tangential (ST)	5 – 10%
Longitudinal (SL)	0.1 – 0.3%
Volumetric (SV)	8 – 18%

(Source: FRI. 1970, Rajput et al. 1996)

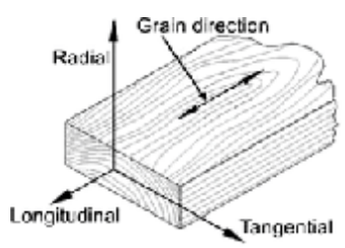
Dimensional stability of wood is one of the few properties that significantly differ in each direction of the three axes due to its anisotropic nature. Dimensional changes in the longitudinal direction between FSP and oven-dry condition are about 0.1-0.3% and do not have much practical significance. The combined effects of shrinkage in the tangential (up to 10%) and radial axis (up to 6%) can distort the shape of wood pieces because of the difference in shrinkage and the curvature of the annual rings. Wood also shows the hysteresis in increasing and decreasing moisture variations. It is to be noted that the differential shrinkages in radial and tangential directions and its accompanying effects such as checking, warping and splitting, etc. (also called faulty seasoning defects or drying defects) constitute wood's most troublesome physical property. Dimensional changes associated with shrinkage and swelling may cause further degradation in wood products. As a result of repeated shrinkage and swelling cycles in the wood during service, various defects may develop such as opening or tightening of joints and changes of cross-sectional shape of wooden objects.

Distortions in timber are deviations from straightness that occur after sawing. Distortion adversely affects the utilisation of timber; limiting the efficient use of the resource, but has little effect on overall strength. The various types of distortion include spring, bow and twist. Seasoning defects such as *cupping, twisting and warping* in wooden planks are also caused due to differences in radial and tangential shrinkages. Similarly, checking in wooden logs and planks is caused due to unequal changes of dimensions as there is some moisture gradient between surface and interior of wood. Traditionally, timber has been either visually or measurably graded on the level of distortion which is given an averaged value. The recovered volume of each grade can be used to indicate severity of distortion.



Mechanical/Strength properties of wood generally relate the resistance it applies to counter imposed external forces. Strength properties are closely related to density which varies widely depending upon the species and moisture content. Wood is generally much stronger in dry condition than in green or wet condition. An exception is impact strength; dry wood tends to shatter with high impact loads. For the sake of comparison of two wood species of different specific gravity, the wood with higher specific gravity values corresponds to the higher strength values. It is also to be noted that the wood is much stronger (7-10 times) when stressed parallel to the grain direction than perpendicular to the grain.

Specific Indian Standard procedures are to be followed for determining the mechanical properties of wood (BIS 1986). Timber species to be used for manufacturing furniture should have adequate physical and mechanical properties such as bending strength, weight (or density at 12% MC), retention of shape (low shrinkage values), etc. For furniture and cabinets applications, timber species are evaluated for their **Strength Coefficient** in terms of teak as 100 for strength as a beam (S1), suitability as a post (S2), splitting coefficient (S3) and retention of shape (S4).All these suitabilityindices (S1, S2, S3 and S4) are computed from the basic wood properties at the green and air dry conditions (Sekhar and Gulati 1972). Suitability figures for green and air-dry conditions are calculated separately which are used to compute the composite Suitability Indices. Finally, Comparative Suitability Index is calculated with respect to teak value, using standard formulae. Various principal basic and auxiliary basic wood properties for computation of suitability indicesare shown in the following Table. The strength coefficient is computed using standard formulae.



Principal basic and auxiliary basic wood properties for computation of suitability indices

Suitability index	Principal basic property	Auxiliary basic property
Retention of shape (S1)	Volumetric shrinkage	Radial shrinkage (SR); Tangential shrinkage (ST) & Shrinkage ratio (ST/SR)
Suitability as a post (S2)	Compressive strength parallel to grain (MCS)	Compressive parallel to grain FS at EL Static bending MOE
Hardness (S3)	Compressive strength perpendicular to grain, FS at EL	Hardness-radial; Hardness -tangential & Hardness-end
Splitting coefficient (S4)	Tensile stress (Radial)	Tensile stress (Tangential)
Strength as a beam (S5)	Static bending strength (MOR) bending FS at EL	Static bending FS at EL, Impact

(Source: BIS 1993, Rajput et al. 1996, Sekhar and Gulati 1972)

Based on above properties and strength coefficients, various Indian timber species have been classified into four different groups for furniture and cabinets as shown in the Table given below (BIS 1993b). It may be noted that the timber species selected for manufacturing furniture and cabinets should have adequate wood working qualities, smooth finish, colour, texture, figure and appearance. Moreover, all timbers should be seasoned to the moisture content of 10±2% using kiln or natural drying procedures. It may be noted that the sapwood of all durable timber species belongs to durability class III must be given proper preservative treatment to avoid fungus and insect attacks (BIS 2001).

Classification of timber species based on properties into different groups as per IS 13622

Group	Strength Coefficient (Teak as 100)	Weight (Teak as 100)	Grain, Texture, Finish, Polish, & Appearance	Examples of wood species
Super Group	>75	85-110	Excellent	Rosewood, Sissoo, Padauk, Teak, Kokko, etc. (13 species)
Group I	≥75	85-110	Very good	Safed Siris, Benteak, Aini, Bijasal, Champ, etc. (14 species)
Group II	≥65	70-120	Good	Haldu, Kathal, Deodar, Mango, Gamari, Laurel, Rubberwood, etc. (42 species)
Group III	≥50	60-130	Satisfactory	Fir, Kadam, Neem, Eucalypts, Chir, Bahera, etc. (34 species)

Need of Furniture Testing and Certification Facilities in Government R & D Sector in India

Furniture manufacturing in India is mostly driven by the designs chosen; the inputs come from in-house designers and market feedback. Manufacturers consider several aspects related to the customer (such as demography, lifestyle, motivation and aspiration, needs and preferences, etc.), raw material (type, quantity and availability) and internal capability (expertise, quantity and availability of labour, production process complexity and delivery time) for developing different designs, which in turn, determine the functionality of furniture, look, feel and value. Depending on the end user requirements, the furniture produced in India falls into two broad categories: domestic furniture meant for home use and commercial furniture meant for the office and hospitality sectors. Domestic furniture represents almost two-thirds of the total output. Manufacturers in the domestic sector typically try to differentiate on the basis of design variety and price; while in the commercial space, having a strong and reliable brand is important.

In present global scenario, there is great opportunity

for the furniture sector of the country to grow and grab the domestic as well as export markets. For this to happen, innovative designs, quality assurance and certification of the furniture are very important aspects with which this sector has to deal with. At the same time, the furniture sector of the country is facing many challenges which are to be addressed for desired growth of industry. India competitiveness in furniture sector is mainly because of following few reasons:

Raw material competitiveness:

(i) Huge gap between demand and supply of good quality timber due to less supply of local woods.

(ii) Suitable timbers are imported from different countries to meet the requirement of furniture industry.

Scale of operation:

(i) Only small percentage of industry operates at larger scale.

(ii) Most of the furniture manufacturing units belong to unorganized sector and operate at very low scale.

Making logistics efficient:

(i) Furniture hubs or furniture parks are required to be developed in different parts of the country.

(ii) Skilled labour force is to be generated by creating more numbers of training centers.

(iii) Supply chain of raw materials as well as finished products need to be strengthened.

(iv) Policy support – Government intervention is needed to make or improve the existing laws and procedures to ease of doing business, required to liberalize export policies.

Quality control through testing and certification:

(i) Testing and certification facilities are to be established in public sector in all the major furniture hubs for better quality control.

(ii) More emphasis to be given for research and development including designing and supporting the skilled force of master trainers.

(iii) CARB testing facilities need to be developed especially for the panel product industry of the country.

Roadmap Ahead for Furniture Sector of the Country (Anon. 2020a, Jha 2020)

- Defining the financing model (public/private/partnership) for the exports hub basis evaluation of special economic zone (SEZ) model and acquiring the land by expediting the regulatory clearances.
- Identifying the land from available land bank across states, basis proximity to port and existing logistics (rail/road) connectivity.
- Developing the investment policy on the basis of SEZ financial model to attract the potential players of the sector.
- Identifying and prioritizing the potential target companies (from both India/Globally).
- Developing the inbound and outbound logistics capabilities for raw material and finished products.
- Reviewing and reducing the import duty on wood logs, sawn wood and FSC/CARB certified panel products being used in the furniture sector.
- Identifying and finalizing local Indian tree species that could serve as the quality furniture raw material.
- Developing a long term forest policy for the identified tree species and implementing a holistic FSC certified plantation program.
- Creating a long-term plantation target policy and certification program & initiate implementation of the same.
- Introduce new design and skill development courses which are priority for the industry.
- Introducing new courses in relevant Institutes/Universities with industry participation.
- Create plan to set-up Training Centers in the furniture hub, based on defined modalities of joint funding by Government and industry.

Need for Furniture Testing and Certification

Furniture has evolved in parallel to the needs, comfort, tastes and status of civilized cultures around the world. As opposed to construction elements (doors, windows), furniture is not subject of certification when it is produced solely for national market. Export products, on the other side, are often required to pass a series of tests and to fulfill requirements prescribed by directives, especially when they are placed on overseas markets. However, furniture for special purposes, such as furniture for healthcare service institutions, is required to pass much stricter requirements. Modern global markets brought additional demand in front of furniture manufacturers in terms of low price, high quality and unfair competition. Indian wooden furniture industry is more or less a low-tech, labour intensive and supplier-dominated one; its pattern of innovation is business driven. The dynamics of innovation in wooden furniture industry is characterized as collective innovation without much emphasis on design aspects, quality assurance and certification. Today's consumers expect quality furniture and furnishings with durability and safe from harmful substances. These requirements defined by customer specifications, industrial requirements or legal norms and standards, need to be tested by a reliable and independent third party. IWST is in process of developing a facility to provide furniture testing services of international standards to ensure compliance of products and facilitate access to and competitiveness in demanding markets.

Current Status of Standard and Certification

No adequate industry standards are in place in this sector against which wooden furniture manufacturing, quality assurance and working environment can be benchmarked. A Standard Authority (Certifying Agency) is therefore required to be formulated to issue performance quality certificates for Indian wooden furniture industry. Sector's Skill Councils are to be more efficient and training standards are also required to be developed. Wooden Furniture R&D has to be a focus area; sector-academia collaboration is to be developed and strengthen. These aspects have to be taken care of, if wooden furniture sector is togain patronage by potential workforce and increase the export potential of the country.

Furniture Testing

Testing of wooden furniture and its components is a very essential service. Customer could use it and try out any offered product before it is delivered. Furniture needs to be tested in accredited laboratory which operates in accordance with International/ National Standards. Structural integrity, safety and durability of the furniture are very important quality parameters. Combination of cyclic and static tests used in performance testing simulate stresses that would be placed on the furniture in a normal-use environment should also be evaluated. The various tests that need to be conducted on furniture:

- Strength, durability, shock resistance, structural stability tests
- Mechanical and electrical safety test
- Material and surface testing
- Flammability testing
- Life cycle tests and ageing tests
- Ergonomic and functional testing and evaluation
- Fitness for usage tests
- Inspection of assembly instructions user manuals, product information
- Testing and analysis for contaminants and harmful substances
- Hygiene tests, assessments for kitchen and bathroom furnishings
- Life cycle tests and ageing tests
- Microbiological tests and assessments-resistance to bacteria and fungi
- VOC and formaldehyde emission testing
- Sustainability assessment

Facilities for testing Performance, Saftey, Flammability, Environmental aspects needs to be established in the testing centre(Anon. 2020b). Performance testing involves evaluation the structural integrity and safety of the furniture. Combinations of cyclic and static tests used in performance testing simulate stresses that would be placed on the furniture in a normal-use environment. Safety testing is used to evaluate the product's electrical, mechanical, and design safety in a normal-use environment. Flammability testing ensures that product does not ignite and pose risk to lives/property in its normal-use environment. Flammability testing has become an important issue as the usage and concerns of flame retardant chemicals in products continue to rise. Environmental Testingis used to evaluate the environmental, health, and sustainable attributes of a product. The demand for VOC emission testing is increasing as product manufacturers, architects, designers, and end users are requesting chemical transparency. Formaldehyde is the well-known example of a potentially dangerous substance that can be released from wood-based panel products such as particleboards, fiberboards, plywood etc. and should be quantified as per standard procedures.

Furniture Testing Standards

A variety of standards are applied in furniture industry, which requires manufacturer's understanding and compliance in order to sell into the market (domestic or importing country). Some of them are mentioned below (Anon. 2000c, Anon. 2000d, Benson and Reczek 2016, Prekrat et al. 2011):

- *ANSI/BIFMA (Business and Institutional Furniture Manufacturer's Association) Standards* develops, maintains and publishes safety and performance standards for furniture products.
- *International Furniture Standards (ISO):* ISO TC-136 Furniture; ISO 7170: 2005 Furniture: Storage units– Determination of strength and durability: International Standards
- *European standards* (EN): EN 14749:2016- Domestic and kitchen storage units and worktops. Safety requirements and test methods; EN 581(1 to 5):2017 Outdoor furniture – Seating and tables for camping, domestic and contract use.
- *American Standards for Testing Materials* (ASTM):ASTM F2057, ASTM F1912, ASTM F1821, ASTM F 2613
- *German standards* (DIN):RAL-GZ 430 (General quality assurance and test criteria for furniture)
- *British standards* (BS): BS 4875 Part 7 & 8, BS 7176, BS EN 12520:2015
- *Netherlands Standards:* NEN ISO 19833: 2018 (Test methods for the determination of stability, strength and durability)
- *Australia/New Zealand* (AUS/NZ): AS/NZS 4688.3:2000 (ISO 7174-1: 1988)
- *Japan* (JIS): JIS S 1017:1994: General rule for test method of furniture.

Bureau of Indian Standards (BIS) is the government body responsible for preparation and implementation of standards in the country; CED 35 of BIS is related with furniture made of woodand lists about 63 different Indian Standards for furniture in the category of 'Methods of Tests' and 'Product Specifications.

Performance and Quality Assurance Testing

Countries like Sweden, Norway, Denmark, and Netherland have developed a unified system of performance tests and common quality assurance labelling system. Although, some differences do exist from country to country, all of these countries make use of a symbol 'MOBELFAKTA' (Facts about Furniture) quality label system. In this system of quality assurance, functionality, durability and surface resistance of the furniture along with workmanship are evaluated. Three levels of performance: Basic, High and Extra High are identified. Results of the tests are summarized on a small tag attached onto each and every furniture items. This helps the consumers to make quick decision about the furniture before purchase (Eckelman 1999, Eckelman and Lee 1981, Prekrat et al. 2011).

Current Industry Scenario - Capacity Building of Ecosystem for Global Opportunities

Furniture industry ecosystem of the country is generally consists of designers, OEMs, material suppliers, distributors, retailers, contractors,

carpenters, polishers, painters, glaziers, upholsterers, influencers and customers. OEMs being the key operator in the furniture ecosystem, they are the natural contenders to take the lead in venturing global markets.

Global Export Opportunity in Next Decade

The global and domestic trade environment, coupled with government intent for the growing indigenous capability in the furniture sector will provide a window of opportunity to exporters in India to harness the latent potential (Anon. 2020e). Exporters have been interested in enhancing their production capabilities by opening up manufacturing bases in identified regions.

India has a great opportunity and potential to be among top global manufacturers and exporters like China and Vietnam due to the following attributes:

- Significantly lower labour cost compared to other countries, may result in significant unit cost reduction
- Cost competitive in raw materials (wood, panel products), cotton fabric (textiles), etc. - most competitive when using locally sourced wood and other materials.
- Differentiated furniture design capabilities- traditional (antique), modular and modern design furniture
- Preferred locationby top global furniture buyers (for certified & cost competitive products).

The furniture industry in India is dominated by micro and small units. Manufacturing units are not well-equipped in terms of technological know-how, access to capital, ability to design and innovate, control quality and market their products in international market. To achieve the production levels, quality and design standards set by the international markets is the key for these micro and small players to maximize their potential and contribute towards the growth of the sector. Cluster based development would help to synergize their existing resources and provide an opportunity for these players to acquire technology, access capital, upgrade skills, encourage indigenous design and help MSME units to handle large orders or cater to the need of the international buyers.

Thus, there is a need to establish a "Furniture Testing and Incubation Centre" which would benefit the entire furniture industry, especially the MSME (Government) segment (Shukla and Dhamodaran 2020). A project proposal for the same is in pipeline at IWST, Bengaluru; a concept of the same submitted to JICA for funding.

Of late, the most recent thought leadership paper published by Price Waterhouse & Co. along with IKEA provides a detailed report covering all issues of the general furniture sector in India which gives more insight into the wood furniture sector too.

The wooden furniture sector being considered as one of the focused subsectors for Steering Committee for Advancing Local Value Added Export (SCALE) constituted recently in the country considering the importance of the furniture sector; there is an urgent need for immediate unlocking of the sector by making available certified wood, reducing cost, skill development and capacity utilization.

Conclusion

Furniture industry in India is expected to expand at a Compound Annual Growth Rate (CAGR) of 12.91% during 2020-2024.Wood based furniture being constitutes 65% of the total furniture sector, about 80% of furniture sector use solid wood and the remaining 20% make use of wood-based panel boards - Plywood, Particle Board (PB) and Medium Density Fibreboards (MDF). Teak, Shisham, Sal, mahogany, cedar, mango, jackfruit, rosewood, deodar, etc. are the popular wood species for furniture sector; teak wood constitutes 50% of the sector. Last few years, rubber wood has also gained significant attention; out of which Kerala produces 95%. Around 85% of the wood-based furniture market is dominated by the un-organized sector. For commercial furniture, use of engineered wood like plywood, particle board, MDF is increasing. USA is a major market to Indian exporters and necessities to meet the CARB and other requirements.

As far the prospects and challenges of wood-based furniture sector in India are concerned, wood based industry being an important segment of MSMEs, immense potential exists to develop a green and self-reliant India making effective use of this sector, as It is predicted that $180-190bn global furniture export opportunity exists in next eight years;China & Vietnam are largest exporters in Asia to USA, Europe & Middle east in 2020, as reported by FICCI. The un-competitiveness of the country in furniture and wood panel exports mainly because of issues in raw material competitiveness, scale of operation, in-efficient logistics and inefficient certification and testing laboratories. Limited availability of certified wood is a major challenge and hence efforts for developing a timber policy to boost locally produced certified solid wood should be of prime concern for promoting the wooden furniture sector, as it being one of the most important wood sectors fetching good quantity of foreign export revenue. It is at least for this purpose, forest and timber certification needs to be promoted.

As there are niche markets for Indian furniture in several developed countries, and as Indian domestic furniture market is expected to grow at an annual rate of 12.9 % during the period 2020 -24, furniture industry is becoming more organized with the industries like Godrej Interio, Furlanco, Fabfurnish, Usha Lexus, Zuari, Durian, Evok, Urban ladder, etc., most of these organized sectors will insist on certified and cost competitive wood products for both Indian and export market. For meeting the environmental & human health standards such as CARB and other formaldehyde emission standards is necessary for export, continued R & D efforts are necessary to develop testing and certification facilities in this sector.

As there is high spike in import of furniture where there is no value addition happening in India under Free Trade Agreement, it is recommended that furniture (HS code 9403) should be kept under the negative list of FTA and increase import duty to 35-40%.Zero custom duty on selected raw materials that are not available with FSC/CARB certification domestically is also recommended.

Over and above all, wooden furniture sector being considered as one of the focused subsectors for Steering Committee for Advancing Local Value Added Export (SCALE)constituted recently in the country considering the importance of the furniture sector; there is an urgent need for immediate unlocking of the sector by making availablecertified wood, reducing cost, skill development and capacity utilization.Need strong support of Government to Research & Training institutes/bodies such as IPIRTI, IWST, NID, National Skill Development Council, ITIs, Furniture and Fitting Skill Council, etc.Furniture Testing, Research and Training Centre Facility needs to be established in newly planned Furniture Clusters in the country. New Skill Development Training Courses relevant to Industry may be designed in relevant institutes with industry participation and government support.

Chapter 10
Wooden Handicrafts Sector

Introduction

Handicraft is the traditional art of creating useful objects or decorative items entirely by hand. Wooden handicraft is a craft where skilled labour is employed to carve wood to create items with bare minimum tools. Each piece of handicraft is unique, owing to its individualistic craftsmanship. The history of Indian handicrafts dates back to the Indus Valley Civilization (B. C. 3000-1700). In India, wooden handicraft has flourished over the centuries; handcrafted wooden items are a prevalent feature of Indian culture. Skilled artisans carve traditional designs on wooden items, and enhance their look by painting them or with intricate metal/ivory inlay work. The magnetic appeal of Indian wooden handicrafts lies in its exclusivity. Handcrafted with skill and expertise, they reflect unparalleled artistic virtues. Wooden handicrafts are available in many sizes, shapes, finishes, and colours. There are many techniques that Indian craftsmen employ to create handicrafts that are nothing short of a masterpiece.

Wood from the vast number of tree species with which the country is blessed are used extensively for the manufacture wooden handicrafts. Wooden handicrafts include idols, utensils, decorative show-case items, boxes, beads, finely carved figurines, accessories, carved and turned portions of furniture and structural or construction elements, etc. Due to this reason, wooden handicrafts

sector overlaps to certain extent with furniture and to a still lesser extent with building or construction sector. Heritage civil structures such as worship places, old buildings, etc. rich with woodcraft are of great archaeological value. However, goods involving mass production employing machinery and conveyor belt system are not considered as handicrafts. Generally, soft to moderately hard, low to medium density durable timbers are preferred. Non-durable timbers require preservative treatment to enhance their durability. Products need to be made only on properly seasoned/dried timbers for dimensional stability.

Skilled craftsmen of each state create handicrafts using wood that is available locally. The most common varieties used to make Indian handicrafts are teak, sheesham, sal, oak, mango, ebony and mahogany. Expensive woods such as sandalwood, rosewood and walnut are used in producing fine pieces of decorative items, utilities and furniture and minor show-casing elements of building/ construction components. There has been a complete revival of the traditional and antique wood craft, owning to its uniqueness and demand in India and abroad. Indian artisans are experimenting with designs to create a blend of traditional and modern woodcraft. Each piece of Indian wooden handicraft is a labour of love, sweat, and patience, which no machine can replicate.

Wood Carving

Wood carving is the technique of creating elaborate designs in wood by hand, with the help of carving tools; hammer, chisels, drills and saws made from steel that were capable of being hardened and tempered to a state hard enough to cut wood without deforming, while not being so brittle as to shatter. The tendency of wood to crack, damage or to suffer from atmospheric changes coupled with the texture of material often proves challenging to the expression of features. Wooden handicrafts refer to the finished product, from individual sculpture to hand-worked mouldings. Different regions of the country manifest their own cultural traditions and ethos through the crafts which are not only unique to the region but are greatly influenced by the availability of suitable natural resources, the ideal species of wood. The nature and style of the woodcraft varies from community to community and region to region; from floral, traditional motifs to geometrical or abstract patterns.

Carving wooden handicrafts is a laborious process as great attention needs to be paid to the minute details.

In India, wood carving is a traditional art passed on by master craftsmen through generations. Wood carving involves shaping wood to make objects of utility and chiselling parts of wood to form intricate designs with the help of hand tools. Articles of daily use like rolling pins, ladles, walking sticks, and combs are made from softwoods; while costly timbers like sandalwood, ebony, walnut, rosewood and teak are used to carve items of decorative value. Indian craftsmen carve a wide range of wooden handicrafts including wooden furniture, decorative panels, screens, toys, spoons, bowls, trays, vases, book stands, jewel boxes, window frames, masks, idols, photo frames, key hangers, beads, etc.

Texture of wood is important in deciding the quality of products. Hardwoods like teak, oak, rosewood, sandal wood, walnut etc. and softwoods like pine, cedar, and fir are traditionally in wide use for carving. Generally, hardwoods are quite brittle and are difficult to carve with a knife or chisel; the most desirable texture for best carving results is softwood with featureless graining. The different techniques of carving consist of:

- **Deep wood carving** with a depth of two inches or more. These carvings are usually replete with intricate floral and animal motifs. This requires a lot of labour and skill, and is the most expensive form.
- **Shallow wood carving** is usually half an inch deep; skilled artisans carve patterns on a flat surface. This form of carving is traditionally characterized by mythological themes.
- **Latticework in wood carving,** involves ornate designs which are carved onto the wood. Mostly used for windows, this form of carving portrays carved motifs of interlaced foliage, animals, and birds, besides others.
- **Semi-carving** of wood is done on a thin panel along the rim of a surface. This form of carving is a carver's delight since it allows the grains of wood to be displayed along with the carver's skills.

The above mentioned wood carving techniques give birth to various wood carving styles such as whittling, chip carving, relief carving, intaglio carving and carving in the round, etc.

A set of tools is extremely essential to carve wood into desired shapes and designs. While carving knives are basic tools for wood carving to begin with, a small set of chisels and gouges would be of great use while carving comprehensive pieces. The more intricate the design the more mechanized the tools have to be.The most common tools used to carve wood include:

- Carving knives in various shapes and sizes are the basic carving tools
- Chisels of square and skew types, having a cutting edge, are forced into the wood to produce carved patterns
- Gouges; chisels with a partly cylindrical blade with curved cutting edges
- Rasps and Files, with separate conical teeth for detailed carving for excellent shaping of decoys
- Grinding/ RotaryTools (to be used in ventilated areas as they generate dust)
- V-Tools/ parting tools, with cutting edges in the shape of V and cutting angles ranging from 25 to 90 degrees, to make sharp incisions and fine carving.

Production Process

- Raw wood available in the form of logs is cut into planks of desired thickness and length.
- The piece of wood is then needs to be preservative treated to impart durability, if it belongs to non-durable species. Boric acid and borax in the ratio of 1: 1.5 is recommended with a concentration of 10% boric acid equivalent (BAE), if treated by the non-pressure dip diffusion treatment and 3-5% BAE, if treated by the vacuum – pressure impregnation (VPI) process; the details of which are available with the concerned Indian Standards (BIS 2001). The treated wood then needs to be seasoned (drying) for dimensional stability and to obtain a texture which is favourable for carving. Details of seasoning techniques were available with the concerned Indian Standard (BIS 1993).
- Decorative patterns are first drawn on the wood with a pencil.
- The design is then carved into the wood with a carving tool.
- Craftsmen inlay the wooden handicraft with metal, bone, or wood which gives off a contrast effect, enhancing the intricacies of the carved design.

- Different pieces of carved wood are joined together to make complete, functional objects.
- A protective coating is applied with a suitable wood finish.
- Chain saws are in use to cut logs for large carvings. Power operated band saws are used to cut off scrap wood effortlessly.
- Drills are primarily used to drill holes; they are available with several attachments to perform sanding, sawing, mixing paint, etc. also.

Lathes are used to turn wood. They are used to make spherical, cylindrical or round objects. They are handy while making vases, bowls, and plates. Primarily used for whittling and chip carving, carving knives are also used to make the surface of the wood smooth.Wood-carving chisels have a sharp flat edge which is used to cut into the wood. They are available in bent, straight, and spoon shapes.U-gouges with curved cutting edges with a 'u' shape are in use to remove large pieces of unwanted wood, to define large shapes, and to round out the edges; V-gouges are used to cut fine lines and for outlining while carving intricate patterns.

Wood Finishes

Wood finishes of different kinds are clear protective coatings applied on the surface of wooden handicrafts, gave protection of the wood from dimensional changes due to swelling or shrinking with climatic conditions (variations in ambient temperature and humidity) as well as durability to certain extent. Different types of wood finishes keep the wooden artefact beautiful due to the shine imparted and also give it smooth surface with colour. Wood finishing actually protects wood from water, dirt and grime apart from the wear and tear of everyday life.

Different types of wood finishes are identified on the basis of two criteria- how the finish is applied and what is left behind on the wood surface? The first category includes, depending upon the method of application, wipe-on, brush-on and spray-only wood finishes are available. Film forming finishes and penetrating or absorbing finishes are the next categories. Almost all the penetrating finishes are of wipe-on types. Even if they are initially applied with the help of a brush, the excess is removed after some time.

Wood finishes are also classified as water based (simple latex paint without any pigment) and oil based. Water based finishes are non-flammable, easy to use, fade-resistant and eco-friendly. They dry very fast and do not acquire yellowish colour with aging. They can be used on all types of woods- bare, stained and even painted. They are ideal for wooden handicrafts and other decorative wood articles. They are not very durable. One has to be extra careful while applying this type of wood finish as they can show up marks of brush strokes. Non-toxic wood finishes are used for certain wood crafts that come in contact with human mouth such as wooden toys. Oil based finishes are natural wood finishes derived from plants and is used to treat and preserve wood products. It is good for bringing a luxurious satin finish on wood surfaces like those needed for decorative wood handicrafts or furniture in living room. It is easy to apply and can easily cover the scratches and nicks. The oil finish dries very slowly. Utmost care has to be exercised while applying this type of wood finish in order to protect eyes. Penetrating wood finishes are absorbent in nature and get soaked into the wood. They act as a wood sealant and protect the wood. Usually the following three types of oils are used for penetrating wood finishing:

Linseed oil finishes: This penetrating type wood finish take days to get dry and remain rather soft for a very long time; generally used on exterior wood siding and log homes.

Tung oil finishes:Tung oil is an exotic naturally drying oil (obtained by pressing the seed from the nut of the tung tree, *Vernicia fordii)* imported from South America and China and is recognized by craftsmen to be the ultimate drying oil for all fine woods. Unlike other finishes that sit on the wood surface, tung oil penetrates deep into wood fibres, cures, and actually becomes part of the wood. They also take a long time to dry are commonly used in the home interiors. They are safe wood finishes and can be used on food contact surfaces like in wood kitchen accessories. Maintenance of wood surfaces finished with tung oil is very simple and it is also very easy to apply another coat on such surfaces.

Danish oil finishes: These are a mixture of tung oil and varnish with pigments added to give colour. Danish Oil is applied on wood surfaces in similar ways as the other penetrating oil finishes; mostly used on interior doors and trim like for wood shutters.

Protective Film Wood Finishes form a film on the exterior of wood surfaces, cannot penetrate into the wood nor do they let any outer element penetrate the wooden surface. As such, they prove to be the toughest clear wood finishes. Varnish, polyurethanes, lacquers, shellac and wax belongs to the non-penetrating surface film forming wood finishes.

Varnish is one of the most durable finishes. The level of protection increases with each additional coat of wood finishes varnish. It can be brush-on as well as spray finish. It acts as a smooth, glossy finish. They are available in a wide variety of sheens and degrees of hardness and can be applied on bare wood as well as stained wood. Varnish is usually combined with polyurethane for extended durability and protection of the finish. The wood surface needs to be cleaned thoroughly for applying varnish and it can also damage the wet surfaces.

Polyurethanes can be brush-on as well as spray finish. It is very popular due to the clear look and abrasion-resistance it provides to the wooden crafts. It is basically a plastic coating and can be used for interiors and exteriors. Though a single coat of polyurethane may be better than a few coats of water-based finish, it is prone to cracking after four to five coats. It is an extremely durable type of wood finish and is also water resistant. It is available in a variety of looks and feels including natural appearance, satin, semi-gloss and glossy sheens. It is an ideal wood finish for wooden kitchen cabinets, doors, furniture and even floors. The major disadvantages of polyurethanes are that it cannot be used for outdoor wooden furniture or other outdoor woods as it turns yellowish or shows cracks when exposed to sunlight. However, when UV light absorbers are added, this disadvantage can be countered. Once applied, it is very difficult to repair the polyurethane finishing.

Lacquer finishes are the darker finishes, and are flexible, durable, and easy to maintain. Regular lacquer dries very quickly, and spray guns can be used to finish with lacquer. However, the fumes are hazardous to health. It is more common as interior wood finish.

Shellac finishes are natural resin with alcohol base, giving a dark hard finish. Shellac dries very fast and is less likely to collect dust. It is available in two forms - flaked and liquid. Both are mixed with alcohol to acquire a thin consistency. It is fairly durable finish, but not as durable as lacquer or varnish. Although, it is a natural resin it is not recommended for food contact surfaces. Shellac finishes can be found in many colours and are good for wood furniture and wooden floors. It is not moisture resistant and thus cannot be used for outdoor woods.

Wax Finishes provide a very glossy surface and can be easily removed too; however, they are not very durable and one has to apply them frequently.

Some Finishing Tips

- Clear finishes give transparent looks; apply varnish, polyurethane, lacquer, water-based and shellac.
- Opaque finishes are paints, which come in various colours. If you want to change the colour of raw wood, use a wood stain. Wood stains also make inexpensive wood such as pine look more expensive (like cherry, oak, or mahogany).
- For weather-proof finish such as for outdoor wooden furniture, use wood stains made with sealers. Give thick finishes to the furniture in high-moisture or high-traffic areas. Examples of such furniture include your garden furniture or living room furniture.
- To get a thicker finish, go for wood varnish, polyurethane, lacquer, water-based finishes, shellac or paint. These can be applied in several layers on the wood surface.
- Oil finishes cannot build up layers and leave the wood surface more natural-looking. To bring out the beauty and the grain in wood, use oil finishes. They work more efficiently on hardwoods such as red oak, maple, cherry, and walnut.
- Use linseed oil finish only on interior projects and for restoring wooden furniture with an existing linseed finish. Out of the regular and boiled linseed oil that are available, use boiled linseed oil for shorter drying time.
- If you are finishing a wooden craft that has not been finished previously, you can use either Danish or teak oil. Danish oil has comparatively low lustre than teak oil.
- For non-toxic wood finish, like for butcher blocks or wooden toys, use mineral oil. For articles that are more exposed to moisture, use tung oil finish. For slightly glossy or flat appearance, use wax finish.

Industrial Overview

Wooden handicraft industries fall in the category of small-scale traditional industries and play an important role in the Indian economy. This industry requires only low capital investment and other resources. The wooden handicraft sector provides a high ratio of value addition, and has emerged as one of the major sources of foreign exchange earnings. Indian wooden handicrafts are much sought after the world over, and form an important export commodity of India. Although India's handicraft exports show a consistent increase of 16% every year, its share in the international market is not more than 2%.The Indian wooden handicraft sector is the second largest employment provider (after agriculture). It employs about six million artisans. Women constitute a large section of the wooden handicrafts industry, including people belonging to the weaker sections of society. The export revenue share of the wood-based handicrafts is close to 40% of the total handicrafts industry (US$ 2 billion) in India (American Hardwood Export Council 2016, Sinha and Pasha, nd).The exported wooden articles market in India has a varied range of products including small gifts and decorative, toys, statues, ornately carved suave and simple masterpieces, furniture and household products.

India has a well-developed traditional wooden handicrafts industry; there are approximately 90,089 carving centres and the number of registered artisans is reported to be more than 2.6 lakhs (NCAER 2001). The actual number of artisans is perhaps higher; for example in Kerala, while there are more than 3,400 registered artisans, whereas, a survey by a private organisation revealed that there were 6,000 wood artisans in Thiruvananthapuram alone. The number of people indirectly involved in the industry is much higher. For instance, in Saharanpur District of Uttar Pradesh, it is estimated that while about 88,000 people are directly involved in wood carving industry, about 350,000 people are indirectly dependent on it (WWF 2003). India has exported Rs. 4,344.4 million Rs. worth woodcrafts in 200-2001 (WWF 2003 cf. Saigal and Bose 2003).

The major wood carving centres are located in Saharanpur- Meerut and Nagina, 'the woodcrafts city' (Bijnor) of Utter Pradesh (for intricate wood carving & inlay works); Jodhpur (the biggest wooden handicraft centre of India) & Jaipur of Rajasthan (for colourful Kathputlies – wooden puppets as well as carving, jali screens, etc.); Hoshiarpur & Amritsar of Punjab (for wood inlay and lacquer works); Srinagar of Jammu & Kashmir (walnut wood decorative items); Arunachal Pradesh (Tirap); Bastar and Jagdalpur of Chhattisgarh; Odessa (Puri); Natungram and Behrampur of West Bengal (for wooden dolls based on mythology and folklore, intricate carving in large wooden pillars and beams); Assam for large carvings of mythical figures; Channapatana, Bengaluru and Mysuru of Karnataka (for wooden toys for children using vegetable dyes protected as GI under WTO, wooden wall plates, table tops, rosewood inlay works, sandalwood carving, etc.); and Madhya Pradesh for wooden tribal masks. Even though for Gujarat, wood was never a locally available material, Gujarati woodworkers transformed the various components of the building – the columns, ceilings, struts, doors, windows, balconies, and beam ends into veritable works of art, as is evident in the Palanpur Nawab's Palace and the intricate jharokhas (windows) carved in wood or havelis (mansions) in Vasco with their wealth of wooden architectural details, are some of the examples of wood carving tradition of Gujarat (Surat and Mahuva). Andhra Pradesh is known for wood carvings for religious centres. Orissa is known for turned wood antiques using creamish 'gamhari', a specialty of the artisans in the regions of Daspalla in Puri District. Kerala (Kochi/ Ernakulum, Trissur and Thiruvananthapuram) accounts for handcrafted wooden furniture to animal figurines and general wood carvings. Chennai of Tamil Nadu is also well known for handicrafts decorating houses and temples. The major wooden handicraft hubs of India and their styles and products are detailed in the Table given below.

Industry gets its raw material from the Forest Department as well as from farmers. Consumption of wood for handicrafts is high; it is estimated that around 25 truckloads of wood are consumed per day by the industry in Saharanpur alone, which translates into roughly 3.2 million cft per annum. It is estimated that 70,800 cft of wood is consumed by the industry in Kerala. The main products made are boxes, figurines, idols, jewellery boxes, incense boxes and stick holders, candle stands, photo frames,

coaster sets, letter racks, stationery holders, pipe stands, tobacco jars, tables, screens and carved furniture (WWF 2003). Exporters play a key role in the industry. They obtain orders from foreign buyers and get the products manufactured in their own units. If they are unable to produce the volumes required, they outsource some production to artisans on a contract basis. India is one of the largest producers of wood carved products in the world. Exports amounted to Rs. 4.344 billion in 2000-01. The main importing countries are the United States (25%) and the United Kingdom (12%).

India's biggest woodcraft cluster, Jodhpur in Rajasthan, is known for its export excellence as a hub of wooden artistic furniture and handicrafts which includes small gift articles, carved items, toys, small utility items and furniture products; US, Europe and France are the major export markets of the wood products manufactured in Jodhpur. Jodhpur is the biggest woodcraft industry of the country providing employment to more than one lakh people, and generating exports of more than 150 million USD per annum. The majority of the people (almost one lakh) are artisans working either at their homes or in the big manufacturing units. The other categories of the people include handicraft manufacturers (medium and large firms), timber traders and other raw material suppliers, exporters and other office staff at these units. Most of the handicraft industries in Jodhpur are using Forest and Plantation wood. More than 60% exporters are reported to be procuring wood from agents/merchants, around 33% handicrafts exporters/manufacturers are using reclaimed wood, mainly from railways and old houses/havelies of Rajasthan, Gujarat, Himachal Pradesh, Kolkata, Maharashtra, etc. and rest of South India; about 5.5 % are purchasing from local depot. Sheesham, mango and Acacias are the main timbers used in Jodhpur handicrafts along with minor shares of oak (2%) and teak (8.6%). Imported teak and oak (mainly from Malaysia, Indonesia, New Zealand and Germany), pine and MDF (medium density fibre board) are also in use in Jodhpur. The Study made by TRAFFIC India for WWF showed that average number of exported container for a unit/organization is 156-180 per annum and 13-15 container/month. A big organization/ unit are exporting between 300-700 container/year. The average turnover of a unit/ organization is Rs. 13.3 crore per year. New Zealand, Australia, Middle East and Far East countries, Germany, Holland, Spain are some of the export markets for Jodhpur handicrafts. Indonesia and China are the biggest competitors in handicraft industry (Sinha and Pasha, nd).

Nearly one-third of all handicrafts manufacturers and exporters use reclaimed wood, mainly Sheesham (*Delbergia sissoo*), Mango (*Mangifera indica*) and Babool (*Acacia* spp.). The other minor woods include Oak (*Quercus* spp.) and Teak (*Tectona grandis*) used in 2.0% and 8.6 % of the total wood consumption. Sheesham (also called North Indian Rosewood) is the most widely used wood in the handicrafts industry. After teak, it is the second-most important cultivated timber species in the state of Punjab. Mango wood is soft and durable to carve small articles like gifts, decorative and other small articles, and is widely used in the wood-based handicrafts industry in Jodhpur. Babool (*Acacia*) is widely found in Rajasthan and Gujarat; around 21% wood used in Jodhpur handicrafts industry is Babool. The last few years were the worst for the handicrafts industry, mainly on account of the global recession; but business is recovering gradually.

Besides the major species of shihsam, mango and babul; Jamun (*Eugenia jambolana* Syn. Syzygium cumini (njaval), Haldu (*Haldina cordifolia*) (manjakadambu) and Neem (*Azadirachta indica*) (Veppu) are also found to be in use in Sharanpur and Nagina (the 'woodcraft city of India'). Around 10,000 artisans are involved in around 1400 units of carving industry in Nagina and it exports worth about Rs. 30 crore per annum. Saharanpur with around 1.5 lakhs wood workers in the carving field, out of which around 15% are women workers, exports worth Rs. 400 crore annually.

Bulk of forest produce processing in India is carried out by small-scale forestry enterprises (SSFEs), and that these enterprises play an important role in the national economy. As well as processing a wide range of products, SSFEs are also involved in production of forest products. It is estimated that more than 90% of India's wood-based products are presently manufactured in the private sector; about a total of around half a million people are reported to be employed in safety match making, sawmilling and wood carving industries. The SSFE in the wood

carving sector is reported to be contributing significantly to the wood products export market. As usual to WBIs, the key threats are growing shortage of quality raw material due to felling bans and restrictions on extraction and transporting. However, it would be better to take this as an opportunity for production enterprises such as farm/agro forestry plantations.

GI Tagging of Wooden Handicrafts

'Geographical Indication' (GI) is a sign used on products that have a specific geographical origin and possess qualities or a reputation that are due to that origin. Geographical indications are typically used handicrafts. GI tagged handicrafts such as the wooden toys of Channapatana, Wood Crafts of Kinnal, Rosewood Inlay works of Mysore from Karnataka; Kondapalli Toys of Andhra Pradesh, Bastar Wooden Craftof Chhattisgarh; Ravanahatha, Rajasthan; Saharanpur Wood Crafts of Uttar Pradesh, and Thammampatti Wood Carving of Tamil Nadu, etc. indicates their uniqueness; GI protection further facilitates its international acceptability along with its provisions of benefit sharing to the producers.

Timber legality in Indian handicrafts sector

Although India strongly supports sustainable forest management, and is signatory to all conventions related to climate change and biodiversity, wood and wood products can be imported into India without verification of legality (certification) or quantitative restrictions, except when species attract CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora) provisions. It has been reported that India is the third largest importer of the illegally logged timber in the world in 2016, after China and Vietnam and accounts for close to 10% of the global illegal wood trade (IUFRO, 2016). For the domestic marketing of the 'made in India' wooden products, certification/ legality verification has not made mandatory so far; much illegal wood is consumed in the manufacture of handicrafts intended for domestic markets as well for export. As many foreign countries has already enacted provisions for penalty, fines and even for prosecution for their import of wooden artefacts, Indian wooden handicrafts sector is at an export risk at present. The Forest Policy Trade and Finance Initiative Report of Norman and Canby (2020) details the risk of trade in illegally harvested wood in India's wooden furniture and handicrafts sector; main species used in Indian handicrafts and furniture and their associated risk assessment while importing, as reported by them, are given in Table 9 & 10 respectively. The report recommended Government of India (GoI) to develop a robust import regulation specifically designed to exclude the import of wood products that are harvested and traded in violation of the laws and regulations in the source country.

For voluntary certification, Government of India has empowered the Export promotion Council for Handicrafts (EPCH) through their VRUKSH -Timber Legality Assessment and Verification Scheme - India for the Chain of Custody (CoC) Certification of Handicraft timbers. This is a great step for meeting the timber legality risk associated with Indian handicrafts. As EPCH being the GoI authority on export-import issues related to wooden handicrafts, voluntary subscription of VRUKSH CoC Certification needs to be promoted for reasons of forest/ resource conservation and legal export and import of wood and wooden products including handicrafts. Apart from EPCH, NCCF (Network for Certification and Conservation of Forests) is in the process of developing certification programme for ToFs which will be great help in using wood from the Agro Forestry (AF) and will definitely be a motivating step for tree farmers. All these current developments will have a positive impact on making sustainable the Indian wooden handicrafts sector through utilizing certified 'AgriWood' from the agroforestry (AF) sector for handicrafts manufacture.

Major wooden handicraft hubs of India and their styles and products

Handicraft Hub	Photo of typical product (s)	Handicraft Hub	Photo of typical product (s)
Utter Pradesh Saharanpur & Nagina *Intricate wood carving & Inlay works*	Saharanpur  Nagina 	**Arunachal Pradesh:** Tirap 	 
Rajasthan: Jodhpur *Wooden Puppets*  Jaipur 	*Colourful Kathputlies-Wooden Puppets* *Intricate wood carving Jali work*  	**West Bengal:** Natungram & Behrampur *Wooden Dolls based on mythology and folklore, Intricate Carving in large wooden pillars and beams*  	  

Punjab:
Wooden inlay works

Hoshiarpur
Lacquer works

Amritsar

Chhattisgarh:

Bastar

Jagdalpur

Assam

Odisha

Puri

Jammu & Kashmir:
Walnut wood carving

Walnut wood decorative items:
Boules & Jewellery Boxes

Andhra Pradesh:
Kondapally & Etikoppaka wooden Toys

Tamil Nadu:

Karnataka
Bengaluru, Mysore & Channapatana
Wooden toys,
wooden wall plates, table tops, rosewood inlay works, sandalwood carving, etc.
Wooden wall plates

Table tops

Sandalwood carving

Orissa:
Daspalla (Puri)
In gambhari wood

Rosewood inlay works

Kerala:
(Kochi/Ernakulum, Trissur and Thiruvananthapuram

Channapatana
Wooden toys for children using vegetable dyes protected as GI under WTO

Madhya Pradesh
Wooden tribal masks

Gujarat:
Surat & Mahuva
havelis (mansions)
& jharokhas (windows)

Himachal Pradesh Pine, Cedrus deodar, walnut, horse chestnut and wild black mulberry are found in abundance in **Himachal Pradesh** Places famous for woodcraft are Chamba, Tisza, Kalpa, Kinnaur district and Kullu.
Village homes are constructed with carvings on doors, windows, balcony panels etc.

Sikkim
Products like *Choktsis* (**carved** table), *bakchok* (square table), wooden masks, decorative screens, lucky signs, alters, lamp stands and other decorative items in typical traditional designs like dragons, birds, phoenix etc.

Nagaland
Within the large group of animal symbols, the Hornbill and the *Mithun* (Indian Bison) were the most common motifs among the diverse **Naga** tribes

Maharashtra:
Nasik

Pune

List of different wood species used in Indian Handicrafts, including toys

Sl. No.	Species	Sl. No.	Species
1	*Acacia auriculiformis* (Acacia sp./Babool)	33	*Juglans nigra* (Black walnut)
2	*Acacia mangium* (Acacia sp./Babool/Mangium) (Benteak)	34	*Lagerstroemia microcarpa* Syn. L. lanceolata
3	*Adina cordifolia* Syn.*Haldina cordifolia* (Haldu)	35	*Maesopsis eminii* (Musizi)
4	*Aegle marmelos* (Golden Apple)	36	*Ficus bangalensis* (Banyan /Peraal)
5	*Ailanthus excelsa* (Maharuk) (White catamaran tree)	37	*Givotia moluccana* Syn. G. rotteriformis
6	*Ailanthus triphysia* Syn. *Ailanthus malabarica* (Maharuk)	38	*Gmelina arborea* (Gamhari)
7	*Albizia lebbek* (Kokko)	39	*Mangifera indica* (Mango wood)
8	*Alstonia scholaris* (Chatianwood)	40	*Meliosma simplicifolia* (Kallavi)
9	*Anogeissus pendula* (Kardahi)	41	*Ochroma pyramidale* Syn. O. Lagopus (Balsa)
10	*Artocarpus heterophyllus* (Kathal/Jackwood)	42	*Pinus roxburghii* (Chir pine)
11	*Artocarpus hirsutus* (Aini)	43	*Pinus wallichiana* (Himalayan white pine)
12	*Azadirachta indica* (Neem)	44	*Platanus orientalis* (Chinar)
13	*Berchemia zeyheri* (Pink ivory)	45	*Prunus serotina* (American Cherry)
14	*Buchanania axlllarls* Syn. B. *Angustifolia* (Kulamavu)	46	*Pterocarpus marsupium* (Bijasal)
15	*Butea monosperma*(Plash/Flame of Forest)	47	*Pterocarpus santalinus* (Red sandalwood)
16	*Buxus wallichiana* Syn. B. *sempervirens* (Boxwood) (Karingotta)	48	*Quassia indica* Syn. Samadera indica
17	*Cedrus deodara* (Deodar)	49	*Quercus robur* (Common oak)
18	*Chloroxylon swietenia* (Satinwood)	50	*Salix tetrasperma* (Willow)
19	*Chukrasia tabularis* (Chickrassy)	51	*Santalum album* (Indian sandalwood)
20	*Cinnamomum zeylanicum* (Cinnamon)	52	*Sequoia sempervirens* (Coast sandalwood)
21	*Dalbergia latifolia* (Rosewood)	53	*Shorea robusta* (Sal)
22	*Dalbergia sissoo* (North Indian Rosewood)	54	*Simaruba glauca* (Oil tree)
23	*Diospyros ebenum* (Indian Ebony)	55	*Sterculia urens* (Gular/ Tapsi)
24	*Diospyrous malabaricum* (White cedar)	56	*Swietenia mahagoni* (Mahogany)
25	*Erythrina stricta* (Coral tree/ Murukku)	57	Syzygium cumini (Malabar plum/Njaval)
26	*Eucalyptus camaldulensis* (River red gum) (Marwar teak)	58	Tecomella undulate Syn. Tecoma undulata
27	*Eucalyptus citriodora* (Eucalyptus sp. / Lemon scented gum)	59	*Tectona grandis* (Teak)
28	*Eucalyptus tereticornis* (Mysore gum)	60	*Terminalia tomentosa* (Indian laurel)
29	*Gyrocarpus americanus*/ G.asiaticus /G. jacquini (Helicopter tree/stinkwood)	61	*Toona ciliate* Syn. Cedrela toona (Toon)
30	*Hevea brasiliensis* (Rubber wood)	62	*Vachelia nilotica* (Gum Arabic tree)
31	*Holoptelia integrifolia* (Indian Elm, Aval)	63	*Wrightia tinctoria* (Dantapala, Dudhi)
32	*Hardwickia pinnata* Syn. *Kingiodendron pinnatum* (Piney)		

Bamboo for Handicrafts

Bamboo offers an excellent potential alternative source of raw material for traditional as well as modern handicrafts of decorative and utility value and is a significant livelihood craft material for the traditional and marginalized artisans of the socially and educationally backward community associated with forest areas. It also provides the basic raw material for making various household articles/ utilities for rural as well as modern city bread people of environmental concern. Bamboo, the eco-friendly alternative raw material, being comparatively easy to grow outside the forests/ home gardens or agro/ farm forestry, its use is traditionally widely accepted for a range of products from 'cradle to *coffin*' (>1500 items) and hence its processing is more familiar to traditional artisans. The availability of bamboo for handicrafts sector is manageable, as except for furniture and building applications, mechanical properties of bamboos are not a significant concern for many of its handicraft applications; its hardness, density and workability are in the acceptable range for handicrafts making. Design interventions are of prime significance in bamboo handicrafts. India has a large bamboo resource, both in terms of diversity and extent, represented by 136 of the total 1,250

species of bamboo in the world, and about 16 million hectares of bamboo-bearing forests crossing about 13% of the forest cover with an annual production of more than 4.5 million tonnes, which was 50% of reported bamboo resources in Asia and 30% of reported bamboo resources in the world (FAO 2007; c.f. Bansal 2020; FSI 2019). India has the world's second largest bamboo resource, next only to China.

Government of India amended the Indian Forest Act in 2017 by omitting bamboo from the definition of tree so as to benefit millions of people growing bamboo in private or homestead land. It is the fastest-growing woody plant, and can grow up to 0.9-1.2 meters/day. Bamboos support livelihoods of people living in the vicinity of forest through income and job opportunities to artisans and rural/tribal people. Bamboo can be grown on degraded/marginal land and, with appropriate enabling policies; it can provide an eco-friendly renewable alternative natural resources for the wooden handicrafts sector.

Half of India's bamboo area is in five states — Madhya Pradesh, Chhattisgarh, Odisha, Maharashtra and Karnataka. The North East (NE) states account for another one-third of the total bamboo forest area in the country. In 1997, NE states had 66% of total national growing stock of bamboo, and the five other states that account for half of the total bamboo area accounted for another 29% of the total bamboo growing stock in the country. The total number of bamboo culms in ToF was estimated to be 3,046 million with an equivalent green weight of 19.7 million tons; the bamboo culms in ToF compute to about 6,500 sq. km. of pure bamboo area.The species *Bambusa bamboos, B. tulda, B. nutans, B. balcoa, Dendrocalamus asper, D. giganteus, D. strictus, Mellocanna baccifera, Ochlandra* spp. and *Gigantochola apus* were reported to be of great priority as far as bamboo utilization in the country is concerned (INBAR 1994).Out of the various bamboo species, B*ambusa bambos, Bambusa nutans, Bambusa pallida, Bambusa polymorpha, Bambusa tulda, Bambusa vulgaris, Dendrocalamus brandisii, Dendrocalamus strictus, Melocanna bambusoides, Ochlandra travancorica,* and *Schizostachyum dullooa,* are reported to be of prime importance for handicrafts associated applications.

Bamboo utilization continues to be an integral part of the culture and the socio-economic scenario in many parts of the country and multiple uses of bamboo (including handicrafts) integrate a number of socio-economic sections of the society in bamboo economy. Some of these sectors include: bamboo collectors, or those who collect bamboo from forest and/or grow it on homesteads and carry out primary processing; craft persons who use bamboo for making value added handicraft products, mats, furniture etc.; traders or intermediaries who facilitate transfer of primary processed bamboo materials and products to larger markets or industries.

Due to the ease of splitting, bamboo has been used in weaving mats and baskets required in agriculture (right from seed sowing to stocking of grains), and for other essential household utility and handicraft items. For making baskets and other artisan products, generally 1-2 year old bamboo culms are used. There are some communities in various states (*Medars* in Karnataka, *Basods* in Madhya Pradesh, *Beteras* in Odisha, *Korku* in Madhya Pradesh etc.) having traditional skills in bamboo-crafts. Some artisans, e.g., in Tripura and Kerala have special skills in making fancy articles and mirror like reflecting mats (*kannadipya*) from the epidermal layer of bamboo culms which fetch higher price due to better durability and aesthetics. Total number of bamboo artisans, who earn their livelihood making baskets, mats and a variety of containers and other articles of bamboo for sale, is estimated to be 2 million (FSI, 2019), which is about 30% of the total number of artisans in the country. According to INBAR, India's total bamboo growing stock in 2015 was estimated at around 80 million tonnes; about 1,500 traditional bamboo applications have been documented in India. Customary uses include construction, agriculture tools, furniture, musical instruments, foodstuff and handicrafts. In 2015, India ranked as the 5th largest importer of bamboo and rattan products, with a value of about USD 35 million. The main imported product category was bamboo raw materials, worth over USD 23 million.

Rattan (Cane) in Handicrafts Sector

Rattans are one of the main alternative raw materials for handicrafts and furniture providing livelihood for millions of tribal and rural populations in the world. Out of about 568 species of rattans over the globe, India represents 60 species. However, being

with a habitat of growing in interior forests and with the thorny climber nature, cultivation of rattans is seldom practiced outside forests. Due to this reason, the contribution of rattans to handicrafts is below bamboos. The unique mix of the physical and mechanical characteristics such as strength, durability, flexibility, etc., makes rattan a very good raw material primarily for furniture and for handicraft industries. Bending nature, golden yellow colour, light weight and durability make canes dearer to furniture and handicrafts industry. A considerable size of rural population is engaged in making rattan furniture and handicrafts work in many countries like Indonesia, Malaysia, India, Sri Lanka, China, Myanmar, Thailand and Philippines. Global trade of bamboo rattan were assessed as worth 60 billion USD per annum.

It is estimated that more than half a million people are directly employed in harvesting and processing rattans in the rural areas of Southeast Asia (Uma Shaanker et al., 2004). In India, the state of Kerala alone has over 300,000 people involved in cane-based industries. It is estimated that the annual global revenue from the rattan trade exceeds US$6.7 billion (Ravikanth et al., 2001).

Locally rattans are made into a wide variety of useful product. Larger canes are used intact as the frames of furniture while the strips of the surface layers and splits are used to weave the back and side panels. The solid roots of the rattan are made into polo balls and mallets. The waste fibre from cane splitting is used for cheap upholstery stuffing. Rattans are also used for walking sticks, umbrella handles, baskets, floor mats and furniture. The solid roots of the rattan are made into polo balls and mallets.

Some selected bamboo handicraft products

Conclusions on Constraints & Solutions

Among the various factors that affect the growth of the Indian wooden handicraft sector, insufficient raw material availability due to overexploitation of the precious forest timber resources in the past resulting deforestation affecting species conservation and regeneration, is the major issue as far as the handicraft wood sector of the country is concerned. The scarcity of raw material coupled with its escalation of price of the suitable species further lead to shifting of the units towards other species which is again affecting the quality of the end products, thereby affecting the share in the international export market. Lack of experience in forest certification and sourcing CoC certified timber along with the absence of skills in assessing the characteristics, lack of standard policies and the difficulty with integrating timber certification adds the risks in wooden handicrafts export. The poor infrastructural facilities for organized production such as: the use of updated technologies and machineries, improved design interventions, training opportunities in human resource skill and management upgradation, etc., pause constraints in the development of the sector for which solutions could arise from the wood technology sector only.

Because of the wood species most useful for wooden handicraft industry are often overexploited from the forests during the past leading the present scarcity of raw material, promotion of tree growing in agro-ecosystems to supply raw material for woodcarving for wooden handicrafts manufacture, thereby reducing the pressure on forests for timber for handicrafts is the only ultimate solution for solving the issue of insufficient raw material availability. As this is directly linked with agro/farm forestry sector, the legal issues pertaining to harvesting and transportation of timber needs to rectified by proper enactments for which actions are in pipeline. Only this can revive the wooden handicrafts sector in India. Actions taken for promoting agroforestry tree farming will naturally benefit the bamboo sector associated with handicrafts too.

The available information on the suitability of various species for carving and turning or their wood working properties needs to be popularized and experimented among the wooden handicraft artisans. Improved design interventions and trainings on the use and operation of simple modern wood working machineries appropriate to handicrafts sector needs to be provided to the artisan communities frequently, considering their social and financial backwardness. Similarly, trainings concentrating wood preservation and seasoning also needs to be regularly conducted for the efficient and value-added utilization of secondary species of less durability. Providing opportunities for training in improved designs and facilitating design interventions by the faculties of leading Institutions in design like the NID is of great importance in handicrafts sector. Skill Development Programmes (SDPs), Entrepreneurship Development Programmes (EDPs) and Management Development Programmes (MDPs) for the revival of wooden (including bamboo) handicrafts sector needs to be considered. Popularization of the bamboo mechanical processing facilities also needs to be taken care as the same is not familiar with many and the improved and uniform quality including the dimensional properties of the products are concerned.

Forest/Plantations/ToFS and CoC Certification should be promoted through education, awareness raising among consumers and stakeholders, and through incentives for industries, balancing the costs and benefits of certification through better export revenue. Reduced timber legality risks in the international scenario will ultimately benefit the UN goals of sustainable development. Awareness of stakeholders regarding criteria and indicators for sustainable management of forests should be strengthened so that they may adopt these principles in resource management as far as possible.

The rising appreciation for Indian novelty handicrafts by consumers in developed countries, cheap and skilled labour and large supply of timber species which made the Indian handicrafts industry one of the important suppliers of handicrafts to the world market. This industry provides employment to over 5 million artisans and supports and provides major opportunity of employment in rural India. In addition to the high potential for employment, the sector is economically important from the point of low capital investment, high ratio of value addition, and high potential for export and foreign exchange earnings for the country. These strengths coupled with appropriate actions to eliminate the existing constraints in the development of the sector will definitely bring the expected prospect to the Indian wooden handicrafts sector.

Federation of All India Timber Merchants, Saw Millers & Allied Industries

Head Office: Federation of Karnataka Timber Merchants & Saw Millees, White Pearl, Flat 201, Bangalore 560026.

e-mail: contact@timberfederation.in

Website: www.timberfederation.in

Sri. Naval Kedia,
President
e-mail: naval@costaawoods.com
Mob: +91 98302 00497

Sri. D. Ramakrishna,
General Secretary
e-mail: dwararamakrishna@gmail.com
Mob: +91 944017 6081

Zonal Offices:

East: "Diamond Prestige", Room No. 409, 41A,
AJC Bose Road, Kolkata - 700017 (WB).
033 - 22640073 / 74

West: "Timber Bhawan", Room No. 409, Plot No. 47,
Sector 8, Gandhidham, Kutch - 370201 (Gujarat).
02836 230676

North: C/O Mahalaxmi Lumbers Pvt. Ltd, 1/57A,
WHS Timber Market, Kirti Nagar, New Delhi-110015.
011 - 41009111

South: Timber Yard, Aryapuram, Rajahmundry - 533101
Andhra Pradesh.
0883 - 2464949

Central: C/O United Timbers, New Timber Market, Fafadih,
Raipur - 492009.
8770862991

Chapter 11
Wooden Toys Sector

Introduction

Toy, being the miniature replica of something with which a child can play with; wood is a preferred safe material for its manufacture. Toys helps to discover the identity of kids, help their bodies grow strong, learn cause and effect, explore relationships, and practice skills they will need as adults; and are a medium to enhance cognitive, social, and linguistic learning. Toys allow the child to imagine and create a personal interpretation of how they view the adult world.

Majority of the earliest toys discovered were all made of wood. Wooden toys continued to be a common part of childhood for years, as is revealed by archaeological studies. Even though plastic toys were much easier for mass production and were more affordable to families with children, wooden toys have still many advantages over the plastic ones. Wooden toys are environmentally sound, especially when made from sustainably sourced, certified wood. Miniature wooden play sets aid in social and emotional development. Wooden toys hold great educational value because of their simplicity. Wooden toys do not contain toxic materials. Wooden toys are the most durable toys and can usually last through generations of play. As an organic, renewable substance, wooden toys are biodegradable and can be recycled. Wooden toys offer further eco-credentials when any paint used

on them is free of toxic chemicals – or if no paint is used at all. The production of wooden toys, particularly when hand-crafted and when all materials are sustainably sourced and certified, offers a stark comparison to the creation of many mass-produced plastic toys, which can contain dubious chemicals and often offer little prospect of renewability. Wooden toys also present a direct connection to the natural world for children.

Today's wooden toys are just as innovative, if not more so, than modern, electronic toys. Cars, trucks, and wooden wind-ups make wonderful gifts and wooden pull along toys delight toddlers. Quiet games like chess and checkers, and even tic-tac-toe can be found made of wood, as well as physical games like ring toss. Wooden toys offer a range of educational qualities, especially for the children and infants who suffered from learning disabilities. Some of the classic staple wooden toys include puzzles, building blocks and miniature construction sets, all of which can help children with numeracy, literacy, motor skills and problem solving.

It is undeniable that toys take quite a battering from their young owners, getting bashed up, thrown around and left out in the weather. Plastic toys can be brittle, while anything digital or audio-visual always has a risk of malfunction or obsolescence. Wood, on the other hand, wooden toys are more durable; they can endure rough treatment and last for generations, ensuring these toys can be handed down through the family tree.

The relentless advance of technology has ensured that toys today are replete with bells, whistles, bleeps, screens, noises, colours and so on. But often, simplicity is best, and less is more. Wooden toys offer children a blank slate upon which they can project all the wildness and extravagance of their burgeoning/firing imaginations.Playing computer games, though increasingly dazzling and wide-ranging in their scope, can often be a solitary activity for children. Wooden toys can foster social interaction with other children and promote sharing and teamwork. Wooden toys, naturally devoid of any possibility of sound or interaction in them, allow for children to supply their own voices and sound effects in collaboration with one another.Some modern toys, with their electronic and interactive capabilities, 'do everything' for the child. Meanwhile, the simplicity of wood allows for role-playing and world-building (creating imaginary communities and towns and so on), and can aid spatial and social awareness as a result.

As far as safetyis concerned, it is an unfortunate fact that plastic toys, especially the cheaply made variety, can break easily, potentially leaving sharp edges and small parts that may harm the child – particularly if they are at an age where everything they come across gets put in their mouth. Wood, strong and sturdy by comparison, offers less risk in this way. Not only are wooden toys safer than plastic toys, wood as a material can offer benefits to a child's health and well-being. A connection to nature through contact with wood can improve mental and physical wellbeing. Education spaces (where toys are often found), have increased rates of learning, improved test results, concentration and attendance when wood is prominent. Wooden toys can aid a child's physical, mental and emotional development. With an ever-expanding range of wooden toys available today, this is a world of play that children and parents can discover together.

Scenario of Indian wooden toy making sector

Wooden toys are manufactured by traditional artisans throughout India; the main hubs are: Cochin in Kerala, Kanyakumari and Tanjavore in Tamil Nadu; Nirmal, Kondalpalli, Ettikopakka, Chittoor, Rajamundry and Tirupathi in Andhra Pradesh; Channapatana, Mysore and Sagar in Karnataka; along with many local spots in the cities of Meerut, Moradabad, Sharanpur, Nagina, Srinagar, Assam,Tripura, Nagaland, West Bengal and Rajasthan, Bhopal and Jabalpur, etc. The following 22 major wood species are listed by Kumar et al. (1995, 1996a & 1996b) that are used traditionally for toy making:

Sl. No.	Species
1	*Adina cardifolia* (Haldu)
2	*Ailanthus excelsa* (Maharuk)
3	*Albizia lebbek* (Kokko)
4	*Artocarpus heterophyllus*(Kathal/Jackwood)
5	*Artocarpus hirsutus* (Aini)
6	*Alstonia scholaris* (Chatianwood)
7	*Anogeissus pendula* (Kardahi)
8	*Azadirachta indica* (Neem)
9	*Chloroxylon swietenia* (Satinwood)
10	*Cinnamomum zeylanicum* (Cinnamon)
11	*Dalbergia sissoo* (Shisham/Indian Rosewood)
12	*Diospyrous malabaricum* (White cedar)
13	*Givotia rottleriformis* Syn. *Givotiamoluccana*(White Catamaran Tree)
14	*Gmelina arborea* (Gamarai)
15	*Gyrocarpus jacquini* (Helicopter tree/stinkwood)
16	*Hardwickia pinnata* Syn. *Kingiodendron pinnatum* (Piney)
17	*Juglans regia* (Walnut)
18	*Lagerstroemia microcarpa* Syn. *L. lanceolata* (Benteak)
19	*Pterocarpus marsupium* (Bijasal)
20	*Sterculia urens* (Gular/ Tapsi)
21	*Toona ciliata* (Toon)
22	*Wrightia tinctoria* (Dudhi/ Ivory wood)

The toy making industry at present faces the acute challenge of raw material scarcity due to over-exploitation of the locally available ideal species, in the past. Due to the non-availability of the region specific species like Givotia rottleriformis in Nirmal and Kondapalli and Wrightia tinctoria inEttikoppakain the state of Andhra Pradesh had reported to be adversely affected the livelihood of many marginalized traditional artisans and industries in those regions (Rao et al. 2001, 2011). Aggarwal et al. (2013), in their review on the situation, suggested for extended R & D and training support including social and design trends and skills; establishing common facility, incubation, Aggarwal et al. (2013), in their review on the situation, suggested for extended R & D and training support including social and design trends and skills; establishing common facility, incubation, testing and certification centers; evaluate the working qualities including carving and turning qualities of alternative grown timbers that can substitute traditional species; efforts to promote the use of alternative plantation grown species suitable for the sector and establish and sustainably managing plantations, etc. as some of the remedial measures to overcome the crises. For shifting to alternative species, studies made in the IWST suggested the following plantation timbers for toys and handicrafts (Kumar et al. 1995):

Acacia auriculiformis (Earpod wattle)
Eucalyptus camaldulensis (River red gum)
Eucalyptus citriodora Syn. *Corymbia citriodora* (Lemon scented gum)
Eucalyptus tereticornis (Eucalyptus hybrid/ Mysore gum)
Leucaena leucocephala (Subabul)
Maesopsis eminii (Musizi/Umbrella Tree)
Swietenia mahogany (Mahogany)
Dalbergia sissoo (Sheesham/Sissoo/ Indian Rosewood)
Simarouba glauca (Oil tree/ paradise tree)

Apart from the species referred above, a few species reported to be suitable for toy making (Nazma et al. 1981) are listed:

Ailanthus triphysia Syn. Ailanthus malabarica (Maharuk)
Bombax ceiba Syn. Salmalia malabarica (Semul)
Buchanania axlllaris Syn. B. Angustifolia (Kulamavu)
Chukrasia tabularis (Chickrassy)
Erythrina stricta (Coral tree)
Holoptelia integrifolia (Indian Elm)
Melia azedarach (Persian lilac)
Ochroma pyramidale Syn. O. Lagopus (Balsa)
Quassia indica Syn. Samadera indica (Karingotta)

Even though, generally, durable species are preferred for any utilization, non-durable species with suitable physical and workability features could also be utilized for toy making by providing appropriate preservative treatments, the technology for the same are available. To investigate the suitability of any species for toy making by making use of its physical properties, an exposure to the following criteria will be of use.

Ideally, soft, light and reasonably strong wood with straight and close grained are preferred for toy making. It shall have good machining properties, shall not chip off during manufacturing operations. It shall also take a smooth finish and good polish. Generally, low density (300-450 kg/m^3) wood with low hardness value is recommended for toy manufacture; however, moderately hard and heavy species with suitable workability are also getting acceptance in situations of reduced availability of the excellent timbers for the purpose. The hardness, wood density and natural durability categories of the prime wood species used in the toy sector are listed below for a further selection of appropriate ones for developing plantations, as this can only assure future availability of wood for this sector.

Wood Species in Toys Sector

Sl. No.	Species	Density kg/m^3	Hardness (N) & Basic Density (kg/m^3)	Durability
1	*Acacia auriculifomis*	500-650	MH; MH	MD
2	*Adina cardifolia Syn. Haldina cordifolia*	700	MH; MH	ND
3	*Ailanthus excelsa*	335-480	S; L	ND
4	*Ailanthus triphysia Syn. Ailanthus malabarica*	400	S; L	ND
5	*Albizia lebbek*	640	MH; MH	VD
6	*Alstonia scholaris*	350-465	S; L	ND
7	*Anogeissus pendula*	946	H & H	D
8	*Artocarpus heterophyllus*	600	MH; MH	D
9	*Artocarpus hirsutus*	600	MH; MH	D
10	*Azadirachta indica*	835	H-VH; H	D
11	*Bombax ceiba Syn. Salmalia malabarica*	365	VS-S; VL-L	ND
12	*Buchanania axlllaris Syn. B. Angustifolia*	605	S-MH; L-MH	ND
13	*Chloroxylon swietenia*	960	H-VH; H-VH	ND
14	*Chukrasia tabularis*	675	MH; MH	ND
15	*Cinnamomum zeylanicum Syn. C. verum*	575	MH; MH	ND
18	*Diospyrous malabaricum*	800-1100	VH;VH	VD

19	*Erythrina stricta*	240-470	S; VL-L	ND
20	*Eucalyptus camaldulensis*	560	MH; MH	D
21	*Eucalyptus citriodora Syn. Corymbia citriodora*	780-990	H; H	MD
22	*Eucalyptus tereticornis*	980	H-VH; H-VH	MD
23	*Ficus bangalensis*	610	S-MH; MH	ND
24	*Givotia rottleriformis Syn. Givotia moluccana*	NA	S-MH;; L-MH	ND
25	*Gmelina arborea*	415-610	S-MH;L-MH	D
26	*Gyrocarpus jacquini Syn. G. americanus*	250-440	S;L	ND
27	*Hardwickia pinnata Syn. Kingiodendron pinnatum*	610	MH;MH	VD
28	*Holoptelia integrifolia*	595	MH;MH	ND
29	*Juglans regia*	520-670	H-VH; MH-H	VD
30	*Lagerstroemia microcarpa Syn. L. Lanceolata*	640	MH;MH	D
31	*Leucaena leucocephala*	640-800	H; H-VH	ND
32	*Maesopsis eminii*	640-720	S; MH	D
33	*Melia azedarach*	710	MH;MH	ND
34	*Meliosma simplicifolia*	495	S;L	ND
35	*Ochroma pyramidale Syn. O. Lagopus*	120-290	VS;VL	P
36	*Populus spp.*	300-550	VS-S;VL-L	ND
36	*Prunus serotina*	460-670	S-MH; L-MH	D
37	*Pterocarpus marsupium*	720-880	MH-H;MH-H	VD
39	*Quassia indica Syn. Samadera indica*	390	S;L	ND
40	*Salix tetrasperma*	385	S;VL	ND
42	*Simarouba glauca*	480	S;L	ND
43	*Sterculia urens*	550	S-MH;L-MH	VD
44	*Swietenia mahogany*	470-550	S;L	D
45	*Toona ciliate Syn. Cedrela toona*	515	S-MH;L-MH	ND
46	*Wrightia arborea*	575	MH;MH	ND
47	*Wrlghtia tinctoria*	575	MH;MH	ND

All the above wood species are equally suitable for use in the general handicrafts industry sector too. In addition to the above species, the following very durable elite species of wood which are seldom used in the toy sector, however, found prominent position in the handicrafts sector, due to its scope for fetching high prices in the product form:

Sl. No.	Species	Basic Density (kg/m^3)	Hardness (N) & Density Category
1	*Dalbergia latifolia* (Rosewood)	815	H;H
2	*Dalbergia sissoo* (Sheesham/Sissoo)	700-800	H-VH; H-VH.
3	*Tectona grandis* (Teak)	650	MH;MH
4	*Diospyrous ebonum* (Ebony)	1150	VH;VH
5	*Pterocarpus santalinus* (Red sander)	600-850	H;H
6	*Santalum album* (Sandal)	950	H;H

Working and carving qualities play a vital role in the judicious utilization of timbers which vary in anatomical features, physical and mechanical properties, durability, seasoning behaviour and other characteristics for furniture, joinery, turning, handicraft, etc. As a typical example, the Forest Research Institute (FRI), India, has evaluated the working and carving qualities of *Populus deltoides* and *P. ciliate* under six major wood working operations, viz., planning, boring, mortising, shaping, turning and sanding; carving behaviour is evaluated under punching, chiseling, fret-saw work and scooping. The results obtained are highlighted below (taking the value of 100 for teak) (Shukla et al. 1991), making *Populous* spp. ideal for toy sector:

Property	Tectona grandis	P. deltoids	P. ciliata
Specific gravity	570	550	400
Best cutting angle in planning	25	20	15
Overall performance	100	39	42
Ease of working (ease factor)	100	119	117
Working quality index	100	94	92
Grouping based on overall performance	I	II	III
Comparative performance (turning)	100	10	52
Overall comparative performance (carving)	100	39	39
Carving quality index	100	52	52

The export market's higher quality standards, exact specifications and large orders necessitated precision, speed and standardisation in the lacquerware (decorative articles, typically made of wood, that have been coated with lacquer; wooden toys), which led to mechanisation. Power lathes are increasingly popularized in this sector, as a result.

Conclusion

Traditional Indian wooden toy manufacturing sector functioning in unorganized cottage industry scale, is under threat from sustenance/survival issues mainly due to non-availability of suitable species of wood due to the over-exploitation happened in the past and degradation of the forests in which they grow. This is affecting adversely the livelihood of the marginalized artisan community of the region. The forests used to supply the suitable species of wood raw material to the sector needs to be conserved, and needs to bring them under sustainable management practices and wherever necessary reforest. Encouraging the use of alternative plantation grown species suitable for the sector and establishing and sustainably managing the plantations are the main way of reviving the sector, for which convincing efforts on revalidation trials with alternative plantation species needs to be done on a commercial scale among the artisans. Making available certified wood for toy making as well as geographical tagging certifications will help greatly in exploring better export and domestic markets. Benefits of using treated and seasoned timber needs to be popularized among the artisans. Other actions required are: providing technological and training and exhibition supports, establishing CFCs, Incubation/Start-Up Centres, Testing and Certification, marketing linkages, exposure to social and design trends, etc.

INDIAN PLYWOOD INDUSTRIES RESEARCH & TRAINING INSTITUTE (IPIRTI)

(Autonomous Body of Ministry of Environment, Forest and Climate Change, Govt. of India)

Headquarteres in Bangalore with two centres in Kolkata and Mohali. IPIRTI is dedicated to Research & Development, Training, Testing and Extension activities in the field of composites based on wood, bamboo, agrowastes and other renewable natural fibres.

- Established in the year 1962 at Bangalore as a Society
- Accredited to NABL as per ISO/IEC 17025
- Recognized by Bureau of Indian standards (BIS) & associated with evolution of relevant Indian Standards
- Independent apex third party testing laboratory
- Winner of International awards for environmental best practices
- Centre for Bamboo Development (CBD) especially dedicated towards research and training activities related with bamboo

RESEARCH & DEVELOPMENT

- Excellent R & D infrastructure with pilot plant facilities and laboratories
- Research Projects sponsored by national and international bodies viz. FAO, UNDP, IDRC, INBAR, TRADA, AHEC, MoEF&CC, DC(H), BMTPC, NMBA, State Forest Departments, Coir Board, etc.

TRAINING & EDUCATION

- One year PG Diploma course on Wood and Panel Products Technology
- Nodal centre of FRI Deamed University for Ph.D
- Short Term training Courses on Panel Products and Bamboo Composites

CONSULTANCY

- Setting up of panel industries & testing laboratories
- Bamboo based housing systems
- Technology transfer of eco-friendly products
- Panel Industry related problems

TESTING

- NABL accredited mechanical and chemical laboratories
- Plywood, Block Board, Flush door, Panel door, Particle Board, MDF and composites from wood, bamboo and other renewable natural fibres
- Modern testing facility for fire resistance doors
- Synthetic resin adhesives used in panels
- Raw material analysis of chemicals used in resins
- Identification/classification of timbers/binders used in panels
- Retention of preservative chemicals in treated wood/plywood
- Fungal/borer/termite resistance of wood/wood-based products
- Specialized testing such as thermal conductivity, acoustic properties, weathering studies, emission of formaldehyde in panels etc.

For Further Details Contact :

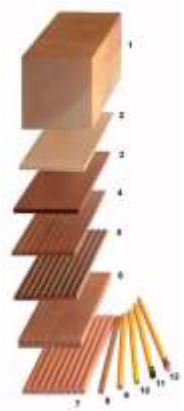
DIRECTOR, IPIRTI, P. B. No. 2273, Tumkur Road, Yeshwanthpur, Bangalore - 560 022,
Ph: Director: +91-080-28394341, Gen: +91-080-28394231-32-33, Fax: +91-080-28396361,
e-mail: director@ipirti.gov.in, contactus@ipirti.gov.in, web : ipirti.gov.in, bamboocomposites.com
Kolkata : 2/2, Biren Roy Road., Sarsuna, Pincode: 700 061, Ph: 033-24983120
Mohali : Plot No. B-65, Phase 7, Indl. Area, Pincode: 160 055, Ph: 0172-5095875

Chapter 12
Wooden Pencil Manufacturing Sector

Introduction

Scientific outlook on pencil making in India started as early as 1945 with Indian Forest Leaflet No. 66 on 'Indian woods for Pencil making' (FRI 1945). Even though about 100 species were reported to be tested for pencil making in the country at that time, majority of the results were not encouraging; *Cedrus deodara* and *Cupressus torulosa* are reported to be suitable for high-grade pencils out of about 100 tested, and 20 other species for utility pencils (Anonymous 1946, Rahman and Gupta 1968). American cedar (*Juniperus virginiana*) is the best and widely accepted species for pencil making because of its suitable physical characteristics and whittling properties, followed by the East African cedar, *J. procera,* which is slightly a harder timber. Indian factories had had to import these junipers for their first quality pencils. The only Indian timber which has been proved suitable for high class pencils is *J. macropoda* which is a slow-growing tree with rugged branches.

Several treatments have been tried to soften and improve the whittling properties of some of the good so-called 2nd class indigenous pencil woods with the object of making them suitable for first –class pencils. The treatment consists of steaming for various periods at different pressures, soaking the wood in weak alkaline solution followed by steaming, and steaming followed by impregnation with oily emulsions (Anonymous 1946).



Earlier, American cedar wood was used for pencil manufacture, which has been later replaced by indigenous species (Tewari 1995). In general, Poplar, cedar and juniper species are the most commonly used commercial wood raw materials in the traditional wooden pencil industries in the country. The problems of bow, crook, honeycombing, warp etc. encountered with many plantation timbers such as poplars due to the juvenile nature of the wood and the presence of residual growth stress has been solved by adopting the Saw-Dry-Rip (SDR) method of sawing and high temperature seasoning so as to enable this species to be commercially used for pencil making (Pandey and Kambo 1993, 2001). According to an estimate made a few years ago, India produced around 1.5 million gross (216 million) pencils every year, for which roughly 14, 200 m^3 of timber in round form was used.

Wood properties and Technology

The timber of pencil slats shall be soft, light and reasonably strong with straight and close grained. It shall have good machining properties, shall not chip off during manufacturing operations and shall whittle well in mending. It shall also take a smooth finish and good polish. Generally, low density (300-450 Kg/m^3) wood with low hardness value is recommended for pencil slat manufacture. Logs of suitable species are first converted into pencil slat blocks of adequate thickness (5.5 +_0.5 mm), length (184+2 mm) and width (70+ 2mm for 8 ply, 63.5+ 2 mm for 7 ply, 55+ 2 mm for 6 ply and 47+2 mm for 5 ply respectively) allowing margin for subsequent shrinkage and depending upon the 'ply' (the number of pencils that can be produced from a double slat block) of slats desired. For best results, the blocks should be air dried before the final sawing of slats to avoid warping of sawn slats. Sawing of slats is a precision job owing to the very close tolerances demanded in slat thickness. If slats are sawn from green or insufficiently seasoned blocks, in addition to the sawing tolerances as prescribed above, another extra 2-3 mm tolerance should be given in width (but need not for length and thickness) in order to account the shrinkage during drying. Slat saws (band or circular) need accurate setting and maintenance to avoid taper in width and length of the sawn slats. The sawn slats need proper stacking with restraint during storage to avoid warping and should finally be allowed to dry to a moisture content of below 12%. The slats shall be free from centre heart/pith, any kind of decay, splits, checks, knots, splinters, borer holes, warp and any other defects which are likely to impair their utility. The slats shall be with or without preservative treatment. Pencil slats shall be bundled together in suitable numbers as agreed to between the purchaser and the supplier and each bundle should be marked with

quantity (number of slats and ply), species, whether preservative treated or not, year of manufacture and name and recognized trade-mark of the manufacturer.

At the pencil manufacturer's end, before the manufacture of pencils, it is essential to improve the wilting property of wood by waxing. If desired, the colour of wood may also be improved by a dyeing treatment. The slats are subjected to a dyeing and waxing treatment either as a two-step or single-step process. In the two-step process, partially air dried slats shall be first charged into a vacuum pressure impregnation (VPI) treatment cylinder and subjected to a desired extent of vacuum for a desired time (of round 55 cm of Hg for about 30 minutes for deodar, cypress and juniper) followed by impregnation of a desired water soluble solution of dye at a desired extent of pressure for a desired time (of around 0.85-0.95 N/mm^2 for an hour for deodar, cypress and juniper); the actual schedule may need to be developed by trial and error method for treating timbers other than the traditionally used deodar, cypress and juniper. The treatment schedule may vary depending upon the permeability of the species, to ensure impregnation. The dyed slates shall then be dried to 12% moisture content in open air or in a dry-kiln. They shall then be dipped in molten paraffin wax at 80-1000 C and the wax shall be allowed to cool through a suitable range of temperature to ensure 8-15% of wax absorption on the basis of the dry weight of slats, depending upon the species. The superficially waxed slats shall be finally given a heat treatment in a kiln at 70-800 C for 12-24 hours to allow the wax to penetrate uniformly into the slats. In the single-step process, the dyeing and waxing of air dried slats is carried out in a single step using suitable water emulsion or dispersion of wax to which dye shall be added provided an absorption of wax between 8-15% of the dry weight of slats is attained. The impregnation with wax emulsion or dispersion shall be carried out by a VPI treatment plant, keeping the treatment solution heated above the melting point of wax. The treated slats shall then be finally dried and conditioned in a kiln for adequate period and the temperature then be finally raised to 70-800 C. The waxed/stained wood slates for pencil manufacturing are fed to a cutting wheelfor grooving and the grooves are filled with a special elastic glue for the lead Pencil ('lead' is created by mixing graphite & clay and baking it in an oven at about 1500°F) fixing. After the lead is added, another slat of wood is loaded on top like a sandwich; A mechanized plunger squeezes the "sandwich" together and the glue dries, the "sandwiches" are sliced into pencils. The pencils go through a lacquering head, getting their colour and sheen.A rubber eraser is added to the top via an assembly machine.

Potential Wood Species

The species suggested by the Indian Standards (BIS 1989) for the manufacture of wooden pencils are given in the Table below. However, as per BIS, other species of timber may also be used subject to prior agreement between the purchaser and the supplier. Generally, 'very soft' to 'soft' (readily indented by finger nail) to 'moderately hard' (not easily indented by finger nail but readily cut by sharp knife) and 'very light' to 'light' (wood density up to 550 Kg/m^3) to 'moderately heavy' (wood density range of 550-750 kg/m^3) nature are recommendedfor pencil slat manufacture. BIS (1981) describe the specification for black lead pencils.

Timber species suggested for pencil manufacture, as per IS 3084: 1989

Sl. No.	Species	Trade Name	Wood Density (kg/m^3)
1	*Alnus spp.*	Alder	420-430
2	*Cupressus torulosa*	cypress	380-650 (Okino et al. 2010)
3	*Cedrus deodara*	Deodar	580 (TRADA. n. d.)
4	*Aesculus indica*	Horse chestnut	520
5	*Juniperus macropoda*	Juniper	510
6	*Endospermum spp.*	Bakota	Nav.
7	*Laphopetalum wightianum*	Banati	300-640
8	*Alstonia scholaris*	Chatianwood	360
9	*Holigarna arnottiana*	Holigent	430
10	*Anthocephalus cadamba*	Kadam	340-640
11	*Hymenodiolyon excelsum*	Kuthan	510
12	*Sideroxylon longipetiolatum*	Lambapatti	Nav.
13	*Elacocarpus tuberculatus*	Rudrak	400

Vatta Wood for Pencil Slats: A Case Report

Wood from a primary colonizing species, Macaranga peltata (local name 'vatta'), mainly from Kerala, is widely accepted in the pencil manufacturing sector in India. This is one of the most widely occurring early successional woody species, profusely found rowing in Kerala and used to supply for pencil wood slates to the other parts of the country. Primary conversion of wood of this species to slates in the growing states generates income to the sawmilling and marginalized labourers working in this sector in Kerala. The low density wood and low hardness of this species makes it suitable for pencil slates. Being a neglected species, otherwise permitted to grow naturally only for its leaves for green manure by the farmers, its woody portion is available at low cost. It was reported that Kollam District of Kerala alone produces 75 to 100 truckloads of pencil slats per year.

However, over- exploitation of this resource for pencil slates is now reported to be causing material of low quality necessitating the pencil manufacturers to go for import which become a threat to the domestic suppliers and the local sawmilling sector and the workers depending certain extent on the vatta pencil slat conversion for their livelihood.

The pencil slat manufacturing industry in Kollam, Kerala had survived many challenges over the years to keep its numero uno status in the country. However, the challenge of finding skilled labour is now crippling the industry in the state. The district produces the largest number of slats used for making pencils in the country. At present, around 3,000 people are employed in as many as 150 slat units in Kollam, against the 5,000 employees in the early 2000.

Slat manufacturing requires skill in cutting softwood, and most of the people who are now working in the sector are from the rubber wood industry. Slat manufacturers continue to depend on manual labour as they find mechanization cost prohibitive.

"Mechanization of pencil slat manufacturing units costs over Rs. 50 lakhs, and as an industry which is persistently troubled by various issues, most manufacturers refrain from making such huge investments. In fact, most units will not survive for more than two years," according to the slat manufacturing units. Slats produced in the state have been recognized by pencil manufacturers in and outside the country. But, according to the slat manufacturers, such recognitions seldom translate into money. Shortage of raw materials and high prices are the perennial challenges being faced by the industry. The cost of raw materials has increased with the ban on selection felling and clear felling of trees in the forest areas. The softwood industries were forced to source raw materials from private properties, mostly in the rural areas. Pencil slats are traditionally manufactured from the softwood of *'Vatta'* (*Macranga peltata*), a resinous tree.

The *'vatta'* wood is collected from Palakkad, Thrissur and from eastern part of Kollam District of Kerala. The manufacturers get the softwood for around Rs. 275/- per cubic meter. The trunk of the tree is cut into blocks of 3.75 to 5 feet. They are then sliced into rectangular pieces of 185 mm length, 80 mm breadth, and 6 mm thickness and are sun dried. As many as 900 such pieces form a bundle which is then transported to various pencil manufacturers across the globe. A bundle fetch them Rs. 1,400/- and an average of 300-400 bundles are transported from each such units in Kollam, Kerala. The pencil slats from Kollam are of high demand in places including, Pollachi, Jammu and Mumbai. Pencil slat consignments are also transported to pencil factories based in Delhi, Chennai, and Gujarat from Kollam. According to the Kerala Slats Factories Association, the big manufacturers in other states often disrupt the price mechanism, which is affecting the small slat manufacturers (Anonymous. 2014).

Pencil manufacturers from Ahmadabad had been

sourcing pencil slats from Kerala. Now, the pencil slat manufacturers in Kerala face the import threat and quality issues. On the request of the Kerala State Small Scale Industries Association (KSSIA) to the Office of the Development Commissioner (DC), MSME, to take measures to protect the domestic pencil slat manufacturers and based on the reports submitted by MSME Development Institute (DI) Thrissur, Kerala and Ahmadabad, the Office of the DC MSME has organized an online interactive session among the stakeholders including technical experts to help MSME in the sector on 15th October 2020. The recommendation was to concentrate on alternative species.

Alternative Resources

List of timber species of potential use in wooden pencil manufacture, as per anatomical features and physical properties are given below:

List of potential species for wooden pencil manufacture

Sl. No.	Species (Wood density values, in Kg/m^3 are given in parenthesis)	Trade Name/ Common name
1	*Ailanthus excelsa* (335-480)	Maharukh
2	*Anthocephalus cadamba* Syn. *Neolamarckia cadamba* (340 640)	Kadam
3	*Betula alnoidss* Syn. *Betula acuminate* (410-530)	Indian Birch/ Bhurjapatra
4	*Bombax ceiba* (330)	Silk Cotton Tree
5	*Givotia rottleriformis* Syn. *Givotia moluccana* (Density value n/v.)	White Catamaran Tree
6	*Gmelina arobrea* (430-610)	Gamhar
7	*Gyrocarpus americanus* (250-440)	Helicopter Tree
8	*Lannea coromandelica* (540-560)	Jhinga/ Indian ash tree
9	*Melia azedarach* (710)	Persian Lilac
10	*Melia dubia* Syn. *Melia composite* (450)	Malabar Neem
11	*Millingtonia hortensis* (540-670)	Indian Cork Tree
12	*Simarouba glauca* (480)	Paradise Tree
13	*Wrightia arborea* (410-620)	Ivory/Lanete

Paulowniaelongate is recommended as another important alternative raw material for wooden pencil industry compared to juniper and poplar wood (Kaygin et al. 2015). The hard wood, Paulownia species, cultivated extensively across the USA, China, Israel, New Zealand and Australia, besides India, is a fast growing versatile tree; starts giving yield in five to six years. The per acre yield of *Paulownia* plant is 600 to 800 trees, each yielding 20 to 25 cubic feet of hard wood.

Paulownia elongata is planted as a forestry tree producing strong, yet light, wood. It is grown for lumber in North America and China. Commercial plantations are normally established from selected clones resulting from micro propagation. They are known to grow up to 15 feet (4.6 m) or more in the first year it is reportedly the fastest-growing hardwood tree. Further, this tree being a beautifully flowering one, it can be used as a good avenue tree too.

The hardness of *paulownia* wood was determined to be low; wood density at 12% mc was reported to be in the range of 300 Kg/m^3 (Akyildiz and Kol 2010) making it suitable for pencil slats.

A compilation of the wood properties of Kerala grown timbers by Nazma et al. (1981) suggests the following species suitable for pencil slates:

ITTO's compilation on 'Lesser Used Species' reports the use of the wood of the species Wrightia

arborea (Lanete) for pencil manufacture. Its wood is lustrous, fine textured, non-durable, easy to saw, machine and work with hand tools, with a basic density of around 560 Kg/m^3. Species like *Maderas latinoamericanas, Calophyllum brasilense, Couratari panamensis, Dendropanax arboretum and Bombacopsis sessilis* are also reported by ITTO for pencil making.

Indigenous Pencilwood Species

Sl. No.	Species	Trade Name/ Local Name	Density (kg/m^3)
1	*Ailanthus triphysa Syn. A . malabarica*	Maharuk	400
2	*Alstonia scholaris*	Satinwood	350-465
3	*Anthocephalus cadamba Syn. A. chinensis*	Kadam	385-640
4	*Blschofla javanica*	Bishopwood	740
5	*Bombax ceiba Syn. Salmalia malabarica*	Semul	365
6	*Canarium strictum*	White dhup	655
7	*Elaeocarpus tuberculatus*	Rudrak	465
8	*Gmelina arborea*	Grnari	415-610
9	*Holigarna arnottiana*	Cheru	430
10	*Hymenodictyon excelsum*	Kuthan	510
11	*Salix tetrasperma*	Willow	385
12	*Sterculia urens*	Karar	545
13	*Toona clllataSyn.Cedrela toona*	Toon	515

Future Options

Apart from wood properties alone, potential species needs to be shortlisted again by considering the criteria of species having long and clear bole and suitable for raising as plantations for concentrating the future efforts for making available suitable timbers to the pencil industry in the country in desired quantity. Species like *Ailanthus, Anthocephalus, Bombax, Gmelina, Melia, Salix, Toona*, etc.,are worth to be considered for such short listing.

As at present, Melia dubia is socially proved to be a potential indigenous plantation species and are of wide interest in cultivating as trees outside forest (ToF) and as plantations of this species do exist among the small holding sector; till other wood resources are available at desired quantity, this species is worth considering for utilizing in the pencil industry. Existing farmers will get benefitted and more farmers will get motivated for extending Melia dubia plantations. *Gmelina arborea* could be the next candidate considering its easily workable soft and light wood.

Being, *seeing is believing*, a programme on testing of the prioritized species for pencil slat and pencil manufacture is also worth attempting. All the different species of light and soft timbers having the potential in raising plantations on a silvicultural angle may be tested for their suitability for pencil manufacture and their techno-economic feasibility will get cleared in such a study for starting the plantation trials as the next step. This will help for the sustainable stabilization of the pencil slat manufacturing sector, which will in turn ensure the livelihood of the marginalized saw mill workers of the sector.

Conclusions

Pencil manufacturing industry sector is reported to be suffering from the non-availability of sufficient quantity of the cost-effective traditional indigenous wood species raw material which in turn affects the livelihood of many local saw mill workers in pencil slats cutting sector. A review of the technically suitable soft and light species revealed the need for relaying on alternative plantation species of the agro-wood sector from ToFs for future sustenance of the sector. The wood hardness and density of the already available plantation species *Melia dubia* and *Gmelina arborea* could be considered for substitution for the time being, which will be a further step to motivate the agro-wood farmers. Other potential indigenous species of low wood hardness and density needs to be tested for pencil making and the successful species may be investigated for their planation scope.

SERVING THE PLYWOOD INDUSTRY

SINCE 1952
WITH INNOVATIVE TECHNOLOGY

Kalyan INDUSTRIES

JET VENTILATED ROLLER TRACK VENEER DRYER
Available in 3 Section 3 Deck to 16 Section 4 Deck

108" SPINDLELESS
ROTARY PEELING

AUTOMATIC PLYWOOD
DOUBLE SIZER

THREE HEAD
WIDE BELT
SANDER

HIGH SPEED HEAVY
DUTY SPINDLELESS
ROTARY PEELING

FULLY AUTOMATIC
PLC LONG CORE JOINTER

TOP & BOTTOM
WIDE BELT
SANDER

DEBARKING
MACHINE

GLUE
SPREADER 108"

Kalyan INDUSTRIES

Jagadhri Road, Yamuna Nagar - 135 001 (Haryana) INDIA,
Tel.: +91 - (1732)-223694, 260682, Fax : + 91-(1732) 260203,
Website: www.kalyanindustries.in, www.plywoodmachines.in,
E-mail: info@kalyanindustries.com

Chapter 13
Wooden Packaging Sector

Introduction

Packaging is the science, art and technology of enclosing or protecting products for distribution, storage, sale, and use. Packaging refers to the process of designing, evaluating, and producing packages. Packaging may be of several different types such as transport package or distribution package; can be the shipping container used to ship, store, and handle the product or inner packages; consumer package as one which is directed toward a consumer or household, etc.

Sustainable materials, those which are produced or sourced locally, are the primary need for packaging. Sustainable materials have a lower impact on environment and are thermally efficient too. Rapidly renewable materials are agricultural products (fibre or animal products) that are quickly grown or raised in 10 years or less, and can be harvested in a sustainable fashion. Examples include bamboo, straw, cork, wool, wheat board, straw board, etc.

Sustainable Packaging

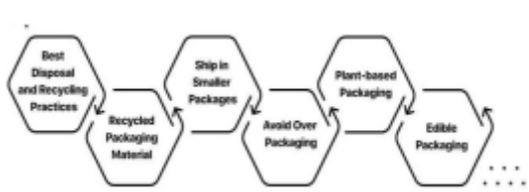
Sustainable Packaging refers to the sourcing, development, and use of packaging solutions that have minimal environmental impact and footprint; sustainable packaging is earth-friendly and doesn't contribute to the further depletion of natural resources. Sustainable packaging is the development and use of packaging which results in improved sustainability. This involves increased use of life cycle inventory (LCI) and life cycle assessment (LCA) to help guide the use of packaging which reduces the environmental impact and ecological footprint. Sustainable packaging is important because it reduces the ecological footprint of all the stages in the product's life-cycle. It helps both the producer and the consumer to reduce the environmental impact. The mission of sustainable packaging is to optimise the overall customer experience by collaborating both manufacturers worldwide to invent sustainable packaging that delight the customers, eliminates waste, and ensures products arrive intact and undamaged. Eco-conscious consumers care about sustainable packaging because they are concerned about the environment, and they are willing to support companies that share the concern. In the US, it was reported that 61% of the consumers wants to support companies that protect the environment.

More than half of the US consumers are nevertheless highly concerned about the environmental impact of packaging, in general. Consumers are willing to pay more for green, but they would also buy additional sustainably packaged products, if more of them were available and they were better labelled.

Strategies for Sustainable Packaging

The widely accepted strategies for sustainable packaging are:

- share disposal and recycling best practices
- ship in smaller packages
- use recycled packaging materials
- use plant-based packaging
- edible packaging
- plantable packaging
- compostable and biodegradable plastic alternatives
- avoid over-packaging throughout the supply chain
- use manufacturing partners with sustainable practice



Packaging can be made sustainable by making it reusable. Reusability can be achieved by:

- minimising damage to package
- reducing raw material use
- imparting prolonged life-span
- less carbon emissions through efficient transit

Wood as Sustainable Eco-friendly Packaging Material

Wooden Packaging, from an environmentally sustainable perspective, has many positive attributes for the reason that wood is a renewable resource; especially when compared to plastics, its manufacturing process alone makes it the environmentally friendly choice in building and packaging materials. Wood, being a negative carbon footprint material (negative carbon footprint is a term that refers to the process which allows carbon to be stored in the wood), use of wood sourced from sustainably harvested forests or certified plantations help to reduce carbon footprint. Being reusable, it is a sustainable packaging material. Wood's strong environmental credentials have been captured in various Life-Cycle Assessment studies and Environmental Product Declarations such as the American Hardwood Export Council's Life Cycle Assessment of Rough-sawn Kiln-dried Hardwood Lumber and the Canadian and American Wood Council's Environmental Product Declaration further clears the fact-based scientifically proven and independently third-party verified environmental attributes of choosing wood. According to the European Confederation of Woodworking Industries, CEI-Bois, the real-life benefits of using wood over alternative materials is declared as:

Every cubic meter of wood used as a substitute for other building materials reduces CO2 emissions to the atmosphere by an average of 1.1 ton CO2. If this is added to the 0.9 tons of CO2 stored in wood, each cubic meter of wood saves a total of 2 tons CO2. Based on these figures, a 10% increase in the percentage of wooden houses in Europe would produce sufficient CO2 savings to account for about 25% of the reductions prescribed by the Kyoto Protocol.

Wood is one of the most sustainable and environmentally favourable packaging materials available. This is due to its ability to absorb carbon dioxide while growing, adaptability as product, and recyclability. Reusable packaging has a much lower environmental footprint (7% in global warming potential – GWP, 60% in eutrophication and 95% reduction in wastage). Unlike many building materials (like steel), wood does not deplete the earth of its material resources. Because it being a resource that more or less stands as its own, it can be grown and harvested over and over again. Fast-growing wood species (like pine) tends to be more sustainable than the slow-growing trees (like oak).

Cardboard is a typical example for sustainable wooden packaging material. Being made from wood fiber, recycling it saves both landfill space and trees. It is 100% recyclable whether it is in the form of corrugated fiber board or paper board and bio-degradable. It does not cause any wastage. Its manufacturing means a reduction up to 60% in carbon dioxide emissions compared to other materials. Hence, they are rightly considered as being amongst the most environmentally friendly and sustainable packaging. Being a reusable organic material, ethical and sustainable, corrugated cardboard is a go-to-go solution for packaging. Usability of packaging is judged by the consumers only. A packaging which is simple to open, easy to fold and sort after usage, and which can be reused will satisfy some of the consumers' requirements. In addition, optimal design influences usability.

Wood is one of the widely used packaging solutions for fragile and heavy applications. In recent years, manufacturers are eying for sturdy and strong packaging formats like wooden & plywood packaging over plastic packaging as a packaging option for several end use products. The advantage

of wooden & plywood packaging are abundant, such as better packaging solution for shipping and logistics. In addition, wooden & plywood packaging also possesses high bearing strength with outstanding durability for bulk transportation. Furthermore, wooden & plywood packaging have admirable static electrical property, chemical resistance, and weathering ability features. Due to such type of features, wooden & plywood packaging are used for filling chemicals such as adhesives, lubricants, paints, etc. Wooden & plywood packaging are usually manufactured by using materials like hardwood such as oak, maple and sometimes in teak too; and softwood such as pines and spruces. Wooden & plywood packaging can resist direct sun light and high temperature and which makes it appropriate for bulk shipment and logistics purpose. All this aspects have created growth opportunities for wooden & plywood packaging market.

Usually, wooden packing cases are made with less durable timbers, as otherwise they are of not much use for valuable purposes. Wood material used for manufacturing packing cases used for other than that for food packaging are recommended to be preservative treated and seasoned for enhanced durability and dimensional stability, which will help for reuse and protection of the contents from attack by bio-degrading organisms. Technologies for preservative treatment are well developed and are easily available (Dhamodaran 2020); eco-friendly water borne boron preservative chemicals of low mammalian toxicity are suggested to use with the simple dip diffusion treatment appropriate to rural context or the vacuum-pressure impregnation (VPI) treatment appropriate to commercial scale industrial plants.

On the basis of material type, the global wooden & plywood packaging market is segmented into:
Hardwood: Oak, Teak, Maple; Softwood: Pines, Spruces: Plywood
On the basis of product type, the global wooden & plywood packaging market is segmented into:
Pallets/Skids (Stringer Pallets., Block Pallets & Pallet Collars); Crates., Boxes., Cases., Bins., Reels., Drums., Barrels., Containers., Dunnage., Spools and Others
On the basis of end use, the global wooden & plywood packaging market is segmented into:
Food, Fruits & Vegetables, Bakery & Confectionery, Meat, Poultry, & Seafood, Ready to Eat, Others (Spices & Condiments, etc.)
Beverages: Alcoholic Drinks, Ready to Drink, Bottled Water, Sports Drinks & Carbonated Drinks
Healthcare & Pharmaceuticals
Chemicals & Petrochemicals
Home Care and Personal Care
Others (Electrical & Electronics, etc.)

Depending on product type, wood packaging materials market is segmented into Wooden Pallets and Wooden Containers. The main advantage of using wooden containers and pallets for packaging is, it can be reused and in case it is damaged it is repaired for reuse. It can be used for 4-5 years. Wood packaging materials are used for packing of Food & Beverages, Grocery, Telecommunications, Dairy, Automotive, Chemicals and Construction. Increasing industrial product packaging demands has brought variety of rigid and flexible packaging designs in the market. Packaging is important aspect for safety of products. It allows clean transition with less interference of human contact. Also it provides advantage while sailing of the products. For shipping of larger consignments, rigid packaging materials like wood are used.

A wooden pallet has up to 25% less environmental impact than a plastic pallet. FEFPEB (European Federation of Wooden Pallet and Packaging

Manufacturers) is a recognized European representative organization of natural timber packaging association, including pallets, light weight packaging, and industrial packaging. Wood has traditionally been used for centuries in the preparation of Packaging, storage and transportation structures. However, the hygiene credentials of wood have been disputed based on the fact wood is an absorbent and porous material. Good manufacturing quality, good handling practice and proper sanitation treatments makes wood a highly suitable material for most applications in packaging.

Wood in contact with food is traditionally used not only in single-use packages or reusable packaging but also in cutting boards and countertops, utensils and kitchen utensils, kebab skewers, toothpicks, ice pops, wine barrels and more. If we use all these items without trouble, we can do it in packaging, too. there are many studies on the hygienic properties of wood that confirm that wood is as good as other materials for use in the food industry, whether on pallets, packages or containers. There is a wide range of wood species and the most commonly used are from continental origin: poplar, pine, spruce, beech, ash, oak, etc. Birch, Fir, Douglas Fir, Acacia, Poplar, Alder, Aspen, Hornbeam, Chestnut, Ash, Olive trees, Maritime Pine, Scots Pine, Sycamore, and Oak has been traditionally accepted wood species for food grade packaging; poplar, beech, walnut and elm are preferred for the package of slid food materials.

There is lack of references to the authorization of resinous and tropical woods for contact with food, or withstanding the well-established use of properly cured softwood without health problems. Fruit and vegetable pallet boxes or tables to cure cheese are good examples of this. In the Nordic countries, pine and spruce are traditionally used for fish, meat and dairy products; while Denmark produces most of ice cream, lolly or other food sticks that we use. In the United States, wooden and kitchen utensils are manufactured with coconut, cherry, mahogany, poplar, walnut, teak, maple, oak, mulberry, pear, elm, apple, yew and other woods. Meanwhile, cutting boards are produced using ash, balsa, basswood, beech, birch, walnut and maple. Fir, willow, beech or birch with basswood and alder, in good condition, is considered adequate, even for fatty foods (FEFPEB 2021). It is important always to use dry wood material for packaging purpose.

Wood in contact with food is regulated - so it should not be treated with chemicals for preservation or phytosanitary treatment, except for a final drying process (reduction of moisture content below 20%) for seasoning purpose. Special coatings are rarely used in wooden packaging. This is more common in household and kitchen utensils of wood, where certain natural coatings (solvents, waxes and oils) are permitted to improve their properties. Wood must not transfer compounds from it (natural volatile organic compounds (VOCs) and those that can be extracted by liquids) in an amount that would alter the composition or the taste of food or that are likely to pose a risk to human health (ref: wine and cheese in wooden package). Risk of migration of extractives, structural porosity, risk of bacterial and fungal contamination bio-hazard (including the physical inhibitory effect of capillarity and moisture), the antibacterial/bactericidal properties of various wood species, etc. are some other factors that needs to be considered when timber packages are considered. However, the above factors are seldom reported to be a negative factor that suppressing the use of wood for sustainable packaging against the use of plastics for the same purpose. The bactericidal effect of wood is in fact reported to be superior to plastic and steel. Many studies reported that wooden pallet packaging surface is comparatively easy and amenable to pressurized water jet cleaning than shredded plastic surfaces. Wood is reported to be reducing bacterial concentration before plastic and steel, and that wood species behave differentially; oak has a better performance than beech or ash, and Scotch pine is found better than fir. No significant differences between the bacterial load of wood and plastic were reported. For wood, a higher degree of disinfection could possibly be achieved with the microwave method. To prevent proliferation of microorganisms, the sanitation, cleaning and disinfection, as well as care in the storage conditions is important in reused packaging. Re-use is more widespread in industrial packaging, in agricultural box pallets, for example, or in pallets where there is no direct contact with food. The bacterial count on the reused pallets of different wood species showed to be on average 15% lower than on plastic pallets. The study concluded that

wood is a hygienic material because it kills bacteria by offering poorer living conditions than plastic or steel; cleaning of the pallets with pressurized water is found helps to kill bacteria.

Use of clean dry pallets; not storing in unprotected outdoors; keeping pallets separated – special pallets for hygienic zones;using pallet inverters to avoid contamination, a cheap and easy solution is to use wooden pallets with a slip-sheet on top (when depalletising one pallet, the receiving pallet also has a slip-sheet on top. The pallets can be kept in separate zones and the slip-sheets can be made of different materials, expendable or reusable);high pressure water jet cleaning of pallets; pasteurizing by using heat treatment by adding an additional drying cycle in a kiln/ high temperature treatment/ microwave technology – are some general rules for handling and storage of pallets.

Indian Standards on Solid Wood Containers and Plywood & Other Types of Cases

The suitability of more than hundred Indian wood species for the manufacture of various components of wooden packaging is given in IS: 6662-1980 - Timber species suitable for wooden packaging. Bureau of Indian Standards (BIS) has around 37 standards concerned/related with wooden packaging.

Pallet (also called skid) is a flat transport structure, which supports goods in a stable fashion while being lifted by a forklift/ cane. A pallet is the structural foundation of a unit load which allows handling and storage efficiencies. Goods or shipping containers are often placed on a pallet secured with strapping, stretch wrap or shrink wrap and shipped.

Case is a collection of items packaged together.

Dunnage refers to the packing material used as protective fill inside the carton, box or other type container used to prevent the merchandise from being damaged during shipment. These materials include bubble wrap; wadded, crumbled or shredded paper; styrofoam; inflated air packs; and other materials.

Bin: Storage structure

Crate is a large shipping **Container**, often made of wood, typically used to transport or store large, heavy items. The term **crate** often implies a large and strong container.

Wooden box is a container made of wood for storage or as a shipping container. Construction may include several types of wood; lumber (timber), plywood, engineered woods, etc.

Reels / Spools: A cylinder on which film, wire, thread, or other flexible materials can be wound (e.g. cable reel).



Barrel/ Drum or Cask is a hollow cylindrical container with a bulging center, longer than it is wide; usually used for storing wine & beer.

Pallet Collar is a modern and highly efficient wooden packaging solution for compact, bulky or friable products of different types, that works together with the classic wooden pallet or various types of custom pallets. This solutions works as a substitution for the classic wooden boxes. The main difference in comparison to the wooden boxes is the possibility to collapse them when they are not in use. As such factors are highly important in professional logistics this solution has gained growing popularity worldwide in the past 20 years, with approximately 20,000,000 new collars manufactured each year worldwide. Each of the pallet collars is stacked on one another in order to form a box type of packing, but because of the convenient design they provide several important benefits that have high value in the storage and transportation industry.


ISPM 15

International Plant Protection Convention
Protecting the world's plant resources from pests

Wood Packaging Material (WPM) made of unprocessed wood is a pathway for the introduction and spread of pests, including pathogens, detrimental to agriculture and to natural, cultivated, and urban forest resources. The United States and other countries have committed to enforce the **International Standards for Phytosanitary Measures (ISPM)** 15 which is a standard of guidelines for regulating wood packing material (WPM) in international trade to reduce the risk of introduction and/or spread of harmful pests. ISPM 15 developed in 2002 by the International Plant Protection Convention (IPPC), part of the FAO, calls for regulated WPM to be either heat treated or fumigated with methyl bromide and marked in a certain way certifying treatment (FAO 2009). Only accredited agencies can perform these functions.WPM covered by this standard includes dunnage, but does not include manufactured wood such as plywood, veneer, fiberboard, particle board, corrugated board, or oriented strand board. Also excluded are loose wood materials such as shavings and excelsior, whisky and wine barrels, wine crates for vintage years prior to 2006, ammo crates, and paper products. ISPM approved treatments are:

- **Heat treatment to a minimum wood core temperature of 56° C/133° F for a minimum of 30 minutes, or**
- **Fumigation with methyl bromide**

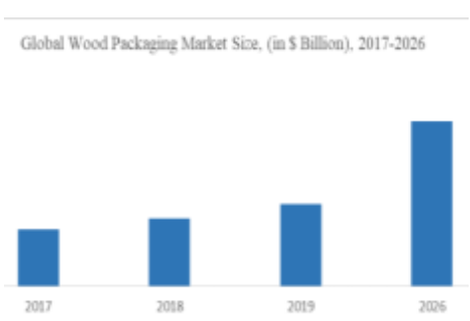
ISPM 15 directly addresses the need to treat wood packaging materials of a thickness greater than 6 mm (pallets, crates, dunnages, etc.) requiring that they must be treated with heat by means of a Heat Treatment (HT) or Dielectric Heating (DH) and marked, often branded, with a seal of compliance.

Implementation of this standard is considered to reduce significantly the spread of pests and subsequently their negative impacts. In the absence of alternative treatments being available for certain situations or to all countries, or the availability of other appropriate packaging materials, Methyl Bromide (MB) treatment is included in this standard (although the use of Methyl Bromide as a treatment method is forbidden within the EU since 18 March 2010). Alternative treatments that are more environmentally friendly are being pursued. ISPM 15 describes that approved phytosanitary measures that significantly reduce the risk of pest introduction and spread via wood packaging material consist of the use of debarked wood (with a specified tolerance for remaining bark) and the application of approved treatments. The application of the recognized mark ensures that wood packaging material subjected to the approved treatments is readily identifiable. The approved treatments, the mark and its use are described.

FEFPEB is the representative of the European timber packaging industry, works closely together with the European Commission, national governmental organizations, scientists and other timber packaging associations on the subjects of revision, emergency measures and the possible extension of ISPM 15 (FEFPEB, nd).

Market & Forecasts

The wooden & plywood packaging market are estimated to grow significantly due to increasing trend for sturdy and strong packaging format for shipping & logistics. Wooden & plywood packaging also offers an option of reusability by cutting the wood for some other packaging use. Furthermore, wooden & plywood packaging like wooden boxes can be used for building & construction applications due to its rigidity and resistance against deformation and breakage.



Global wood packaging market size is forecast to reach $4.21 billion by 2025, after growing at a CAGR of 5.4% during 2020-2025, owing to wide usage of wood to manufacture containers because it's relatively plentiful, inexpensive and easy to obtain characteristics. There is an increasing demand for wood packaging as they are easier to shape and less fragile. Also, wood packaging has durability characteristics that permit extensive reuse. Moreover, the wood packaging is engineered to allow for re-use multiple times and allows wood packages to be mechanically disassembled and rebuilt into new pallets with recycled wood components, which is anticipated to drive the wood packaging market substantially during the forecast period (IndustryARC, nd).

Asia Pacific region held the largest share in the wood packaging market in 2019 up to 31%, owing to increasing adoption of wooden packaging in the food and beverage industry to transport food and beverage products because of its ability to absorb bacteria naturally, which helps protect these products from cross-contamination. The market is flourishing in North America region as well. The rising food and beverage industry coupled with the increasing export value of commodities cause increase in the demand for wood packages in the region, which is anticipated to further drive the wood packaging market in North America and Asia Pacific during the forecast period of 2020-'25. In 2016, according to the Federation of Indian Chambers of Commerce & Industry (FICCI), the packaging industry stood at USD 700 billion and was one of the fastest-growing industries globally. In developing countries like India, it grew at a CAGR of 16%.Increasing Construction Activities in the country is a major driver for wooden packaging market demand in India. Technology launches, acquisitions, and R&D activities are key strategies adopted by the players in the wood packaging market.

Some of the major players in the wood packaging market are Universal Forest Products Inc., Shur-way Group Inc., Palcon Cox Co., Bay Wood Products Inc., Rowlinson Packaging Ltd., C & K Box Company Inc., InterAgra S.C. and Brambles Ltd., Nefab AB., Edwards Wood Products Inc., Green Pack Industries., Napa Wooden Box Co., Ongna Wood Products Inc., Shur-way Industries Inc., C Jackson & Sons Ltd., Arrington Lumber and Pallet Company., LJB Timber Packaging Pty. Ltd., etc.

Another global market report on wood packaging materials by product type (wooden pallets, wooden containers), by application (Food & Beverages, Shipping, Transportation) and by region (North America, Latin America, Europe, Asia Pacific, Middle East, and Africa) forecast for a growth of a CAGR of 4.5% for the period 2020-2027(Data Intelligence, nd). Due to rising awareness about the negative impact of usage of plastic on the environment will grow the market for the wood packaging in the forecast period. India can emerge as a significant global player, if the sector strengthens its capabilities in terms of technology, skills, and efficiency.

The impact of Covid-19 on the packaging sector has been mixed depending on the portfolios of different end-user industries. The Indian packaging sector, even in the pre-Covid era, has been witnessing considerable growth largely due to increased globalization of trade in goods and services and emergence of new trade models, such as e-commerce and organized retailing. E-commerce in India is projected to grow rapidly at a CAGR of 27 per cent from 2017 to 2026 to reach $200 billion by 2026. This has been further boosted by the current pandemic due to closures of store retailing consequent to the lockdowns. With the projections of the impact of the pandemic to be long drawn, consumer preferences towards e-commerce and e-retailing will continue to be a trend beyond the crisis. Currently, India's share in the overall parcel shipments (transit packaging) worldwide is less than 1 per cent only. With steep growth of e-commerce and e-retailing globally, and in India, transit packaging and omni-channel packaging are emerging as the most potential segments — maintaining safety, hygiene, and integrity of goods — and where the Indian packaging industry has considerable scope for expansion.

The Indian packaging industry is expected to reach $72.6 billion by 2020, growing at a CAGR of 18 per cent during 2016-21. Covid-19 may have derailed this growth considerably; however, certain manufacturing sectors, such as pharmaceuticals, packaged food and beverages, functional food and hygienic products, have been less affected by the crisis, and have rather seen a sizeable growth both in demand and in production, raising the demand of packaging (Sumana Sarkar 2020).

By far, with a low share of 1.4 per cent in global exports, India is a net exporter of packaging materials. The export of packaging materials from India was estimated at $843.8 million in 2018-19, witnessing a y-o-y growth of 14.1 per cent. Nevertheless, China dominates the sector and is the largest manufacturer and exporter of packaging materials and products globally. While the trade in the sector has been severely affected by the global pandemic lockdowns as in the case of other sectors, the pandemic driven isolation of China have been forcing the packaging companies worldwide to relook at their supply chain vulnerabilities, which is accelerating shifting of their businesses and sourcing to other second world countries, preferably India.

Despite limited activity in the packaging space in India, historically, the last decade has witnessed the Indian packaging industry emerging as an attractive investment avenue for the global players, largely in the flexible packaging segment. Predominantly an unorganized set-up, the flexible packaging industry has undergone a certain degree of consolidation in the recent years, due to the acquisitions and mergers, which has brought in much-needed investments in the industry in technology, scale and skill development.

The industry is constantly faced with several challenges in terms of cost, technology, knowledge,

regulations, and environment. The changing economic conditions, trade and market preferences imposed by the pandemic have added to the woes of the industry in the form of raw material shortages, particularly seen in Kraft paper based packaging, imports of machineries, and slowdown in production and commerce.

Notwithstanding the challenges, the growth drivers are distinctly defined for the industry even during this current crisis. It is thus, for the industry to leverage the considerable opportunities available in the various spaces and emerge as a significant global player in the sector. Strengthening capabilities in terms of technology, skills, efficiency, and competitiveness will be crucial going forward. Package manufacturing and packaging services are the two potential segments for the Indian packaging sector, where the industry can expand considerably both onshore and offshore.

Use of treated and dried wood

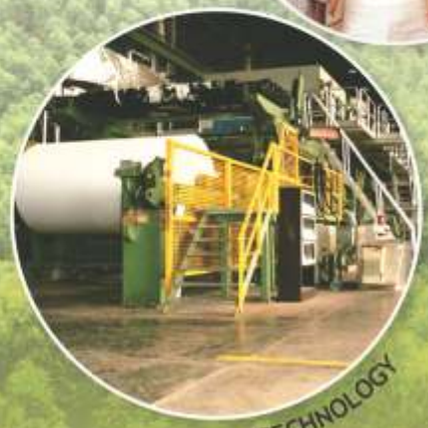
- Less components, less resources, less space, less burden for disposal - try to use the least amount of packaging to ship the product safely
- Sharing with consumers, the best practices for disposal and recycling. 'How 2 Recycle' pamphlets/ inclusion of a link or QR code to a page in the company's site could be considered for effective/efficient implementation of the recycling/reuse/disposal of the wooden packing material. The more recycled material you use, the less new resources you're using from the planet.
- Improved designs of packaging for reducing the size/ space - by design research interventions
- Avoiding the need of over-packaging throughout the supply chain.

Conclusion

Definitely, wood is one among the most environmentally/eco-friendly sustainable material for packaging. Property wise also, this could be an appropriate material for strong and sturdy packaging requirements like pallets/skid, boxes, crates/container, cases, bins, reels, drums/ barrels/casks, pallet collars, and general purpose packing cases of various thicknesses and finishes for the packing of various materials including from food to heavy machineries. Being expensive than cardboard, solid and re-constituted wood packaging essentially needs to be reusable; and for the same purpose the same should be durable and dimensionally stable also to the extent possible, thereby making preservative treatment essential for the timber used, except in cases for packaging food and especially when they are in direct contact and wood seasoning (drying) for all the purposes. Being a negative carbon footprint material, use of selective species of low to medium density wood of low hardness which are otherwise unsuitable for structural purposes, sourced from sustainably harvested forests or certified plantations, for manufacturing packaging will be a nature-friendly enterprise as far as the wooden packing case sector and related industry is concerned. This concept needs to be promoted and reuse of the wooden packaging material needs to be popularized. Among the various widely accepted strategies for sustainable wooden packaging, ensuring the following practices will be of great social and economical value:

AGRO FORESTRY

RURAL EMPLOYMENT



TECHNOLOGY

GROWTH with SUSTAINABILITY

Sustainability is at the core of India's Paper industry. Paper is one of the most environmentally sustainable products as it is biodegradable, recyclable and is produced from sources which are renewable and sustainable.

Paper Industry is not only conserving the environment but also regenerating natural resources. Through the agro-forestry initiative of the Indian Paper Industry, more than 1.2 million hectares of land has turned green and thousands of jobs in rural India have been created.

Of the total demand for wood by India's Paper Industry, over 90% is sourced from industry driven agro-forestry. The industry is wood-positive, that is, it plants more trees than it harvests. Pioneering work has been carried out by the industry over the last three decades in producing tree saplings (e.g. Eucalyptus, Subabul, Casuarina, etc.) which are disease and drought resistant and can be grown in a variety of agro climatic conditions. Substantial amounts have been spent by the industry on plantation R&D, production of high quality clonal saplings, technical extension services and hand holding of marginal farmers.

Indian Paper Manufacturers Association

PHD House (3rd Floor), 4/2 Siri Institutional Area (Opposite Asian Games Village) New Delhi - 110 016 (India)
Tel : +91-11-26518379, +91-11-41617188, Email : sg@ipma.co.in / secretariat@ipma.co.in
Website : www.ipma.co.in

IPMA Members

Andhra Paper Limited
THE FUTURE OF PAPER

bilt

CENTURY

emami

ITC
Enduring Value

JK PAPER LTD.

NAINI

ORIENT PAPER

PUDUMJEE

Seshasayee Paper and Boards

STAR PAPER

TNPL

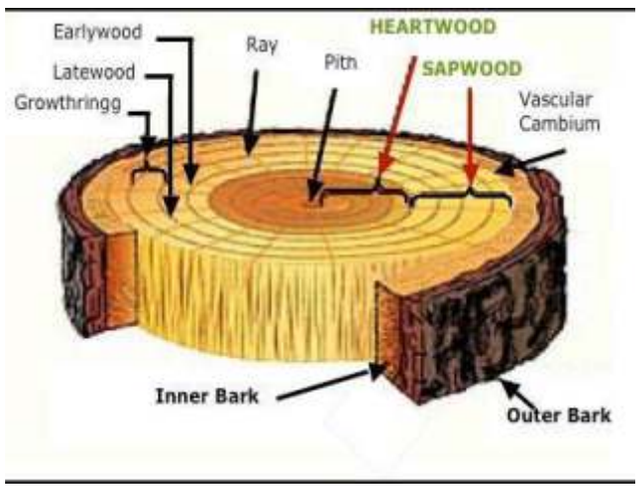
TRIDENTGROUP

West Coast Paper Mills Ltd

YASH PAKKA

Chapter 14
Wooden Construction Sector

Wood has been used as a building material for thousands of years. It is the most eco-friendly raw material for building construction, in terms of carbon emission. One of the main engineering reasons for choosing timber as a building material is its excellent tensile strength; its remarkable mechanical/strength properties make it the perfect choice for heavy-duty building materials such as structural beams. In addition, the heat conductivity of wood is relatively low in comparison to other materials such as aluminium, marble, steel, or glass. Wood also contains highly-sought-after acoustic properties. It can absorb sound and echoes, and is a favourite material of choice for the construction of structures where proper acoustics is important, such as concert halls. Wood is resistant to electrical currents, making it an optimal material for electrical insulation. Of the many construction materials that a person can choose from, wood stands out as a unique and amazingly versatile product of aesthetic appeal and ease of fabrication enable it to remain a favourite choice for use in an extensive array of construction applications. Hardwood is typically heavier and denser than softwood and is usually utilised for construction of walls, ceilings and floors high-quality furnishings, solid wood mouldings and interior joinery. In general, depending on the species, wood has MOE and MOR values of 800,000–2,500,000 psi and 5,000–15,000 psi, respectively. Specific species are better suited for various uses than others. Some of the top priority



properties of timber used in construction is their strength, specific gravity/wood basic density, moisture content, shrinkage and swelling, colour, grain and odour. Wood was the traditional choice of building material for manufacturing structural beams, doors, windows, wall panelling, flooring and many other applications because of the availability, practicality and appearance.

As construction material, bamboo has a very strong fibre. The compressive strength of bamboo is two times higher than concrete, while the tensile strength is close to steel. Bamboo fibre has a shear stress that is higher than wood. Bamboo has wider span than wood.

Total projected demand of raw wood by the construction industries in India (in million m^3) during 1998-2020 is:

Yea r	1998*	1999*	2000*	2005*	2010*	2015**	2020**
Quantity	13.6	14.6	15.9	19.4	22.1	26.3	28.5

Actual demand;Projected demand; (Source:Indiast at 2015 & Ghosh and Sinha 2016)*

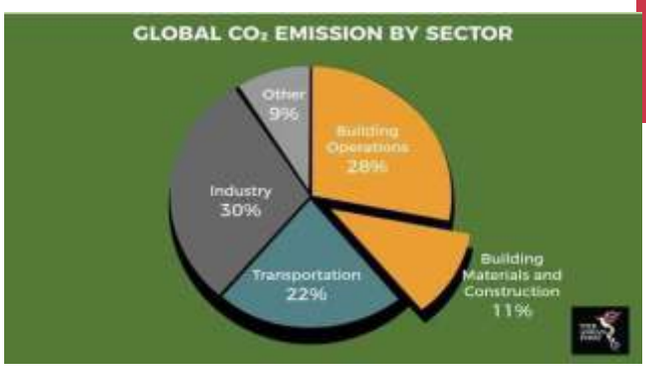
About 28% of the sawn wood produced by the sawmills is reported to be consumed by the construction sector in the country (GoI 1999; Saigal and Bose 2003). According to Shrivastava and Saxena (2017), in the total wood balance, out an availability of 71 million m3 round wood and within a total consumption of around 69 million m3, 48 million m3 consumption go for the combined use in construction, furniture and agricultural implements; many times the quantity of consumption reported for construction is likely to be overlapped slightly with the furniture sector due to the traditional/usual inclusion of cabinets and fixtures used in buildings in the furniture sector. Cabinets and fixtures, doors and windows, etc. are likely to be conveniently included jointly and severally in both the construction and furniture sector. The projected demand of wood for the construction sector alone, according to THE

Network for Certification and Conservation of Forests (NCCF) is about 29 million m^3.

Growing pressure to reduce the carbon footprint of the built environment, engineers and architects are increasingly being called upon to balance functionality and cost objectives with reduced environmental impact. Wood helps to achieve that balance and it outperforms concrete and steel in terms of embodied energy, greenhouse gas emissions and air and water pollution. Wood showcases the beauty of nature, radiates warmth and adds value.

Windows and Doors play an important role in design aesthetics of the interiors of any place or home décor. In India, the door and windows market is still growing as people are exposed to innovative products and increasingly looking for enhanced lifestyle and living standards with modern design and concepts. Based on housing stock growth trends, annual demand for doors stands at 36 million. According to industry sources, readymade doors accounts for less than 15% of the market per year. In this, wooden doors account for 70% per year. Flush doors account for 70% of the market and panel doors account for about 10%. Doors made from MDF and moulded-skin high density doors account for another 10% of the market. Doors made of other materials, such as rubber wood, make up the rest of the market. In value terms, the Indian market for readymade wooden doors is estimated to be in the region of US$ 520 million (American Hardwood Export Council - AHEC 2016).

The hospitality segment offers more growth for the timber-based industry. India presently has an estimated 114,000 hotel room spread across various hotel categories. This sector will see a rise of over 65% in total hotel inventory by 2017 as nearly 52,000 new hotel rooms are expected to come into the market. The key influencers in this sphere of Interior Decoration include the builders and developers, product manufacturers, architects and product distributors. The Indian market for interior building material sectors estimated to be worth US$ 4.2 billion in 2012 with most segments growing at a compound annual growth rate of 20% and 10% of this aggregate market comprises the rapidly growing premium segment. India is expected to become the third-largest construction market in the world by the year



2025. It is estimated that India requires 25 million doors every year and the potential is so huge that more than double the present capacity is required to fulfil the demand for doors.

Traditionally, carved wooden door is an integral part of every home in India. The thickness of imported wood is not as per Indian Specifications which are affecting the industry. The Pre-hung doors or Door-set concept is becoming popular now in India and the market is poised to see growth. Carpenter-made wooden windows are quite common in Indian homes across the country but majorly concentrated in the unorganised manufacturing sector. Though largely an unorganised sector, interior design market in India is growing at a whopping 60 per cent. Rapid urbanization and growing consumption have changed the way Indian people do up their homes, this has fuelled the interior décor industry, which provides everything - from design services to even customizing interiors according to personal choices. The Indian Home Décor market, which stood at $13 billion in 2010 and the growing demand for residential projects consisting of specifically western style houses with wooden frame constructions has favourably impacted growth.

Wooden flooring is considered as a status symbol as a result of which it has been witnessing significant adoption rate in India over the last few years. Indian wood and laminate flooring market size was estimated to be USD 113.5 million in 2013. Increasing renovation and floor replacement activities in residential and commercial application is expected to drive the industry. Domestic sourcing accounts for just a handful of the supplies in the wood flooring market; a vast majority of the supplies are imported from sources as diverse as Scandinavia and China. The commercial wood and laminate flooring market

accounted for over 55% of the share in 2013 on account of high demand from corporate offices, five-star hotels, restaurants, showrooms, and retail outlets. Although wood flooring is very popular, few people prefer to get their entire house covered by it. Mainly wooden flooring is done in bedrooms and living room for aesthetic appeal. Moreover it is even costlier than good quality tiles and marble. If past consumption patterns are observed, then wooden flooring should take in about 15% of the market or almost 10 times the current size. The current growth rate of about 20% per annum in this category is a good indicator of things to come. Flooring is one area in the construction industry that has been witnessing rapid changes over the past two decades. The advent of several new technologies and the increased use of specialised machinery have meant that the field has changed beyond recognition. Today, about 500 million square metres of wooden laminate flooring and another 120 million square metres of engineered wood flooring are consumed annually. As awareness about different products increases, customers want to move away from conventional materials like stone, mosaic, ceramic tiles and carpets to newer, more versatile material such as laminates and engineered wood flooring. If recent consumption patterns are observed, wood flooring should take in about 15% of the market, or almost 10 times the current size! The current growth rate of about 20% per annum in this category is a good indicator of things to come.

The **modular kitchen** market in India has been growing at a rapid rate, albeit beginning from a low base. The market is largely unorganised, with the presence of local and small players. The unorganised market (estimated at 75% of the total) includes carpenters making custom-designed kitchens based on the varied requirements of different households. Modular kitchens are largely focused towards the middle class and affluent households in urban India, and offerings are based on functional practicality, design and appeal. Increase in the number of nuclear families, rise in the number of working couples, higher disposable incomes, and increased affordability of such offerings are all factors that have driven awareness levels and increased demand for modular kitchens. The organised kitchen market is currently pegged at US$ 169 million. Of this, the premium segment accounts for US$ 46 million and is growing at 18% year-on-year. Total estimated production of kitchens in the unorganised sector (small producers) amounted to 0.43 million units in 2014. Imports account for 32% of the modular kitchen market, dominated by Italy (51%) and Germany (27 %) (American Hardwood Export Council 2016).

Reconstituted/Engineered Wood in Construction

Mass Timber Structures – multi-storeyed timber buildings are of recent interest, considering the benefits of timber utilization as a bio-refinery material. Engineered wood commonly includes the well-known panel board products such as plywood, particle boards, block-boards, medium density fibre boards (MDF), etc. and the later developed Glue laminated wood (Glulam), Cross Laminated Timber (CLT), Laminated Veneer Lumber (LVL), etc. are used for a wide range of applications from furniture, walls, flooring, doors, roofs, cabinets, columns, beams, and staircases, among others, and being suitable for exclusive mass timber structures. There has been rapid advance in the development of engineered wood products and growth of their use in the construction sector in recent decades. In Europe, CLT, LVL, Glulam, experienced annual growth rates between 2.5% to 15% (Hildebrandt et al. 2017). Rising use of engineered wood products is driven by the adoption of new regulations and superior physical, environmental and economic properties for these products compared to mineral-based building materials. Studies have shown that:

- *Glulam beams have superior performance characteristics and result in fewer carbon dioxide (CO2) emissions than steel beams (Hassan et al. 2018)*
- *Buildings with wood frames result in fewer CO2 emissions than buildings with reinforced concrete materials (Sathre and Gustavsson 2009);*
- *The central production of prefabricated products reduces costs relative to conventional building techniques (Brandner et al. 2016).*

The use of CLT—a wood panel product made by gluing layers of solid-sawn lumber together stacked at 90-degree angles—is predicted to grow rapidly in the future. CLT was originally developed in Europe but there is now growing research, development, and use in many other countries, including Canada, the US, Japan, China and New Zealand. CLT allows the construction of high-rise timber buildings and has been used in the construction of the world's tallest timber buildings (Brandner et al. 2016). An evaluation of the economy-wide impacts of replacing carbon-intensive construction inputs, such as steel and cement, with lumber products revealed that the ability to substitute lumber-based building materials increases production from the lumber and forestry sectors and decreases production from carbon-intensive sectors such as cement. Under a carbon cap-and-trade policy, the ability to substitute lumber products lowers the carbon price and the GDP cost of meeting the carbon cap, with more overall emissions abatement in the construction industry (Winchester and Reilly 2018). The global engineered wood market was 22, 91, 20, 000 cubic meters in 2020 and the market is projected to register a CAGR of 5% during the forecast period (2021-2026) (Globe Newswire 2021).

The usage and manufacturing of engineered wood require less energy compared to conventional building materials like concrete and steel. As engineered woods are manmade, they are designed to meet the requirements, reducing wastage, time, and overall costs. The wood products are often used as beams and columns in construction and even support heavy loads and show greater strength.

The application of cross-laminated wood has been increasing rapidly. For low-rise construction, the increased loadbearing capacity of CLT wall panels adds further benefit over conventional stud-framed walls. Cross laminated timber is now an established system in the mid-rise residential sector in Europe and North America. In addition to that, there are now increasing examples of cross-laminated timber being used to construct skyscrapers for buildings over 150 m tall. The growing application of OSB in various residential applications, such as walls, flooring, and roof, is estimated to drive the market. All types of engineered woods are significantly used in various applications in the residential sector.

Cross-laminated

Cross-laminated timber (CLT) is when layers of timber are glued together with the grain alternating at 90-degree angles for each layer. Glue-laminated timber (glulam) is when laminates are glued together by layering them with the grain, which produces larger and longer length members. CLT is typically used for roofs and walls in commercial construction, where glulam is often used for posts or beams. Their use typically goes hand in hand.

LVL – Laminated Veneer Lumber – is a veneer based product composite of layered wood veneers and adhesive. It belongs to the category of engineered wood called structural composite lumber. It has the better of two worlds: the beauty of natural wood and the higher reliability of a structural



Mass Timber Structures: High Rise Buildings and Small Houses made with CLT

element made using the most modern technology. It is very similar to plywood. The difference between LVL and plywood is the orientation of the veneer layers; LVL is manufactured from veneers all oriented in one direction.

LVL is generally produced in 44 mm wide sections and is similar in appearance to plywood, but in plywood the veneers switch direction while stacking and in LVL the veneers all stack in the same direction. The stacking of these veneers into a complete board, called a billet, produces a single piece of LVL with the same direction of wood grain. In LVL, the direction of the wood grain is always parallel to the length of the billet.

In India, about 500 million sq.mt of laminate flooring and another 120 million sq. mt of engineered wood flooring are consumed annually. Out of the one billion sq. m flooring market in India, wood

based floors currently accounts only for about 1.5% of this. If past consumption patterns are observed then wood flooring should take in about 15% of the market or almost 10 times the current size. The current growth rate of about 20% pa in this category is a good indicator of things to come in the country.

No ban on the use of timber in CPWD works!

The Central Public Works Department (CPWD) ended the ban in place since 1993 on the use of timber in its construction projects, saying that the Union Ministry of Environment, Forest and Climate Change (MoEF&CC) had asked for the ban to be lifted in order to boost the economy, generate jobs and encourage farmers to plant more trees. The MoEFCC has asked to remove the ban on use of wood in construction, since it will create demand for wood-based industries that would spur the local economy, particularly in rural areas, create large scale employment and encourage farmers and others to bring degraded areas under tree cover that, in turn, will augment production of a multitude of ecosystem services for the benefit of the country. CPWD admitted that the life cycle economic cost of the versatile material, timber, is much lower in comparison to other construction materials such as steel, aluminium, PVC, glass, cement and polymers that are used in place of wood and depends on non-renewable sources of raw materials with polluting and energy intensive methods of production, whereas timber is naturally available. Capture and storage of atmospheric carbon in growing forests and timber would help in addressing climate change, adding with the country's commitment to the target of creating an additional carbon sink equivalent to 2.5-3 billion tonnes of carbon dioxide by 2030 and raising the demand for forest products was needed for that. Therefore, it has been decided to remove the ban on use of timber in construction and to promote its use in construction of buildings/habitat development, in the works undertaken by CPWD in India. The CPWD, which is the Union Housing and Urban Affairs Ministry's construction agency, carries out projects all over the country as well as in some international locations. The CPWD will also be carrying out the construction of the proposed new Parliament building and common Central Secretariat in Lutyens' Delhi.

Role of Bamboo in the Construction Sector

Bamboo is rightly called as the 'Green Gold' as it qualifies under many of the categories listed for green building materials. In its natural form, bamboo as a construction material is traditionally associated with the cultures of South Asia, East Asia, the South Pacific, Central and South America; for beams, trusses, posts, walls, roofs, and floors. As far as its traditional structural uses are concerned, in China and India, bamboo was used to hold up simple suspension bridges, either by making cables of split bamboo or twisting whole culms of sufficiently pliable bamboo together. Bamboo has also long been used as scaffolding; the practice has been banned in China for buildings over six stories, but is still in continuous use for skyscrapers in Hong Kong. In the Philippines, the 'nipa hut' is a fairly typical example of the most basic sort of housing where bamboo is used; the walls are split and woven bamboo, and bamboo slats and poles may be used as its support. In the Japanese architecture, bamboo is used primarily as a supplemental and/or decorative element in buildings such as fencing, fountains, grates and gutters, largely due to the ready abundance of quality timber. In Central and South America, bamboo has formed an essential part of the construction culture. Vernacular forms of housing such as the 'bahareque' have developed that use bamboo in highly seismic areas. When well-maintained and in good condition, these have been found to perform surprisingly well in earthquakes. Over the past few decades, there has been a growing interest in using bamboo round poles for construction, primarily because of its sustainability. In Costa Rica, 1000 houses of bamboo are built annually with material coming only from a 60-hectare bamboo plantation. If an equivalent project used timber, it would require 500 hectares of threatened tropical rainforests (Bhattacharya nd.) In Limon, Costa Rica, only bamboo houses stood after a violent earthquake in 1992. Because it is flexible and lightweight bamboo enables structures to "dance" in earthquakes.

To date, the most high profile bamboo construction projects have tended to be in Vietnam, Bali (Indonesia), China and Colombia, being handled by famous bamboo architects and builders include *Simón Velez, Marcelo Villegas, Oscar Hidalgo-López, Jörg Stamm, Vo Trong Nghia, Elora Hardy, John Hardy*, etc. The greatest advancements in structural use of bamboo have been in Colombia, where Universities have been conducting significant research into element and joint design and large high profile buildings and bridges have been constructed. In Brazil, bamboo have been studied for more than 40 years at the Pontifical Catholic University of Rio de Janeiro PUC-Rio for structural applications. Some important results are: the deployable bamboo structure pavilions and the active bending bamboo amphitheatre structure with flexible joints, the bamboo space structure with rigid steel joints, bamboo bicycles, etc. Bamboo has been used successfully for housing in Costa Rica, Ecuador, El Salvador, Colombia, Mexico, Nepal and the Philippines. An appropriate way of using bamboo for housing is considered to be the bahareque (the Latin America vernacular construction system; a derivative of wattle and daub) or improved bahareque or engineered bahareque.




The first structural design codes for bamboo in-the-round were published by ISO in 2004 (ISO 22156 Bamboo - structural design, ISO 22157-1 Bamboo – Determination of Physical and Mechanical properties: Part 1, and ISO 22157-2: Bamboo – Determination of Physical and Mechanical Properties - Part 2: Laboratory manual. Colombia

was the first country to publish a country-specific code in the structural use of bamboo - NSR-10 G12. Since then, Ecuador, Peru, India and Bangladesh have all published codes (Gatoo et al.2014); however, the Colombian code is still widely considered to be the most reliable and comprehensive. BIS (2016), in their National Building Code of India details with Wood and Bamboo Code of Practice for Structural Designs (Which was separately denoted as IS 15912: 2012, for bamboo structural designs component, BIS 2012).

India is the second largest producer of bamboo in the world and has a rich tradition of bamboo in indigenous construction. Bamboo being a fastest growing and highest yielding plant, its maintenance does not require much labour and is a source of livelihood to many people in the region. Bamboo has been one of the oldest and most versatile building materials with many applications in the field of construction. Lauded in environmental circles for its quick growth and the fact that it can be harvested without harming the plant, bamboo seems a perfect way for promoting green economy. As wood becomes more scarce bamboo construction will hold more and more value where the benefits of its use have been known for millennia. Bamboo being extremely lightweight thus building with bamboo can be accomplished faster with simple tools than building with other materials. As such bamboo constructions are easy to build, resilient to wind and even earthquake forces.

The housing sector in India is growing rapidly but with increased cost it is getting out of reach of people. Utilization of bamboo as a construction /structural element in various building components such as floor, roof, beam, wall-panels, columns etc. as well as for partial replacement of steel reinforcement, is gaining immense importance today, mainly on account of the improvement in the economical aspect combined with ecological benefits. Engineered Bamboo can substitute steel in making tensile stresses of RCC members and also reduces the consumption of cement in building. Both cement & steel are the most dominant and energy intensive materials used in construction. Bamboo has a proven testimony as one of the oldest construction material throughout the world. It provides a good thermal insulation and has an advantage of being renewable and fast growing, contributes to higher carbon credit. With proper engineering, use of bamboo in construction can aid in the growth of alternative and sustainable development meeting the challenges of industry and growing housing sector.

Traditionally, it is being used as a construction and engineering material. Bamboo can be utilized as a building material for scaffolding, bridges, houses and buildings. Bamboo, like wood, is a natural composite material with a high strength-to-weight ratio useful for structures. Bamboo can be used extensively for applications like the construction of walls/partitions, flooring, roofing, scaffolding etc. in the construction sector. Bamboo sizes commonly suggested for construction purpose are 80-100 mm diameter with 10-12 mm wall thickness for columns, and 18-20 mm wide with 8-10 mm thick strips for wall infill panels. Round bamboo columns and trussed rafters act as the main load bearing element. Composite bamboo grid/cement mortar infill panels act as shear walls to resist wind and seismic forces. The system consists of – Foundation: individual column footings; Columns: bamboo culms set in/on concrete footing; Wall Infill: a grid of split bamboo covered in wire mesh and cement mortar; Floor: raised by 2-3 brick courses, filled with rubble and screeded; Roof Structure: bamboo rafters or trusses supporting bamboo purlins; Roof covering: corrugated bamboo mat board for; Doors & windows: bamboo mat board shutters.

Bamboos are some of the fastest-growing plants in the world, certain species of bamboo can grow up to 91 cm within a 24-hour period, or nearly 4 cm/h. The country is home to more than 135 different species, 50% of which are grown in the Eastern/ North-eastern states of India. Some of the species including *Bambusa Balcooa, Bambusa Nutans and Bambusa Polymorpha* and some of the Dendrocalamus spp. are reported to be ideal for construction. *Guadua angustifolia* (*Guadua bamboo*) (native to South

America) and *Phyllostachys edulis* (Moso bamboo) are undoubtedly the best bamboo species for construction and industrial use, especially in regards to strength and size. Due to its light weight and elasticity, bamboo is a popular building material in areas of the world where earthquakes, hurricanes and typhoons strike more frequently. Bamboo absorbs the shocks of seismic activity and high winds far better than rigid concrete and steel structures.It has greater tensile strength (or resistance to being pulled apart) than steel, and it withstands compression better than concrete. Bamboo has high tensile strength as compared to Steel because of its fibres runs axially. Bamboo has good elastic property so that it is widely used in the earthquake-prone areas. Bamboo has high fire resistance and it can withstand up to 4000 degree Celsius. One major disadvantage of bamboo is its poor resistance to fungi and bacteria. It is sensitive to attack from insects. So it must be preservative treated against them, otherwise, the material has a very short life.Bamboo shrinks much greater than any other type of timber especially when it loses water and hence care has to be taken to ensure only properly seasoned/dried bamboo should be used (Gnanaharan 1993).

Engineered Bamboo can substitute steel in making tensile stress members of RCC and also for reducing the consumption of cement in building. Both cement and steel are the most dominant and energy intensive materials used in construction. The use of bamboo as reinforcement in Portland cement concrete has been studied extensively throughout the world. Bamboo reinforced concrete for the key structural elements like slab, walls, columns and beams, of a modest dwelling unit can be successfully utilized for structural and non-structural applications in construction. Roofing and walling are two crucial elements of a house and several R & D institutions like Building Materials and Technology Promotion Council (BMTPC) and the Indian Plywood Industries Research and Training Institute (IPIRTI) and RV-TIFAC Composite Design Centre, Bengaluru, India, have been engaged in developing innovative, alternative roofing and walling materials/products and construction systems. Among the Bamboo Mat Board (BMB), Bamboo Mat Veneer Composites (BMVC) and Bamboo Mat Corrugated Sheets (BMCS) developed by IPIRTI were commercialized; Bamboo Ply boards and bamboo flooring tiles are commercially produced by the Kerala State Bamboo Corporation (KSBC) and Bamboo Mat Corrugated Sheets (BMCS) by M/s. Timpack Pvt. Ltd., Meghalaya. Ready to use bamboo building model systems using treated and seasoned round and split bamboo, BMB for walling, door and window shutters and BMCS roofing were also developed by IPIRTI. BMTPC (nd.) illustrates the potential of bamboo for the different elements for housing.

Bamboo composites have similar properties to wood composites. They have been widely used in the construction sector to partly take the place of timber, steel, plastic, etc.being strong, easy to process and acceptable in price. **Engineered bamboo products (EBPs)** result from processing the raw bamboo culm into a laminated composite, similar to glue-laminated timber products. These products allow the material to be used in standardised sections and have less inherent variability than the natural material. Engineered bamboo products have properties that are comparable to or surpass that of timber and timber-based products and hence of great potential in the construction sector. The mechanical properties of two types of commercial engineered bamboo products, viz., **bamboo scrimber** and **laminated bamboo,** indicated that both the products have properties that compare with or surpass that of timber (Sharma et al. 2015).

EBPs can replace timber and engineered wood in architectural works where higher performance is desired, both in terms of sustainability and dimensional stability. Architects are beginning to find that structural engineered bamboo can serve well in contexts where metal, steel, or extruded aluminium assemblies are the norm. Hybrid solutions are also more common in recent years, a

design approach pairing bamboo with steel, concrete, and other structural materials. Modular, prefabricated components of performance-grade engineered bamboo are used for building enclosures to provide high performance, sustainability, and dimensional stability.With increased use of engineered bamboo, building projects are getting qualified for several credits toward LEED v.4 certification, including: EAc2: Optimize Energy Performance; MRc3: Sourcing of Raw Materials; MRc4: Material Ingredients; EQc2: Low-Emitting Materials; and Inc1: Innovation (Sullivan 2018). EBPs are used for facades, cladding, curtain walls, structural glazing, as well as a range of window and door solutions. One manufacturing method produces **strand-woven or parallel-strand bamboo,** made from crushed fibre bundles soaked in resin and treated under pressure to create solid, dense slabs. A second method, known as **laminated bamboo**, also maintains the longitudinal fibres as the parallel-strand process does, but it also takes advantage of the natural culm matrix. The bamboo stalks are cut and planed, and then processed as desired prior to the lamination and compression in board form. This process typically utilizes less adhesive and tends to provide higher strength-to-weight values.

For varied enclosure systems such as fenestration, curtain walls, and rain screens made with engineered bamboo products offer a few inherent advantages. While the engineered bamboo functions in ways similar to hardwoods and can be worked with standard carpentry tools, it can be more sustainably sourced, and it tends to have very minimal shrinkage and better dimensional stability. Engineered bamboo products have natural antimicrobial properties so they resist moisture build-up and through unique processing methods can help prevent decay or rot from the core of the materials. Bamboo's high silica content acts as a natural insect deterrent. Engineered bamboo tends to have a slightly higher density than common hardwoods, which increases its capacity to be used in applications where traditional hardwoods would perform poorly.

These products also offer aesthetic attributes where other materials used in these applications need to be covered up by additional building materials to achieve a certain look wanted by the architect and designer. Bamboo provides a unique aesthetic that can be admired by the end user. The unique look of engineered laminated bamboo is becoming more accepted and appreciated by today's architects and designers looking for a natural product that does not need to be covered up by additional building materials which help reduce overall cost of time and labour in projects. In summary, Structural Bamboo Products (SBPs) (includes fabricated common dimensional components, glulam beams, and hybrid structural applications) can be described as similar to wood glulams but with more functional consistency and better dimensional stability, all things being equal. SBPs also can provide reduction in overall cost for projects by reducing the need to utilize additional building materials to cover up the exposed engineered bamboo materials. In summary, EBP, SBP, and LVB products are now being recognized in the architectural and building markets where manufacturers have dedicated their time and resources to enable access to this great building material to architects, engineers, interior designers, product specifiers, building owners, and other decision makers that focus on sustainable building practices. Through continued advancements in technology and engineering practices, EBP, SBP, and LVB products will become better and more available and allow for further expansion of utilizing these products through all facets of design. Laminated veneer bamboo (LVB) is a relatively new building product made from layers of glued bamboo and used in applications similar to lumber. LVB is a product that uses multiple thin strips of bamboo combined with an adhesive to form a board or sheet product. Manufactured by *Glubam, Moso and Lamboo©Inc.*, to

Engineered bamboo products used as rain screen and structural supports for the overhang (Source: Sullivan 2018)

name but a few, it typically consists of 3, 5, 7, and 9 layers laminated veneer bamboo is manufactured in a similar way to OSB or Plywood. A series of thin strips of bamboo are laminated together in alternating 90 degree angles for each layer.

Laminated Bamboo Lumber (LBL) is a relatively new concept that involves gluing together bamboo material in various forms (e.g., strands or mats) to form rectangular boards, similar to lumber. LBL has gained particular interest as it can be manufactured in well-defined dimensions, similar to commercially available wood products with the bamboo's mechanical properties. A Review of the processing, performance and economic considerations were made on LBL by Mahdaviet al. (2011) listed the challenges to laminated bamboo construction. Mahdavi states that "Normal precautions should be taken for moisture and dimensional stability as would be done for wood." While this is true, laminated bamboo is more dimensionally stable than laminated wood products. A second challenge is that "Adhesives do not bond well to bamboo without adequate surface treatment." To mitigate the bond issue, the natural wax present in the external surface of the bamboo culm must be chemically removed or preferably scrapped from the culms. The only challenge to this problem is one of economy. Any additional step in the lamination process requires more labour. Mahdavi addresses this by stating "Bamboo's cost is competitive in its natural form but significantly more expensive than alternatives in its processed form." But the most significant challenges listed by Mahdavi are that "Construction and engineering professionals around the world are not yet adequately familiar with modern bamboo structure design" and "Formal codes and standards have not yet been developed." There is a stigma associated with bamboo. It is considered a construction material of the indigent. In cities such as Dhaka, bamboo construction is shunned in favour of unreinforced masonry construction despite the seismic risks. In the United States, many designers have not been introduced to bamboo as a building material during their architecture education and are baffled by the lack of building codes in existence to direct its use. Despite these challenges, laminated bamboo can be a practical structural solution in many design applications.A simple, practical and low-technology approach for LBL fabrication that could be carried out in any part of the world in which bamboo currently grows is proposed by Mahdaviet al. (2012). Twelve 4-ply LBL specimens were fabricated using the proposed approach and an investigation on the mechanical properties of the LBL produced indicated that the end product is mechanically suitable for use in structural applications. They had shown that structurally reliable LBL can be fabricated using hand tools, screw-driven mechanical presses, and widely available, economical adhesives. Properties of the LBL are reported to be comparable to or surpass those of wood-based products and achieve the same good performance as other engineered bamboo products (Chen et al. 2020).

As a structural material, the properties of LBL vary depending on the way in which it is processed. Generally, the material is engineered by combining raw bamboo culm with a laminated composite. However, there are three different primary methods with which LBL is made. The first utilizes roller press crushers to flatten and smooth the culm into zephyr mats. These are then stacked and adhered to each other to create a panel. Another method feeds the culms through a splitter machine, creating strands that are then placed together and glued, while a third involves cutting each culm in half, flattening it, and then once again gluing them together. These methods are all tested and compared in a 2011 investigation for the Journal of Materials in Civil Engineering, with the resulting interpretation that the third is the most cost-/resource-efficient and the best option for structural applications. This conclusion stems generally from the method's higher dimensional stability and modulus of rupture, although a number of different properties were considered. Compared to timber, structural bamboo

is surprisingly strong, with up to three times the structural capacity as normal timber. Despite this, there remain some concerns about the bamboo's resilience, as it decays more quickly than wood if not treated with the right preservatives.

The cost of production of LBL may greatly depend on location. For areas with local bamboo forests, the cost benefits are immense. For places like the U.S., however, shipping costs associated with transporting the bamboo drive up costs by up to four times as much as conventional lumber. Additionally, sustainability benefits decrease significantly when heavy loads of bamboo are needed to be shipped across the globe. While the literature on structural bamboo remains sparse, it appears to have promise as another structurally sound and sustainable alternative to high-polluting conventional building materials. Though more research and consideration needs to be directed to this issue, existing scholarship seems to suggest that when location, production, and preservation are considered, LBL may be a strong contender for the next mass timber.

Engineeredbamboo flooring consists of a backing layer made from cross-laminated plywood or fibreboard. A very thin veneer of natural bamboo is glued to the backing layer. To get the veneer, stalks of bamboo are sliced into strips, and the skin is removed.

A proven joinery methodology is necessary to develop whereby the stress is distributed evenly and channelled to a fixture that easily can be bolted to another. With the right structural design columns, beams and floors made of bamboo as reinforcement instead of steel could replace steel reinforced concrete and steel structures to a large extent. Given that laminated bamboo columns and walls can support two to three times more weight than timber equivalents, it is logical to explore LBL as a material for high-rise structures. There has been research and development in the design of wood high-rise structures in the past few years. Life-cycle Tower in Bregenz, Austria, designed by Hermann Kaufmann is an example of efforts that utilize mass timber and prefabrication. Michael Green Architecture in Vancouver is also exploring Mass Timber. Mass Timber is a term that applies to Cross-laminated timber (CLT), Glue-laminated Timber (GLULAM) and Structural-Composite Lumber (SCL) which includes Laminated Veneer Lumber (LVL) and Oriented Strand Board (OSB). Given that LBL has higher allowable stresses, it makes sense to explore the possibility of LBL high-rise structures. Structurally and environmentally, LBL makes sense on large-scale construction. The barriers to use include lack of recognition by building codes and cost. LBL beams today are in limited use. Manufacturers of LBL do not have the economy of scale to reduce prices. From an initial cost perspective, Laminated Bamboo Lumber will become more competitive with steel if demand for LBL structures rise. In the United States, the cost of LBL could be reduced by using locally grown bamboo. Most LBL manufactured in the United States uses bamboo grown in Central and South America. A life Cycle assessment of laminated bamboo purchased from China, but manufactured in the Netherlands (Lugt 2012) shows that 29.6% of the carbon footprint and 54.8% of the eco-costs (cradle to gate) are generated by transportation. The South-eastern United States has a humid subtropical climate ideal for growing bamboo. If bamboo were propagated and processed on former tobacco fields, transportation factors of LBL would be eliminated. This would have the added benefit of phasing out tobacco without destroying the livelihood of farmers. ASTM 11a 5456 – Laminated Veneer Bamboo is a new addition to the ASTM standards for evaluating structural composite lumber products. This is the first step in true codification of LBL. As a recognized material, LBL can be easily specified for use. This milestone indicates that acceptance and recognition of LBL as a structural material is growing in the design community.

A sustainable building, or green building, or green architecture was fundamentally seen in so many ancient civilizations and traditional architectures. So

it is no more a new trend except that in the present it is viewed through a new perspective and with proper technological support. Main characteristic features which makes bamboo as a potential building material, are its high tensile strength and very good weight to strength ratio. It can withstand pressure in the tune up to 3650 kg/cm2. It can be easily worked out by simple tools and machines. Above all bamboo is renewable raw material resource from agro-forestry. Properly treated and industrially processed, components made by bamboo not only are cost-effective; it can have reasonable life of 30 to 40 years. Construction techniques using as main material have been found very suitable for earthquake resistant housing. It is an environment-friendly, energy-efficient and cost-effective construction material. Bamboo is one of the oldest traditional building materials used by mankind. Imaginative design and the use of other locally available materials within the cultural context can make the bamboo building desirable rather than just acceptable.

However, before using it in construction, it is imperative that bamboo is treated for termite and rot resistance. Some of the treatment procedures include dipping or pressure treating bamboo in a solution of borax and boric acid (Dhamodaran et al 2020); boron is also a fire retardant to some extent but further treatment for fire could also be carried out by other methods.

Way forward?

The National Building Code of India (NBC) mentions and advocates bamboo for use in construction under Part-6, Section-3 'Timber and Bamboo'. Rapidly renewable (fast growing), it is seen as an effective and eco-friendly alternative to wood which can sometimes take decades to replenish. Despite this, however, the material's use in urban India's building industry has been negligible. Lack of research and willingness to innovate and to move away from conventional materials is a prime reason. However, considering the fragile environmental situation today, it is time architects and builders explored this wonderful, aesthetic, eco-friendly and versatile material for its use in building construction.

In order to fully exploit the potential of bamboo for construction, concerted developmental efforts are directed at the key areas of preservative treatment for enhancing durability, jointing, structural design, etc. Efforts are needed to promote government institutional and policy support and integration with the private sector, integrating bamboo with local building materials and promote a broader range of bamboo construction projects, preparation of bamboo building codes and construction product standards, etc. Once these issues are successfully addressed, bamboo will be ideally placed to become a principal engineering and construction material for 21st century and beyond.

As global wood resources continue to decline, bamboo housing construction is one practical option to look towards drawing on ancient building traditions to create a modern housing solution with aesthetically appealing results.There should be strict policies in place to control the harvesting of only the matured culms forests and plantations. Also, research findings indicate that this renewable resource is under a high threat of depletion, and hence high yielding species should be introduced across tropical and subtropical countries where bamboo growth is sustainable. The key issues that need to be addressed to institutionalise the bamboo construction-based development in the country include an effective federal bamboo policy enabling legislative changes, a robust institutional framework, transfer of advanced technology, appropriate business development, an initial niche market facilitated by government, adopting maximum use of bamboo structures, and incentives in taxes and subsidies, etc

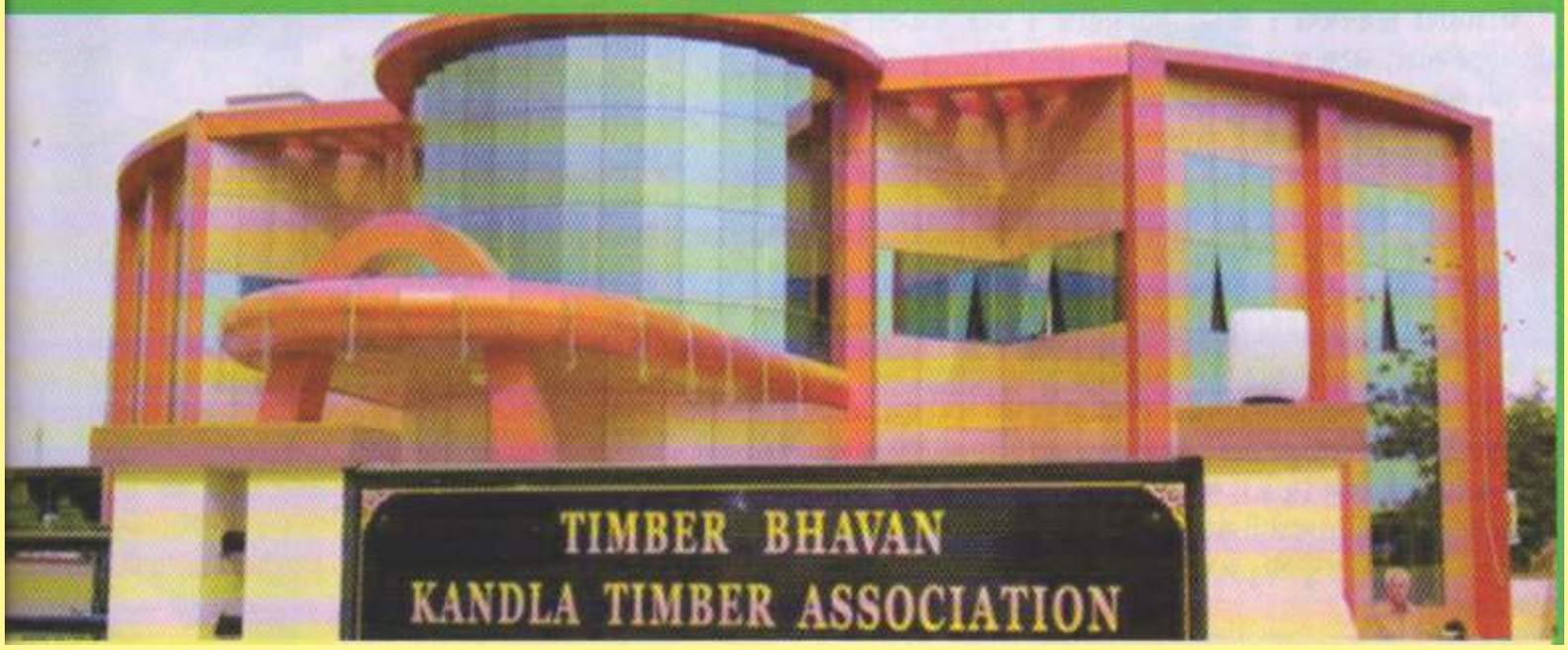
National Working Plan Code 2014 mandates to set aside 10% of the area for plantation working circle. This would take care of the need of production forestry especially for long rotation timber species suitable for building purposes. The state governments can decide how to manage the areas under plantation working circles to enhance productivity and production. A tripartite agreement can be made by including Forest Department, Local stakeholders and

A Traditional Mass Timber South Indian Koothambalam (Sanskrit Theatre) Archeological Heritage Structure

wood user company for forest areas mandated under plantation working circles. The Forest Development Corporation of the concerned state should shift to long rotation indigenous species and may adopt this partnership model. This arrangement would ensure a sustained certifiable raw material for the construction as well as furniture sectors. E-marketing platform like TimberCart may be developed on all India basis, to facilitate timely auction of Wood from Government Depots.There is also the need to launch Missions on augmenting supply of teak and pine timbers in the country since they form bulk of imported timber in the country.

(Source:Eduardo Souza. 2017. If we were to design the ideal building material, it would look a lot like bamboo. ArchDaily. December 23, 2017. <https://www.archdaily.com/885748/if-we-were-to-design-the-ideal-building-material-it-would-look-a-lot-like-bamboo>)

Kandla Timber Association



Association of Timber Importers, Traders, Saw Mill Owners, Plywood & Veneer Manufacturers

MANAGING COMMITTEE

Shri Navnit R. Gajjar President	**Shri Hemchandra B. Yadav** Vice President
Shri Swaminath Dubey Hon. Secretary	**Shri Saurabh Agarwal** Joint Secretary
Shri Bharat H. Patel Hon. Treasurer	**Shri Parveen Bansal** Joint Treasurer

Timber Bhavan: Plot No. – 47, Sector-8,Gandhidham - Kutch - Gujarat 370 201
Phone: 02836-230676, 232613
Telefax: 02836-222337, E-mail: kata.gdm@gmail.comi
Web: www.kandlatimber.org
Azim Sheikh 9925228799

Chapter 15
Miscelleaneous Products

Safety Matches

Safety matches are essential consumer commodity needed by all sections of the society. Wood is the major raw material for this industry. There are approximately 12,000 safety match making units in the country, and all except five, are in the small-scale and cottage industries category (officially, the cottage industry in match making is defined as any manual production unit producing less than 75,000 cases of match boxes per year). 82 Percent of the production is in the small-scale and cottage sectors. The industry as a whole employs around 250,000 people out of which only 6,000 are in the large-scale mechanised sector (Saigal and Bose 2003). Over two-thirds of India's matches are produced in just two districts - Ramanathapuram and Tirunelveli, both in Tamil Nadu. The bulk of the wood comes from neighbouring Kerala, where there are over 400 small-scale units making veneers and splints for supply to the match industry. This ancillary industry employs over 15,000 people directly and indirectly and produces goods worth Rs. 150 million annually. The safety match industry is facing shortage of raw material, especially of veneer quality wood. According to one estimate, the projected shortfall for the year 2000 was 900,000 m^3. While farm forestry plantations, especially poplar, have increased raw material availability in the north, most match units are located far away in south India (Tandon 1991).

There is growing trend of centralised ownership of many smaller units. In fact, just 18 families known as the "Match Kings of India" now control 67% of production. The Khadi and Village Industries Commission have provided support to many cottage units but the performance of cottage units hasn't been very good and the sector has not expanded much. The industry has also been accused of providing poor working conditions and exploitation of women and child labourers Bansal (2021).

The major raw materials used in the production of safety matches are softwoods used to make the match sticks (also known as "splints") and boxes. Bulk of the wooden match production in India is in handmade small-scale (67%) and cottage (15%). The only one unit representing the mechanized sector, namely M/s Wimco Ltd. contributes about 18% of current match production with factories in several states. Annual requirement of wood in India was around 2 lakh cum. Wimco initiated plantations of Poplar for matchboxes and splints. However, the species is now mainly used in plywood and panel industry. As much as 44% of all the wood used in match production goes into the production of matchboxes. Gradually, cardboard boxes have substituted wooden boxes and wax instead of wooden splints has resulted in major reduction in wood utilization. Now several species including Ailanthus spp. Albizia falcataria, Boswallia serrata, Alnus, Hevea brasillensis, Ceiba pendandra, Melia dubia, Bamboo, Simarouba glauca, Gmelina arborea are used. Widespread use of gas lighters at home and to an extent, increased awareness on the harmful effects of smoking and its ban in public spaces have also reduced the demand for match boxes.

As the match industry has been traditionally depending on only few timbers like aspen, semul, sawal, kadam, poplar, rubber wood, etc. for making the match splints and as many of these species are now in short supply, bamboo is found to possess the potential for replacing the conventional timbers for matchstick manufacturing, as an alternative raw material resource. Anatomical structure of bamboo with respect to strength and fast growing features has encouraged its adoption for production of match splints. Being a short rotation species, bamboo is cheaper than wood, and can be easily converted into splints of required sizes by using simple tools. The utilization potential of bamboo for match splints worth special attention, as apart from being available from natural forests, bamboos can be grown on a very short rotation of 2-4 years in many countries in diverse climatic conditions. However, several

intrinsic characteristics of bamboo, including the penetration of wax required for good incandescence and burning quality is found poor for bamboo, and have constrained their use for making matchsticks. IPIRTI, in the above context and with the support of INBAR, has appropriated the technology for successful utilization of two widely occurring species of bamboo in the southern India, viz., Bambusa bambos and Dendrocalamus strictus. Future R & D efforts on the potential of other species for the same purpose may be investigated in order to widen the bamboo raw material spectrum for match splints industry.

The manufacturing process for bamboo matches splints:

Cross cut bamboo poles (Dendrocalamus strictus and Bambusa bambos) can be split ether manually or mechanically; split bamboo is converted into slabs and later sized into splints of 37 mm length and 1.5 x 1.5 mm cross section (splints are usually made from dry bamboos), were treated with sodium meta silicate, followed by dipping in diluted hydrogen peroxide for 15-20 minutes. The splints are then washed in water and dipped in boric acid or boric acid-borax mixture solution for about 5 minutes and dried. Treated splints are then required to be waxed (dipping in molten wax at 80-1200 C for 8-12 seconds) followed by heating at around 1500 C for 2-3 seconds on a hot plate and head-fixed. For providing burning heads to the bamboo match splints, standard chemicals and processes followed in the case of wooden match splints is adopted and the process was undertaken at an existing match factory. Yellowish to reddish green bamboos usually bleached optionally, followed by carbonization which improves easy quenching of afterglow of the matchstick. The splints once made has a clean surface and the stick possesses high tensile strength and do not break easily. Post incandescent treatment is given to prevent afterglow for match splint with boric acid which also offers good resistance to borer attack. The bamboo match splints were found conforming to IS 2653-1993 & IS 10374-1982 and the process is patented (MAS/627/2000 dated 07-08-2000). A financial profile is also prepared and published; cost per box is tuning to 28 paise for bamboo whereas for wood match stick it is reported to be coming to 35 paise per box.

Fuelwood: Almost nine-tenths of all wood produced in India is consumed as fuelwood. Wood is a major source of energy for cooking in Indian households, mainly in rural areas, and meets around 60 per cent of all domestic energy needs of the country.

Out of a total wood production of 456.2 million m3, a quantity of around 385.3 million m3 is recorded to be total fuelwood production; 333 million m3 (around 216 million tonnes) (per capita about 17.7 kg in rural and 6.3 kg in urban areas) is estimated to be the total annual consumption for fuelwood (Shrivastava and Saxena 2017).

About 853.87 million Indians make use of this source of energy. Out of this, about 200 million people source nearly 90 million cum (59 million tonnes) of fuelwood from forests alone. In recent years, the number of people dependent on fuelwood has been increasing at a rate slower than the rate of population growth. This provides a golden opportunity to the government to promote alternative sources of energy in the rural landscape. The major consumption of wood in India is still in the form of fuel wood accounting for 75 % in the rural areas and 21.7 % in the urban areas (NSSO). It is estimated that about 270 million tons of fuel wood is extracted from the forests of India annually (Bansal 2021).

Automobile Body Building: It is estimated that construction of the body of each truck consumes 6.25 m3 of sawn timber; over 7% of the total SSFEs were auto body building units.

Wooden Agricultural Implements: A large number of wooden agricultural implements are manufactured each year. Most of the work is done in small-scale units or by individual artisans. According to an estimate, the total annual consumption of wood for this purpose was around 4 million tonnes and there were 54,975 wood working units in the small-scale sector (Tewari 1995). In terms of volume, the projected demand for timber for agricultural implements for 2020 was 2.5 million m3

(Shrivastava and Saxena 2017).

Sports Goods: According to an estimate made in 1986, there were 1,500 registered wooden sports goods units, out of which three-quarters were in Punjab, Uttar Pradesh and Jammu and Kashmir. Nearly half the units were located in two towns, Jullundhar and Meerut. Around 85% of the units were in the small-scale sector. The main raw materials used were willow, cane, mulberry, maple, ash and rosewood According to projections made by the Forest Survey of India, the total wood demand for the sports goods industry was estimated to be 101,000 m^3 in 2000 (Tewari 1995, cf. Saigal & Bose 2003).

Wooden Catamarans: Sizable quantity of wood is required every year for making catamarans in the coastal states in the country. Catamarans are non-mechanised fishing crafts used for catching the fish in large scale in water bodies. The simplest type of fishing craft may be taken as the one formed by a few curved logs of wood joined together forming a kind of floating raft. Four types of catamarans are prevalent in Indian waters, namely the Orissa type, Andhra type, Coromandal type and Kanyakumari type. To enhance service life of wooden catamarans IWST, Bangalore has developed methods comprising seasoning followed by treatment with Copper Chrome Arsenic. In recent years wooden catamarans are getting replaced with other materials including plastics and fibre glass.

Textile industry: Traditional looms made of wood are extensively used in the handloom sector in many states in the country. Similarly, wooden bobbins, spindles, spools are used in power looms and textile industry in various parts of the country. Bobbins are made up of compressed densified wood.

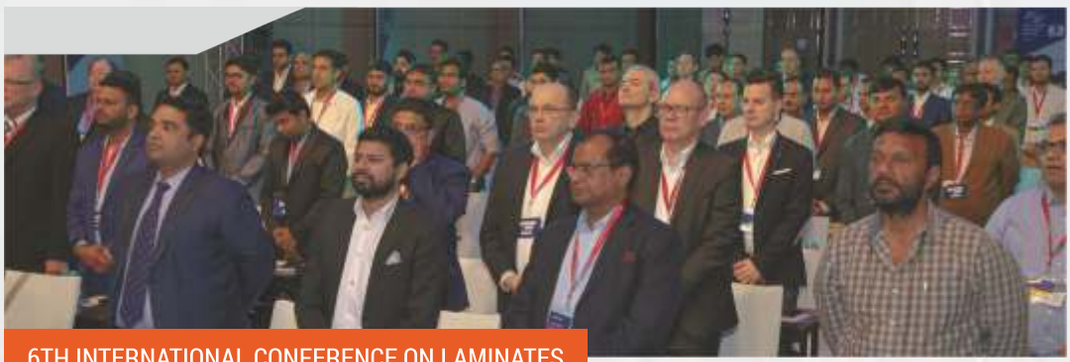
Musical instruments: Rosewood (Dalbergia latifolia) and red sander (Pterocarpus santalinus) are used in manufacturing musical instruments. Flute is a typical Indian musical instrument made from bamboo. Solid wood is also find use in the making of south Indian percussion instruments like the various types of drums (Chenda, Maddalam, Thakil, Mrudamgam, Edaka, Udukku, etc).

Traditional South Indian wooden percussion & musical instruments

www.ilma.org.in

INDIAN LAMINATE MANUFACTURERS ASSOCIATION

ILMA



6TH INTERNATIONAL CONFERENCE ON LAMINATES

Strength of Unity

Indian Laminate Manufacturers Association (ILMA) is nonprofit making organization of manufacturers of Decorative and Compact laminates or high pressure laminates, Particle Boards, Plywood and Pre-lam (Short Cycle Laminates). It is the only registered association of the laminate industry at national level and we are proud to complete 20years since 1998. More than140 manufacturers of Laminates of India are the registered members of ILMA.

ILMA is a place where companies collaborate to get more opportunities to grow their business. ILMA is a symbol of Indian Laminate Manufacturer's unified commitment to provide seamless & world-class decorative surfaces. ILMA assembles its manufacturers on a unified platform & voices out its fair opinions. It unanimously provides a healthy competition, creating great opportunities by using different strategies and combining the views of the manufacturers.

Key Achievements

1. Organized six International Conference on Laminates between 2010 to 2018
2. ILMA Institute of Technology to enhance production capabilities of members employees
3. Restrict import of low quality laminate
4. Study on Cleaner Production
5. Launch of Technical book on laminate
6. Catalogue shows at National and International Level
7. Launch of awareness video on Laminate application
8. Networking with members for raw materials, production, market and government policy related issues
9. Export incentive benefits to laminate exporters
10. Support to PM Cares fund during pandemic

Upcoming Events

1. 7th International Conference on Laminates during Delhi wood March 2021
2. Catalogue show at Interzum, Germany 2021
3. Online technical workshop on production and environment aspects during October 2020.
4. Environment clinic with Pollution control board (December 2020)

FOR REGISTRATION

Contact us on +91 9904125666/ +91-79-400 53443
Write to us at ilma@live.in
Join us on Facebook.com/ilma.org.in
Visit our Website www.ilma.org.in

REACH OUT TO US AT

INDIAN LAMINATE MANUFACTURERS ASSOCIATION
Regd. Office:
301, ILMA, Shubham Complex, Nr. Vastrapur Lake, Opp. Sanjeevani Hospital, Vastrapur, Ahmedabad, Gujarat, INDIA 380015.

Chapter 16
Reconstituted Wood Panel Board Sector

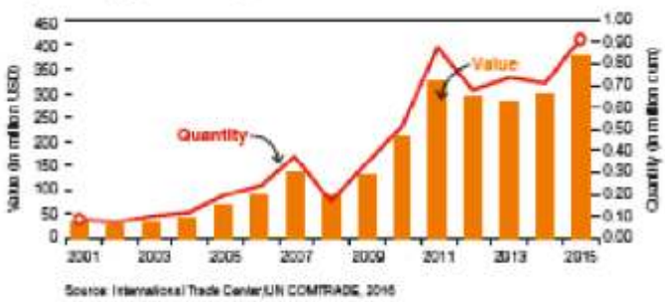
Production and consumption of wooden panel products like Plywood, Medium Density Fibre Boads (MDF), AND Particle Boards (PB) has been growing rapidely during the last decade. Figures for the Indian wooden panel production and import in 2019 (Pandey & Roy 2020) was as under :

Panel Board Items	Production (Million m^3)	Import (Million m^3)
Plywood	10.0	0.4
Particle Boards, OSB & Other Boards	1.20	0.2
Fibre Boards – HDF/MDF	1.0O	0.2

Plwood is manufactured from thin layers of wood called as veneers that are glued together with adjacent layers having their grain orientation perpendicular to each other.Plwood Industry is retaining its dominance to the tune of 80-85% share in all the panel products use in building, cabinets and furniture sub-sectors, with a market size of approximately Rs. 25,0000/- crore with a CAGR of 6-7%; the rest comprising engineered panels like MDF and Particleboard. Their product categories include veneer sheets, particle board, fibre board, plywood from hard and softwood, veneered panels and laminated woods and medium density fibre boards. Enterprises in this sector is reported to give employment to more than a million people directly through about 3,200 units in the unorganized and about 100 units in the organized sector, totalling to around 3,300 units in the small, medium & large industry sector and almost same figure of 1 million for indirect employment too. About 87% of plywood factories fall into the small enterprise category.

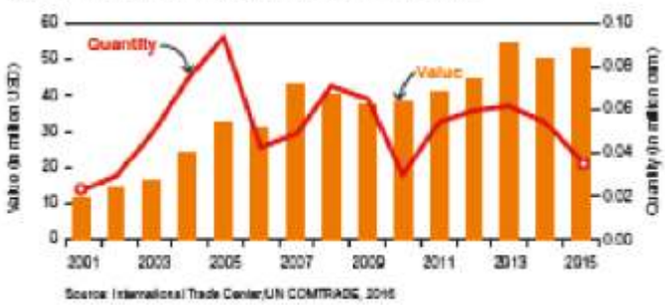
Indian plywood industry is estimated at US$ 1,200 million and the laminate industry at almost US$ 462 million, expected to grow 10% annually. Among the organized players, Century Plyboards India Ltd. And Greenply Industries Ltd. are the main pan India

Imports of plywood and panel from 2001 to 2015



Source: International Trade Center,UN COMTRADE, 2016

Exports of plywood and panel from 2001 to 2015



Source: International Trade Center,UN COMTRADE, 2016

players dominating the organized marketwith a share of nearly 26 per cent for each, totalling to 52%. Other key players in the market are National Plywood Industries Ltd, Kitply Industries Ltd, Sarda Plywood Industries Ltd and Mayur Plywood. The projected demand for timber for plywood for 2020 was 29.2 million m3 (Shrivastava and Saxena (2017). Plywood industry consumes major share of composite wood in India. Most of the manufactured plywood and panel ends up in the furniture, modular kitchen, and wood flooring markets. There has been a boom in these markets in the last 15–20 years due to growth in the real estate sector.

The most popular forest wood traditionally used in India for making plywood is Gurjan, a Dipterocarpus species comprising more than 35 individual species; the main species used for plywood making are: *Dipterocarpus turbinatus (Keruing),Dipterocarpus bourdilloni and Dipterocarpus indicus.*

Plywood forms a major segment of the wood-based industry in the country. For the housing interiors industry, the Indian market is still dominated by plywood and block board, although the trend is changing following a growing share for particleboard and MDF. Plywood comprises around

60% of the interior infrastructure industry and is set to gain the most. According to Federation of Indian Plywood and Panel Industry (FIPPI), the total output of the plywood and panel products sector is about 220 million square metres, with a market turnover of approximately US$ 585 million. The industry operates at less than 33% of capacity, due to the shortage of domestic raw materials and the poor financial health of several players (AHEC 2016).

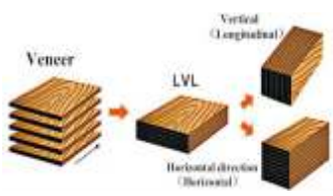
Medium Density Fibre (MDF) Board is manufactured from wood ifbres, combined it with wax and a resin binder, and forming panels by applying high temperature and pressure. Typical density of 600–800 kg/m³ . MDF Industry's installed capacity is estimated as 1.4 million m^3 plus an import of around 0.25 million m^3 annually, with a market size of nearly Rs. 1600/- crores. With the current production of around 1.15 million m3, 80% capacity utilization is reported to be achieved in this sector. MDF sector is growing at a CAGR of 20%. Century and Greenply dominate in this sector also with a respective share of 26 and 23 per cents. Eventhough roughly 30% of the MDF is imported now, imort is expected to decline t the level of 15% , as many Indian Companies are ramping up to the MDF capacity.

Particle Board (PB) is manufacturedfrom woodchips, including sawdust, and a suitable binder, which is pressed or extruded. Particle Board Industry had about 30 units in the country; many of them in the un-organized sector. It is reported that very few industries are found manufacturing particle boads conforming Indian Standards (Pandey and Roy 2020); hence caution is warrented among the end-users. This sector is producing around 1 million m^3 boards of various thicknesses; annual import to fill the demand-supply gap is nearly around 0.16 million m3. Still, imported MDF and PB are available at a cheaper rate than locally manufactured ones (due to high cost of domestic wood), import quantity and trend is growing in this sector. China boasts the No. 1 in the world productio n of plywood (75%), MDF (43%) and PB (27%); India produces a megre 4% of the world's plywood, and the share in the production of MDF and PB are not even worth mentioning, <1% of world's production. The number of units of medium and large wood-based panel industries in India is as shown below:

Oriented Strand Boards (OSB) are formed by adding adhesives and then compressing layers of wood strands (flakes) in specific orientations.

Sl. No.	Industry	No. of Units
1	Plywood	61
2	Veneer	14
3	Block Boards and Flush Doors	98
4	Particle Board	11
5	Fibre Board	5

Laminated Veneer Lumber (LVL) is a composite of wood veneer sheet elements with wood veeners primarily oriented along the length of the member, where the veneer element thicknesses are 0.25 inch (6.4 mm) or less.



Cross Laminated Timber (CLT) is made from at least three layers of solid-sawn lumber that are stacked crosswise and bonded together with structural adhesives to form a solid, rectangular-shaped panel.

For Glue Laminated Timber (Glulam), layers of timber are cut in the same grain and jointed and glued together. This

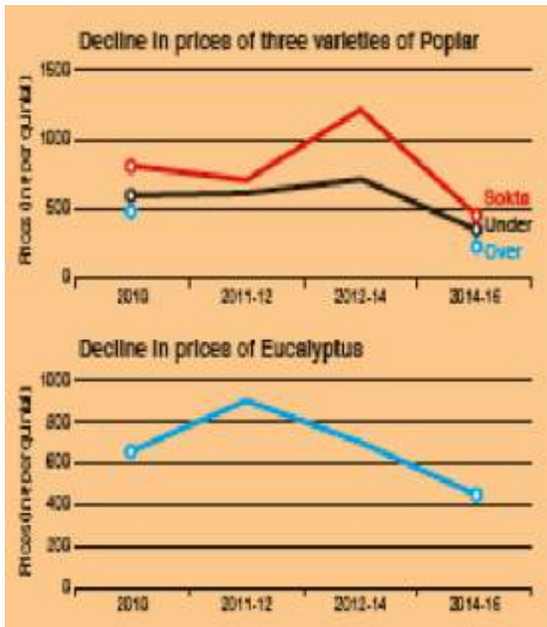
gives the glulam strength in one direction and for this reason glulam is predominantly used for structural beams.

Finger Jointing is employed for maximizing use and reduction in wastage of wood along with for imparting improved aesthetic value.

Agroforestry(AF) and Trees Outside Forests (ToFs) remains to be the main raw material resource for wooden panel sector in the country; poplars and eucalypts in the northern India and rubber wood and silver oak in the southern India. Plantation timber lops and tops, wood wastes and agro residues form the basic raw material for the particle board industry and hence are being utilized by this sector, threby the tree growing agri-farmers are benifited from tree/wood waste utilization too. Promoting the use of wood from sustainably managed AF and ToFs would play a significant role in mitigating climate change ensuring sustainable living, thereby contributing to SDGs of the UN. Realizing this aspects many Indian States like Punjab, Haryana, Karnataka, Tamil Nadu, Andhra Pradesh, Gujarat, Utter Pradesh, etc. have already started massive plantation programme. The 2017 break-up account of timber requirement for all industrial purposes has been estimated to be 57 million m3 (Pandey and Roy 2020) as under:

Saw Mills	29 Million m^3
Veneer & Plywood Mills	19 Million m^3
Paper Mills	9 Million m^3
Total	57 Million m^3

-against a total availability of 83.5 million m3 (FSI 2017), emergence of more AF based wood industries could definitely be promoted for more employment generation and livelihood improvement of the Agri-farmers. Imports constitute 20% of the total annual wood consumption in India, while plantations and forestry contribute 58% and 22% respectively. India imported plywood worth US$ 249 million with total quantity of 51.6 million. China is the largest supplier of plywood accounting for imports worth US$ 104 million followed by Indonesia and Malaysia which exported plywood worth US$ 72.5 million and US$



26.2 million respectively. The contribution of this sector has gone up to US$ 15.7 billion in 2010-'11 compared with US$ 5.5 billion in 2004-05, registering annual compound growth of 19.16% (AHEC.2016). Growing shortage of quality raw material due to felling bans and restrictions on extraction in several states pauses a key threat to the small scale forestry enterprises (SSFEs) in India.

Fall of Poplarin Yamunanagar

The Yamuna Nagar timber market is the largest for pulpwood and plywood timber in Asia. About 2.6 million tonnes of wood is supplied annually to it from Haryana and other adjoining states, having 65 per cent share among those states. The district accounts for 80 per cent softwood production in India, with an annual turnover of more than I2, 500 crore. Around 5,000 small, medium and large wood-based units have been set up in Yamuna Nagar, which produce almost 50 per cent of India's plywood, and employ around 50,000 people. According to local stakeholders, poplar alone has 95 per cent share in the Yamuna Nagar timber market. In the last few years, farmers and the timber merchants have been facing problems due to steep decline in the prices of poplar and eucalyptus. The reasons for this decline are many, non-issuance of new licenses, use of *Chinese-made peeling machines, which can peel thinner slices, reducing the rotation period, and lack of government-run sawmills, which gives private saw-mill owners monopoly and power to determine prices.*

Integration of Agroforestry and Wood based Industries

Farmers and communities are important producers though their contribution is not widely recognised or acknowledged. Joint forest management communities are now protecting over 18% of India's forests and half the industrial wood supply is coming from non-forest sources, mainly farms. Growing import trend can be controlled by making available more locally grown agro-wood from the AF promoted plantations of tree growing farmers. To meet the shortage of raw materials, WIMCO Seedlings Ltd. (UK) and ITC, Bhadrachalam Paperboard Ltd. (A.P.) promoted the farming of poplar and clonal eucalyptus through providing quality plants, package of practices and assured buy back arrangements in 1984 and 1989. These models have ensured the backward integration of raw material with wood-based industries, mainly with pulpwood industries and then for panel board manufacturers. Yamunanagar city in the state of Haryana, the 'plywood capital' of the country, which has the capacity to manufacture about 45% plywood of the country has developed the Yamunanagar model AF plantations, mainly due to flowing of Yamuna river, highly fertile region, progressive farmers, liberal policies of the Government of Haryana and closure of plywood industries in North-Eastern India. This model has benefitted many stakeholders like farmers, labourers, contractors, transporters, traders and industrialists (Sapra 2020).

However, the most important change waiting for a golden era for this sector is a legal declaration from the Government side stating that AF produce as Agro-based produce which can enjoy all the tax benefits that is derived by agricultural products. This should be coupled with a removal of wood based industries solely dependent on plantation wood (like eucalypts, poplar, silver oak, rubber wood, Melia dubia, etc.) and imported wood wherever in the country from forest licensing. The forest produce production enterprises (e.g. farm forestry plantations) face restrictions such as requirements of felling and transit permits and land ceiling laws. The policy environment also varies according to the industry. For instance, while there are special environment protection provisions for hazardous industries. The traditional mind-set that the licensing helps check illegal wood flow from natural and reserved forests is totally absurd and illogical (Pandey and Roy 2020), as a lot of alternative effective and safe measures could be developed for the above. Removal of licensing could result in an increase in the number of panel mills in the plantation centres which could also help to improve the agro-wood farmers' income thereby their improved livelihood. Along with promoting AF, the industry also needs to be supported by liberalizing permit requirements for transportation and processing of the AF timber. As this sector is depending on timber imports also, the present Indian plant quarantine legality that only methyl bromide (MB) fumigated timber is permitted to import being against the legality in many exporting countries that MB is banned in those countries, needs to be urgently looked into by the GoI, as due to the present situation, much good and competitive wood cannot be imported because of the harsh conditions existing in the plant quarantine sector.

As a follow up of the recently issued MOEFCC guidelines for the benefit of plywood and panel industries of the country, *"Industries/ Processing plants which use round log/ timber from species declared as agroforestry/ agricultural crop and/ or exempted from the purview of the felling and transit regime in the concerned State/UT, and procurement from legitimate sources do not require License"*, IWST Bengaluru has initiated the drafting of a bill for enactment by the Government (Singh 2020a & b, Singh & Singh 2020) to promote and facilitate the sustenance of wooden panel industries of the country. It is expected that the proposed enactment will remove the present legal restrictions experienced in the harvesting, transporting and processing of the AF plantation timber by the wooden panel board manufacturing industries and the same will prosperity to the sector – industries and farmers.

Conclusion

Wood-based panel with formaldehyde is a cause for indoor air pollution. Formaldehyde, the main adhesive resin component in many re-constituted wooden panel board productshas been classified as a known carcinogen toxic to the nervous system, immune system, and liver of human being and the main sources of formaldehyde emission are being from wood-based products, as the resins used are urea-formaldehyde (UF), melamine-modified urea formaldehyde (MUF), phenol formaldehyde (PF). CARB (California Air Resource Board) certified products are mandatory for export of wood and wood-based panel products to USA and other countries. Products certification to meet the environmental norms of the western countries is a major hindrance to the export. Due to increasing significance of USA as export market, R&D and testing infrastructure for CARB need to be established. IPIRTI (Indian Plywood Industries Research and Training Institute) is currently involved in promoting the export of panel products by way of certifying the emission of volatile organic compounds in par with international standards. There is also a consistent demand from the panel industry that IPIRTI should act as a third-party certifier for California Air Resource Board (CARB). IPIRTI has also initiated the process for obtaining CARB third party certifier.Considering the importance of IPIRTI as the only one single national level R & D Institution dedicated for the development of reconstituted wooden panel board products, strengthening of this institution need to be considered; the presence negligence from the Government side in this regard should do away. Recently BIS has also adopted (with the serious inputs from IPIRTI) Emission Standards for panel products for volatile organic compounds.

PLY insight

A Monthly Magazine for

PLYWOOD | LAMINATE | TIMBER | MACHINERY | FURNITURE | MDF | PARTICLE BOARD

05 Expand your Business with PAN India Circulation

04 Search & Connect with People
visit
www.plyinsight.com/dealers
www.plyinsight.com/manufacturers

03 Promote your Brand through : Webinars

02 Advertise with us
Simultaneously in magazine & website
www.plyinsight.com

01 Choose Plyinsight
Market News
Technical Updates

www.plyinsight.com

@ plyinsight

857 829 8590, 8591, 8592

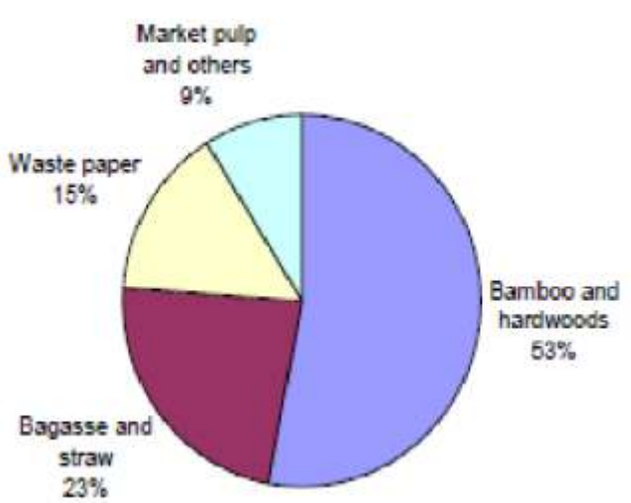
Chapter 17
Pulp and Paper Sector

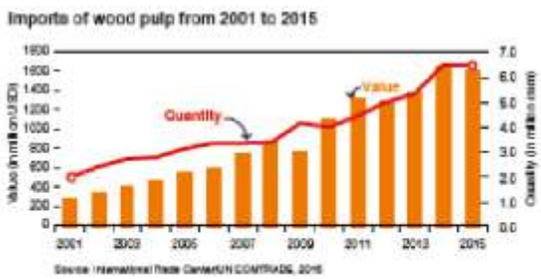
The 2015 figure for Indian import of timber for pulp and paper was reported to be 6.5 (worth 1610 million USD) and 4.2 million m^3 (worth 2424 million USD) respectively, accounting to a total of 10.7 million m^3 (worth >4000 million USD); whereas the export figures for the same was reported to be 0.02 million m^3 (worth 10.9 million USD) for pulp and around 1.4 million m^3 (worth1,130 million USD) for paper sectors, accounting to an insignificant figure (compared to import) of around 1.4 million m^3 timber worth around 1140 million USD. The projected demand for timber for the paper and paper board sector for 2020 was 35. 84 million m^3 (Shrivastava and Saxena 2017).

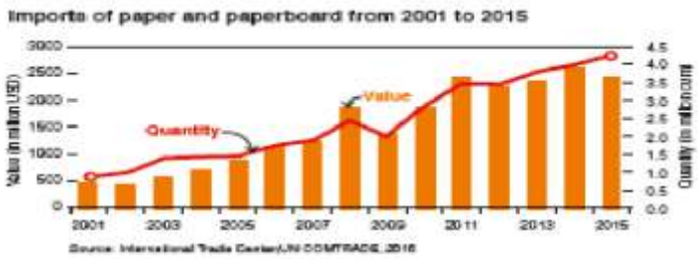
Out of a total wood balance of around 71 million m^3 industrial timbers in the country, a quantity of around 12.5 million m^3 is reported to be consumed by the Paper and Paper Boards and Newsprint Sector. With the rise in demand steadying at around 8%, India is considered the fastest growing paper market in the world. The annual per capita consumption of paper is projected to be 17 kg by 2020. Indian paper industry is fragmented, consisting of 813 small, medium and large paper mills having capacities ranging from 10 to 1,500 tonnes per day. Of them, only 31 are reported to be using wood-based raw material, the rest use agricultural by-products and recycled waste paper and fibre. Large integrated paper mills have a production share of around 26 per cent. The industry produces around 15 million tonnes of paper annually, which is 3.7 per cent world's production, and consumes 29.6 million tonnes of wood-, agriculture- and recycled fibre-based raw material. The paper industry has strong backward linkages and has established a system for sourcing 60 % of the raw material from agroforestry and social forestry. Yet, availability of quality raw material remains a challenge because India is a fibre deficient country. There is not enough land for captive pulpwood plantations, and gestation periods are long. Some of these issues can be resolved by making use of cultivable wastelands (12.65 million ha) and total fallow lands (24.58 million ha), which can provide much more than what the industry seeks, if proper supply channels for wood are established between the industry and the farm and agro-forests.

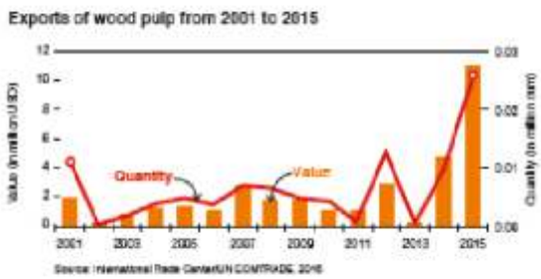
Paper and Newsprint Industry

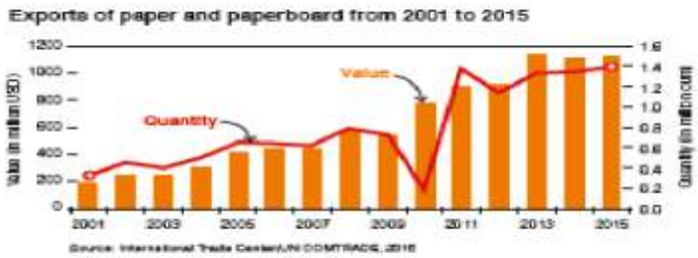
In 2109-20, the member industries of the Indian Paper Mill Association (IPMA) had total installed capacity of 4.8 million tons of paper and paper boards and capacity utilization was close to 90%. The total installed capacity (3.9 million tonnes) of the industry has grown at a compounded annual growth rate (CAGR) of 6% over the past decade; however, the actual production is about 2.6 million tonnes (GoI 1999). It is estimated that presently 66% of the installed capacity (nearly 94% of paper mills) is in small units (Pradhan and Barik 1999). A production capacity of 2.6 million tonnes with an actual production of 1.7 million tonnes is reported from in the small units. Most of the small units use agricultural waste and waste paper as raw material. The current mix of raw material in the industry is as shown below (GoI 1999; c. f. Saigal & Bose 2006):

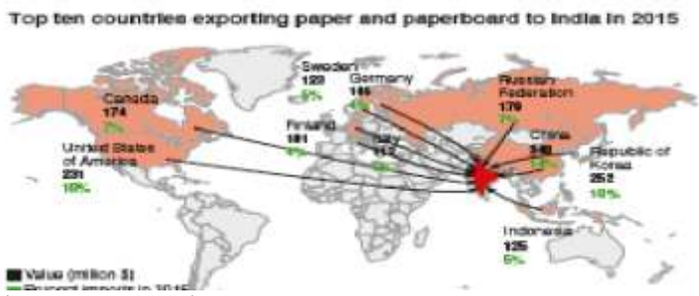








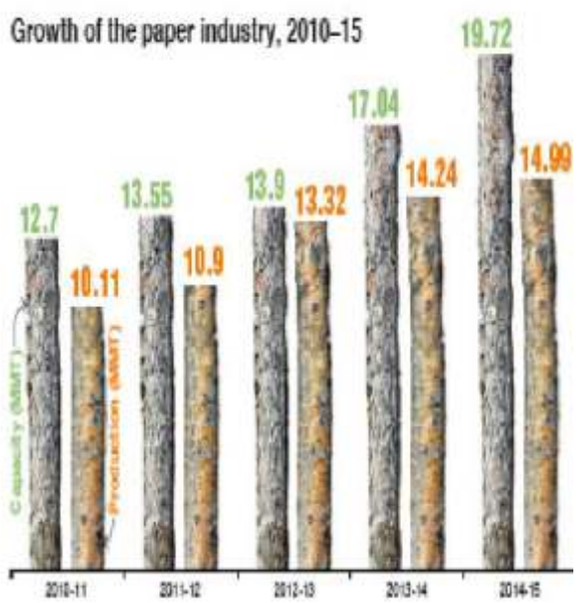




(Source: Bansal 2021)

Varieties of paper made from different raw materials

Type of mills	No. of mills	Raw material	Consumption (million tonnes)	Production (million tonnes)		
Wood-based (large integrated)	31	Wood pulp	8.7	Writing/ printing grade	2.67	3.54
				Packaging grade	0.85	
				Newsprint grade	0.02	
Agro-based (medium-scale)	135	Bagasse	5.8	Writing/ printing Grade	0.54	1.61
				Packaging grade	1.07	
		Wheat straw	2.8	Newsprint grade	0	
Recycled fibre-based (medium- and small-scale)	647	Waste paper	12.5	Writing/ printing Grade	2	9.84
				Packaging grade	6.37	
				Newsprint grade	1.47	
Total	813		29.8	14.99		



With increasing standards of living the per capita demand of is continuously increasing although it continues to be low by global standards. In 1995, the per capita consumption stood at 3 kg and by 2003 it was just 5 kg and in 2013 it was 9.3 kg compared to even other Asian countries such as Indonesia (at 22 kg) and China (at 42 kg). Production growth for paper and paper boards has been lower than the increase in demand, necessitating imports. The average import values for the period 2015-2020 are reported as:

Government heavily supported the paper industry's increasing raw material needs by offering raw materials (bamboo and wood) at extremely low rates from state forests. However, the change in The National Forest Policy (NFP) 1988 regarding supply of raw material to Industry and pressure from environmentalists and increasing fear of an impending raw material crunch by the industry changed the fibre sourcing patterns in the country. Most of the paper mill switched over hardwoods, that too farm grown, as the main raw material. CSE paper industry report 2013 mentions that on the whole, government forests contribute to only 13 % of the total share of wood and bamboo sourced. Over the last two decades, paper industry has been in the forefront in promoting tree cultivation of pulp wood species by farmers under agroforestry models, including clonal plantations, extending over an estimated 125,000 ha that has also contributing to tree cover in the country, apart from creating employment. At the current estimate, wood based segment of the paper industry uses 80% of the total requirement from farm produced wood. To make the farm forestry plantations (part of ToF) productive as well as viable, industries like ITC, JKPM, IP-APPM came forwarded to establish farm-industry partnerships. These agencies invested huge resources in R&D for genetic improvement and clonal propagation of high-yielding and disease resistant plants of short rotation tree species that are suitable for fuelwood, fodder and pulpwood. Many such plantations are FSC certified. Some species in these plantations are also suitable for veneering and manufacturing plywood.

According to a latest report by Sapra (2020), paper industry employs more than 10 lakh people in about 800 paper mills across the country and its projected demand of pulpwood is about 360 lakhs m3. The capacity-wise breakdown of the industry is shown below:

Sl. No.	Installed Capacity (Tonnes/annum)	No. of Mills
1	Up to 5000	140
2	5001-10000	112
3	10001-20000	88
4	20000-33000	32
5	33001 and above	34
6	**Total**	**406**

(Source: c. f. Saigal &Bose 2003

The structure of paper industry in 1985, as detailed by Rao (1989):

Scale (Million Tonnes)	No. of Units	Capacity
Large	23	1.15
Medium	17	0.27
Small	211	0.94

The production, import and export of paper and newsprint during 200-'01 is reported as follows:

Material	Lakh Tonnes				
	Installed Capacity	Production	Demand	Import	Export
Paper	5200	4795	4726	200	200
Newsprint	950	700	780	487	--

(Source: ICFRE 2001; cf. c. f. Saigal & Bose 2003)

The figures indicate that while India is more or less self-sufficient in paper production, it is heavily dependent on imports for meeting its newsprint needs. Even in the case of paper, significant quantities of pulp/wastepaper are imported by Indian paper mills. Before economic liberalisation, newsprint was manufactured only in the public sector. However, since 1994, 30 new private mills have come up, mostly in the small-scale sector. The handmade paper industry, a traditional craft producing around 5,000 tonnes with a sale value of around Rs. 40 million, being generally utilises textile fibre derived from rags, gunny bags, cotton linters and other waste material only, and is hence not depending on traditional pulpwood requirement.

THE INDIAN ACADEMY OF WOOD SCIENCE

Working Office: Institute of Wood Science & Technology Campus,
P.O. Malleswaram, Bengaluru-560 003 (India)
E-Mail: iaws.india@yahoo.com Website: http://www.iaws.org.in

The Indian Academy of Wood Science was founded in 1968 to advance the knowledge of wood science & technology and covers in its activities all the aspects related to wood, cellulose and their products such as logging, saw milling, wood working, plywood, fibre boards, particle boards, improved and composite woods, cellulose and cellulose based sciences and industries and allied fields. The Academy runs a Journal called "Journal of the Indian Academy of Wood Science". In addition to this, it also organises seminars and workshops. During some annual meetings, lectures from eminent scientists are also arranged. The Academy has joined hands with Springer, an internationally reputed publishing house, for bringing out the journal fully online for wider international readership. Authors may submit the manuscript of their research papers online following the Springer publication link http://www.editorialmanager.com/jiaw

APPLICATION FOR MEMBERSHIP

To,

The General Secretary
Indian Academy of Wood Science
Institute of Wood Science & Technology Campus
P.O. Malleswaram, Bangalore-560 003 (India)

Sir,

I wish to become a member of the Indian Academy of Wood Science and give below the necessary particulars for enrolling as "Corporate Member/Institutional Member/Individual Member" (as the case may be). Necessary remittance of Rs.* ..... is made by a Demand Draft/Cash, which may please be acknowledged. I agree to abide by the constitution of the academy and agree to the code of ethics contained therein.

Place: ..... (Signature of the Applicant)

Date: .....

1. Name of applicant in full (in block capitals)	
2. (a) Date of Birth, (b) Age (in case of individuals only)	
3. Academic and professional qualifications (in case of individuals only)	
4. Present employment/how engaged and brief history of previous career in case of individuals (separate sheet may be attached, if necessary)	
5. Brief description of general activities in case of Corporate, Institutional Members	
6. Address to which communications should be sent including phone, fax & e-mail	

* *Demand Draft should be drawn in favour of 'Indian Academy of Wood Science' and payable at Bangalore.*

Membership Type	Annual Fee	Life Time Fee
Indian :		
Corporate	N. A.	Rs. 100,000
Institutional	Rs. 2,000	N.A.
Individual	Rs. 500	Rs. 5,000
Foreign :		
Corporate	N. A.	US $ 2,500
Institutional	US $ 50	N.A.
Individual	US $ 20	US $ 200

(To be Photocopied for Use)

REFERENCES

Aggarwal, P. K., Rao, R. V. and Joshi, S. C. 2013.Wooden Toys in India.Unasylva 240 (64): 57-60.

Akyildiz, M. H. and Kol, H. S. 2010.Some technological properties and uses of paulownia (*Paulownia tomentosa Steud*.) *wood.Journal of Environmental Biology* 31: 351-355.

American Hardwood Export Council 2016.India Wood Sector Market Study 2016.America Hardwood Export Council.Woodzon, Bengaluru, India.44 Pp.

Anonymous. 1946. Indian woods for pencil making. Nature, No. 3999, June 22, 1946. p. 85.https://doi.org/10.1038/157851a0

Anonymous. 2014. Pencil Slat Industry Paints a Bleak Picture. *The New Indian Express*. 29th December 2014.

Anon. 2020a.Furniture market & opportunities, Indian Brand Equity Foundation (IBEF), India Brand Equity Foundation c/o Confederation of Indian Industry, Gurgaon. Report by KPMG for IBEF. www.ibef.in

Anon. 2020b.Furniture testing 101 "The definitive guide to North American Furniture testing". Intertek, Kentwood, MI 49512 (USA). www.intertek.com/furniture

Anon. 2000c. AS/NZS 4688.3, Australian/New Zealand Standard Furniture-Fixed height chairs, Part 3: Determination of stability-Upright chairs (ISO 7174-1:1988, Furniture-Chairs-Determination of stability, Part 1: Upright chairs and stools).

Anon. 2020d.Business and Institutional Furniture Manufacturers Association (BIFMA), Grand Rapids, MI (USA). https://www.bifma.org

Anon. 2020e.Forest policy trade and finance initiative India's wooden furniture and wooden handicrafts: risk of trade in illegally harvested wood marigold Norman and Kerstin Canby, report, September 2020, www.forest-trends.org/wp-content/uploads/ 2020/09/India Report_ FINAL.pdf

Anon. 2020f.https://en.wikipedia.org/wiki/List_of_Indian_timber_trees

Anon. 2020g.Growing India's agricultural exports through crop-specific, state-led plans.High Level Expert Group on Agriculture.Submission to xvth Finance Commission, GoI, July 2020.

Anon. 2021.Strategic roadmap for furniture sector - Thought Leadership Paper.Detailed Report.Price Waterhouse & Co. and IKEA.58 Pp.

Anoop, E. V., Jeeshma, V. J., Dhamodaran, T. K., Vidyasagaran, K., Lukose, S. and Scaria, F. 2018. Treatment of coconut palm wood using inorganic preservatives.Entomon 43 (4): 263-270.

Bansal, A. K. 2020.Unlocking the potential of bamboo sector in India. NCCF Working Paper 2/2020. Network for Certification and Conservation of Forests (NCCF), New Delhi.64 Pp.

Bansal, A. K. 2021. Sustainable trade of wood and wood based products in India. NCCF Policy Paper 1/2021. Network for Certification and Conservation of Forests (NCCF), New Delhi, India.30 Pp.

Bansal A.K. and Prasad, T. R. N. 2004. Manufacturing Laminates from Sympodial bamboos - An Indian Experience, *Journal of Bamboo and Rattan 3* (1): 13-22.

Bansal, A. K. and Zoolagud S. S. 2002. Bamboo Composites - Material of the Future, *Journal of Bamboo and Rattan*, 1, (2): 119-130.

Bansal, A. K., Rangaraju, T.S, and Shankar, K. S. 2002. Matchsticks from Bamboo, *Journal of Bamboo and Rattan,* 1, (4): 333-340.

Bansal A. K, Pandey, C. N, and Nath, S. K. 2013. Bamboo Composites – IPIRTI Technologies, Book published by IPIRTI, Bangalore. 138 Pp.

Becker, H. H. (nd). Laminated Bamboo Structures for a Changing World.Material Understanding.ACSA. FALL. 13.21. pp. 195-202.
https://www.acsaarch.org/proceedings/Fall%20Conference%20Proceedings/ACSA.FALL.13/ACSA.FALL.13.21.pdf

Benson L.M. and Reczek K. 2016.A Guide to United States Furniture Compliance Requirements.Standards Information Centre, National Institute of Standards and Technology (NIST), U.S. Department of Commerce, USA. https://nvlpubs. nist.gov/ nistpubs/ir/2016/NIST.IR.8119.pdf

Bhajanka, S. 2021. Plywood and panel industry in India: Current scenario and key issues. Wood is Good., IWST Magazine 1 (3): 17-21.

Bhattacharya, A. K. (nd.).Construction with Bamboo: Building Carbon Negative Sustainability. EPIC World.https://www.epcworld.in/p/post/construction-with-bamboo-building-carbon-negative-sustainability

Brandner, R., Flatscher, G., Ringhofer, A., Schickhofer, G. and Thiel, A. 2016. Cross laminated timber (CLT): Overview and Development. European Journal of Wood and Wood Products, 74: 331–351.
Doi: 10.1007/s00107-015-0999-5.

Building Materials and Technology Promotion Council (BMTPC) nd. Bamboo: A Material for Cost Effective and Disaster Resistant Housing. BMTPC, Government of India (GoI), Bengaluru. 24 Pp.

Bureau of Indian Standards (BIS). (nd). https://bis.gov.in/ BIS, New Delhi, India.

Bureau of Indian Standards (BIS) 1974.Methods of sampling of model trees and logs and their conversion for timber testing.IS: 2455.BIS, New Delhi. 18 Pp.

Bureau of Indian Standards (BIS). 1981. Specification for black lead pencils. IS 1375: 1981.Bureau of Indian Standards (BIS), New Delhi, India. 21p.

Bureau of Indian Standards (BIS). 1986. Structural timber in building – Specification. IS 3629: 1986. BIS, New Delhi. 31 Pp.

Bureau of Indian Standards (BIS) 1986.Methods of testing of small clear specimens of timber. IS: 1708: Part 1 to 18 (Reaffirmed 2015)BIS, New Delhi. 64 Pp.

Bureau of Indian Standards (BIS) 1989. Pencil Slats – Specification. IS 3084: 1989.Bureau of Indian Standards (BIS), New Delhi, India. 2p.

Bureau of Indian Standards (BIS). 1990. Indian timbers for door and window shutters and frames- Classification. IS 12896: 1990. BIS, New Delhi. 7 Pp .

Bureau of Indian Standards (BIS). 1991. Moisture content of timber and timber products - Methods for determination. IS: 11215(Reaffirmed 2015)BIS, New Delhi.

Bureau of Indian Standards (BIS). 1993. Seasoning of Timber- Code of Practice. IS 1143: 1993 (Reaffirmed 2004). BIS, New Delhi. 26 Pp.

Bureau of Indian Standards (BIS). 1993. Indian Timbers for Furniture and Cabinets - Classification. IS 13622: 1993 (Reaffirmed 2003). BIS, New Delhi. 11 Pp..

Bureau of Indian Standards (BIS). 1999. Wooden flush door shutters (solid core type): Part 1 Plywood face panels. IS 2202 (Part 1): 1999. BIS, New Delhi. 16 Pp.

Bureau of Indian Standards (BIS). 2001. Preservation of Timber – Code of Practice. IS 401: 2001 (Reaffirmed 2002). BIS, New Delhi. 23 Pp.

Bureau of Indian Standards (BIS). 2001. Preservative treated and seasoned sawn timber from rubber wood *(Hevea Brasiliensis)* – Specification. IS 14960: 2001 (Reaffirmed 2012). BIS, New Delhi. 6 Pp.

Bureau of Indian Standards (BIS). 2012. Structural Design using bamboo – Code of Practice. IS 15912: 2012. BIS, New Delhi. 30 Pp.

Bureau of Indian Standards (BIS).2016. National Building Code of India. Volume 1, Part 6. Structural Design.Section 3 -Timber and Bamboo.3A. Timber (56 Pp.) & 3B.Bamboo (30 Pp.). BIS, New Delhi.

Chaturvedi, A.N. 1981. Poplar for planting. Uttar Pradesh Forest Department Bulletin No. 50, Lucknow, 27 Pp.

Chavan, S. B., Keerthika, S. K., Handa, A. K., Ram Newaj and Rajarajan, K. 2015. National Agroforestry Policy in India: A low hanging fruit. Current Science 108 (10): 1826-1834.

Chen, Guo., Yu, Yunfei., Li, Xiang and He, Bin. 2020. Mechanical behaviour of laminated bamboo lumber for structural application: an experimental investigation. European Journal of Wood and Wood Products.78(6). DOI:10.1007/s00107-019-01486-9.

Convention on International Trade in Endangered Species (CITES) 2018. https://www.cites.org/sites/default/files/notif/E-Notif-2018-031.pdf

DataIntelligence. (nd). Wood Packaging Market, Size, Share, Opportunities and Forecast, 2020-2027.

https://www.datamintelligence.com/research-report/wood-packaging-market

Dhamodaran, T. K., and Bhat, K. M. 2007.Advances in oil curing technology for value-added aesthetic products from rattans. Journal of World Bamboo and Rattan 5(1):5-11. (Paper presented in the International Workshop on Sustainable Development of the Global Rattan Sector. Beijing, China, July 23-27, 2006).

Dhamodaran, T. K. 2008. Status of Rubber wood processing and utilization in India: A country report. Proceedings of the International Workshop on Promotion of Rubber wood Processing Technology in the Asia – Pacific Region. Haikou, Hainan, China. December 08-10, 2008. Pp 16-37.

Dhamodaran, T. K.2009. Commercial utilization of coconut wood and shells. Proceedings of the Seminar on Value Addition in Coconut Sector, 16-17, February 2009. Department of Agriculture Government of Kerala. Pp 16-26

Dhamodaran, T. K. 2020. A Wood Technology Research Trail.Volume 1. Pp. 12-15. Kerala Forest Research Institute, Peechi – 680 653, Kerala, India.56 Pp.

Dhamodaran, T. K. and Babu, S. 2010. Rattan processing technology for manufacture of value-added products: An Overview. (*Chapter in Book*) In: Renuka, C., Bhat, K. V. and Pandalai, R. C. (Eds.), "Rattans of India – Taxonomy, Biology and Utilization", pp 302-323. Kerala Forest Research Institute, Peechi – 680653, Kerala, India.

Dhamodaran, T. K. 2021. Forest Products Research and Wood Industries in India: Relevance and Applicability of Research at the Industrial Scale Needs - An Analysis of the Emerging Trends for Prioritization of Forest Products Research in Wood Science and Technology for Suggesting a Road-Map for the Country. Report of the Chair of Ecellence (Forest Products), ICFRE 2021.Institute of Wood Science and Technology, Bengaluru-560 03, India.

Dhamodaran, T. K. Jino Johny and Ganesh Gopal, T. M. 2020a. Four decades of bamboo technology research in Kerala Forest Research Institute supporting bamboo-based industries: A Review. Journal of Non-Timber Forest Products 27(2): 91-98 & KFRI Occasional Paper. Kerala Forest Research Institute, Peechi – 680 653, Kerala, India.

Dhamodaran, T. K., Jino Johny and Ganesh Gopal, T. M.2020b. KFRI's Trail in Wood Science and Technology Research.KFRI Occasional Paper No. 3. Pp. 13-16. Kerala Forest Research Institute, Peechi – 680 653, Kerala, India.83 Pp.

Dhamodaran, T. K., Anoop, E. V., Ganesh Gopal, T. M., and Jino Johny. 2020c. Potential of coconut stem wood for utilization in wooden furniture sector. Wood is Good Magazine 1(2): 35-39.

Dhamodaran, T. K., Jino Johny and Ganesh Gopal, T. M. 2020.A Manual for Preservative Treatment of Bamboo.KFRI Handbook No. 18.Kerala Forest Research Institute, Peechi – 680 653, Kerala, India.20 Pp.

Eckelman, C. A. 1999. Performance Testing of Side Chairs.Holz als Roh- und Werkstoff 57:227-234.

Eckelman, C. A. and Lee, M. (1981).Performance and quality assurance testing. Journal of Interior Design Education and Research 7(1):18-24.

Eduardo Souza. 2017.If We Were To Design The Ideal Building Material, It Would Look A Lot Like Bamboo.ArchDaily. December 23, 2017.https://www.archdaily.com/885748/if-we-were-to-design-the-ideal-building-material-it-would-look-a-lot-like-bamboo

European Federation of Wooden Pallet and Packaging Manufacturers (FEFPEB).nd. https://www.fefpeb.eu/wooden-packaging/properties-of-wood#tradition

Export Promotion Council for Handicrafts (EPCH). 2018. VRIKSH - Timber Legality Assessment and Verification Standard- India. VRIKSH-STD-01-01 V1.5 EN.EPCH, New Delhi, India.29 Pp.

Export Promotion Council for Handicrafts (EPCH) 2018. VRIKSH India; Notification to the Parties No. 2018/031).https://vrikshindia.in/external_file/letteron03mar2017.pdf

Food and Agricultural Organization (FAO) 1985. Saw Doctoring Manual. FAO Forestry Paper 58. FAO, Rome. 227 Pp.

Food and Agricultural Organization (FAO) 1990. Manual on Sawmill Operational Maintenance. FAO Forestry

Paper 94. FAO, Rome. 61 Pp.

Food and Agricultural Organization (FAO). 1991. High value markets for tropical sawn wood, plywood and veneer in the European Community, (Ed. Cooper, R. J.). FAO. Rome.

Food and Agricultural Organization (FAO).2000a. Global Forest Resources Assessment 2000. FAO, Rome. http://www.fao.org/3/y1997e/y1997e08.htm

Food and Agricultural Organization (FAO). 2000b. The global outlook for future wood supplies from forest plantations. (By: C. Brown) FAO Working Paper GFPOS/WP/03. FAO, Rome.

Food and Agricultural Organization (FAO). 2001a. Mean annual volume increment of selected industrial forest plantation species (Eds. Ugalde, L. & Perez, O.) Forest Plantations Thematic Paper Series. FAO, Rome. (*Unpublished*, c.f. FAO 2000).

Food and Agricultural Organization (FAO). 2001b. Promotion of valuable hardwood plantations in the tropics: A global overview. (Ed. Odoom, F.K.). Forest Plantations Thematic Paper Series. FAO, Rome. (*Unpublished,* c.f. FAO 2000).

Food and Agricultural Organization (FAO). 2001c. Plantations and wood energy. (By: D. Mead). Forest plantations thematic paper series. FAO, Rome. (Unpublished., c.f. FAO 2000).

Food and Agricultural Organization (FAO). 2001d. Role of forest plantations as substitutes for natural forests in wood supply - lessons learned from the Asia-Pacific region. (By: T. Waggener). Forest Plantations Thematic Paper Series. FAO, Rome. (*Unpublished*.c. f. FAO 2000).

Food and Agricultural Organization (FAO). 2001e. Plantations and greenhouse gas mitigation: A short review. (By: Moura Costa, P. & Aukland, L). Forest Plantations Thematic Paper Series. FAO, Rome. (*Unpublished*.,c.f. FAO 2000).

Food and Agricultural Organization (FAO). 2007. World Bamboo Resources – A thematic study prepared in the framework of the global forest resources assessment 2005. Non-Wood Forest Products 18. Rome, Italy.

Food and Agriculture Organization (FAO) 2009.India Forestry Outlook Study.Ministry of Environment and Forests, Government of India.Working Paper No.APFSOS II/WP/2009/6.

Food and Agricultural Organization (FAO). 2009. Regulation of wood packaging material in international trade. International standards for phytosanitary measures.Revision of ISPM No. 15.16 Pp.

https://www.fefpeb.eu/cms/files/2016-01/revised-ispm-15-2009-.pdf

Food and Agriculture Organization (FAO) 2015.Global Forest Resource Assessment (GFRA) 2015.

Food and Agriculture Organization (FAO) 2020. State of World's Forests 2020. FAO, Rome. 2020.

https://www.fao.org/state-of forests/en/?utm_source=twitter&utm_medium=social+media&utm_campaign=fao

Food and Agricultural Organization (FAO) (nd.). Appendix 1 - List of wood densities for tree species from tropical America, Africa, and Asia.http://www.fao.org/3/w4095e/w4095e0c.htm

Forest Research Institute (FRI). 1945. Indian woods for pencil making. Indian Forest Leaflet No. 66 – 1945 Utilization. Forest Research Institute (FRI), Dehra Dun, India.

Forest Research Institute (FRI).1970. Indian Forest Utilization.Vol. I. Forest Research Institute and Colleges, Dehra Dun, India.508 Pp.

Forest Research Institute (FRI) nd. Study on constraints in the export of carved wood products and its economical and social impact bon the livelihood of dependent people in North India. Survey and Utilization Division, FRI, Dehra Dun.118 Pp.

Forest Research Institute (FRI).1972. Indian Forest Utilization. Vol. II. Forest Research Institute and Colleges, Dehra Dun, India.

Forest Survey of India (FSI) 2017. India State of Forest Report (ISFR) 2017. FSI, New Delhi. 363 Pp.

Forest Survey of India (FSI) 2019. India State of Forest Report (ISFR) 2019. Volume I., FSI, New Delhi. 185 Pp. https://fsi.nic.in/forest-report-2019

Forest Survey of India (FSI) 2020.Trees Outside Forest Resources in India.Technical Information Series Volume 2 No. 1. 30Pp.

Gatóo, A., Sharma, B., Bock, M., Mulligan, H. and Ramage, M. 2014. Sustainable Structures: Bamboo Standards and Building Codes. Proceedings of the Institution of Civil Engineers: Engineering Sustainability. 167 (ES5): 189–19. doi:10.1680/ensu.14.00009. S2CID 55205294.

Ghosh, M. and Sinha, B. 2016. Impact of Forest Policies on Timber Production in India: A Review. Natural Resources Forum 40 (1-2): 62-76.
<https://doi.org/10.1111/1477-8947.12094>,<https://onlinelibrary.wiley.com/doi/full/10.1111/1477-8947.12094>

Globe Newswire 2021. Engineered Wood Market - Growth, Trends, COVID-19 Impact, and Forecasts (2021 - 2026). Intrado Globe Newswire, New York, May 03, 2021.

Global Agricultural Information Network (GAIN) 2019. India: Wood and Wood Products Update 2019. GAIN Report No. IN9033. USDA Foreign Agricultural Service.13 Pp.https://www.fas.usda.gov/data/india-wood-and-wood-products-update-2019

Gnanaharan, R. 1993. Shrinkage behaviour of bamboos grown in Kerala. BIC-India Bulletin 3(2): 1-16.

Gnanaharan, R. and Dhamodaran, T. K. 1988.Comparison of wilt-diseased and non-diseased (over-aged) coconut stem wood with respect to their utilization potential. Final Report of a Research Project submitted to Coconut Development Board (CDB), Cochin, Kerala, India. 18 Pp.

Gnanaharan, R. and Dhamodaran, T. K. 1989.Preservative treatment of stem wood of wilt-diseased coconut palms.Journal of Tropical Forest Science. 1(4): 341-345 (Paper presented in Palm Wood Utilization Meeting (Asia); Los Banos; Philippines, 1989 January 22-26).

Government of India (GoI). 1999. National Forestry Action Programme – India. Ministry of Environment and Forests, GoI., New Delhi.

Government of India (GoI). 2014. National Agroforestry Policy 2014. Department of Agriculture &CCooperation, Ministry of Agriculture, GoI, New Delhi, India.29 Pp.https://agricoop.gov.in/sites/default/files/National_agroforestry_policy_2014.pdf

Hassan, O. A. B. and Johansson, C. 2018. Glued laminated timber and steel beams: A comparative study of structural design, economic and environmental consequences. Journal of Engineering, Design and Technology.https://doi.org/10.1108/JEDT-12-2017-0130

Hildebrandt, J., N. Hagemann, and Thrän, D. 2017. The contribution of wood-based construction materials for leveraging a low carbon building sector in Europe. Sustainable Cities and Society 34: 405–418.

Indian Council of Forestry Research and Education (ICFRE). 2001. Forestry Statistics India – 2001. ICFRE, Dehra Dun, India.

Indian Council of Forestry Research and Education (ICFRE). 2010. Forest Sector Report India 2010.ICFRE, Dehradun, India.

Indian Council of Forestry Research and Education (ICFRE). 2011. Forestry Statistics India. ICFRE, Dehradun, India.http://www.icfre.org/UserFiles/File/Institute–ICFRE/2013/Stat/Forestry–stat–07Mar13.htm

IndiaStat 2015.Industrial roundwood production.http://www.indiastat.com/forestandwildlife/13/forestproduce/17875/stats.aspx

Indian Council of Forestry Research and Education (ICFRE). 2019. ICFRE Vision 2030. ICFRE, Dehra Dun, India.48 Pp.

IndustryARC (nd).Wood Packaging Market - Forecast (2021 - 2026). <https://www.industryarc.com/Report/18490/wood-packaging-market-research-report-analysis.html>

International Network for Bamboo and Rattan (INBAR). 1994. Priority Species of Bamboo and Rattan, INBAR Technical Report No. 1, INBAR, New Delhi, India. 68p.

International Network for Bamboo and Rattan (INBAR) 2012.International Trade of Bamboo and Rattan.INBAR, Beijing, China.58 Pp.

International Network for Bamboo and Rattan (INBAR) 2017.Trade Overview 2017 Bamboo and Rattans commodities in the international market.INBAR, Beijing, China.29 Pp.

International Network for Bamboo and Rattan (INBAR). 2018. Trade Overview 2015, Bamboo and Rattan Product in International Market. INBAR, Beijing, China.

International Network for Bamboo and Rattan (INBAR). 2019a. Trade Overview 2017: Bamboo and Rattan commodities in the international market. INBAR, Beijing, China. 29Pp.

International Network for Bamboo and Rattan (INBAR). 2019b. Trade Overview 2018: Bamboo and Rattan Commodities in China. INBAR, Beijing, China.17 Pp.

International Trade Centre (ITC) 2020. https://trademap.org/Index.aspx

International Tropical Timber Organization (ITTO) 2015.Status of tropical forest management – India.https:www.itto.int/sfm/

International Tropical Timber Organization (ITTO). (nd). Lesser Used Species. <http://www.tropicaltimber.info/> <http://www.tropicaltimber.info/specie/lanete-wrightia-arborea/?print=true>

International Union of Forestry Research Organizations (IUFRO) 2016. Illegal logging and related timber trade – Dimensions, drivers, impacts and responses; A global scientific rapid response assessment report. IUFRO World Series Volume 53.IUFRO, Vienna, Austria.148 Pp.

Jha, A. 2020. Furniture industry: A sunshine sector for India. Trade Promotion Council of India.https://www.tpci.in/indiabusinesstrade/blogs/furniture-industry-a-sunshine-sector-for-india.

Kaygin, B., Kaplan, D. and Aydemir, D. 2015. Paulownia tree as an alternative raw material for pencil manufacturing.Bioresources 10 (2): 3426-3433.

Kedia, N. 2020. Furniture industry in India: View of Industry Federation. Wood is Good 1(3): 23-28.

Kulkarni, H.D., 2013. Pulp and paper industry raw material scenario – ITC plantation a case study. IIPTA, 25(1): 79–89.

Kulkarni, H. D. 2020. Agroforestry for wood based industry: A New Proposal. Wood is Good., IWST Magazine 1 (1); 53-62.

Kumar, p., Sujatha, M., Shashikala, S. and Rao, R. V. 1995. Wood Handicrafts: Traditional and alternative timbers. Wood News, October-December, 1995.

Kumar, p., Sujatha, M., Shashikala, S. and Rao, R. V. 1996a. Wood Handicrafts: Traditional and alternative timbers. Wood News, January-March, 1996.

Kumar, p., Sujatha, M., Shashikala, S. and Rao, R. V. 1996b. Wood Handicrafts: Traditional and alternative timbers. Wood News, April-June 1996.

Kumar, A. 2020.Meliadubia Cav.: as multipurpose tree species and quality industrial raw material. Wood is Good., IWST Magazine 1 (2); 55-62.

Mahdavi, M., Clouston, P. L., and Arwade, S. R. 2011. Development of Laminated Bamboo Lumber: Review of Processing, Performance, and Economical Considerations. Journal of Materials in Civil Engineering 23 (7), ASCE July 2011. <https://doi.org/10.1061/(ASCE)MT.1943-5533.0000253>

Mahdavi, M., Clouston, P. L., and Arwade, S. R. 2012. A low-technology approach toward fabrication of Laminated Bamboo Lumber.Construction and Building Materials.Volume 29, April 2012, Pages 257-262.

Mishra Swati Anand and Sunderaraj, R. 2020. Indian wooden furniture: A tale of culture and ethnicity. Wood is Good 1(3): 33-38.

Muraleedharan, P. K. and Bhat, K. M. 1989.A techno-economic study of saw milling industry in Kerala. KFRI Research Report 60. Kerala Forest Research Institute, Peechi -680 653, Kerala, India.81 Pp.

National Council of Applied Economic Research (NCAER). 2001. An Assessment of Small-Scale Informal Forestry Sector. Report prepared under the project "Instruments for Sustainable Private Sector Forestry" coordinated by International Institute for Environment and Development and EcoTech Services and supported by DFID-India. New Delhi: NCAER (Unpublished report).

Nazma., Ganapathy, P. M., Bhat, K. M., Sasidharan, N., and Gnanaharan, R. 1981. A Handbook of Kerala Timbers. KFRI Research Report No. 9. Kerala Forest Research Institute, Peechi-680 653, Kerala, India.260 Pp.

Network for Certification and Conservation of Forests (NCCF) (nd).https://www.nccf.in/chain-of-

custody/#:~:text=NCCF%20has%20adopted%20PEFC%20Chain,forests%20and%20trees%20outside%20forests.&text=It%20is%20available%20worldwide%20and,or%20sell%20forest%2Dbased%20products

Norman, M. and Canby, K. 2020. India's wooden furniture and wooden handicrafts: Risk of trade in illegally harvested wood. Forest Policy Trade and Finance Initiative Report.Forest Friends & UK Aid. September 2020. 68 Pp.

Norman, Marigold and Canby, Kerstin. 2020. Forest Policy Trade and Finance Initiative Report 2020. India's wooden furniture and wooden handicrafts: Risk of trade in illegally harvested wood. Forest Trends.68 Pp.https://www.forest-trends.org/wp-content/uploads/2020/09/India_Report_FINAL.pdf

Okino, E. Y. A., Santana, M. A. E., Alves, V. S. A.., Melo, J. E.., Coradin, V. T., Souza, M. R.., Teixeira, D. and Sousa, M. E. 2010.Technological characterization of Cupressus spp. wood.Floresta e Ambiente, Seropédica 17, (1): 1-11.

Pandey, C. N. and Kambo, A. S. 1993. Sawing and seasoning of Populusdeltoids by saw dry rip (SDR) process. Wood News, April-June 1993. Pp: 21-24.

Pandey, C. N. and Roy, S. 2020. Plywood and panel industry in India. Wood is Good, IWST Magazine 1 (1); 15-17.

Pandey, C. N. and Kambo, A. S. 2001.Properties and processing of Populus deltoids for producing quality sawn and seasoned timber.Indian Forester 127 (2). Feb. 2001.

Pandey, C. N. and Rangaraju, T. S. 2008. India's industrial wood balance. International Forestry Review 10 (2): 173-189.

Ply Reporter. 2021. Wood Furniture Trends Dominates Global Market, Good Sign for Indian Wooden Industry. April 2021. https://www.plyreporter.com/article/40734/wood-furniture-trends-dominates-global-market-good-sign-for-indian-wooden-industry

Prekrat, S., Pervan, S. and Smardzewski, J. (2011).Optimization of furniture testing. Annals of Warsaw University of Life Sciences – SGGW Forestry and Wood Technology No 73: 60-65.

Programme for Endorsement of Forest Certification (PEFC) (nd). https://www.pefc.org/

Programme for Endorsement of Forest Certification (PEFC). 2017. Furniture manufacturing and Certification. How your business benefit from PEFC. 6 Pp. <https://www.nccf.in/wp-content/uploads/2020/11/Furniture-manufacturing-and-certification_how-your-business-benefits-from-PEFC-1.pdf>

Rajput S. S., Shukla, N. K., Gupta, V. K. and Jain, J. D. 1996. Timber Mechanics: Strength, Classification and Grading of Timber. 2nd Edition, ICFRE-38, Dehra Dun.189 Pp.

Rao, Y.A. 1989. The Paper Industry in India: Status and Prospects. Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi, India.

Rao, K. S., Khan, B. A., Reddy, K. S., Rao, R. V., Adkoli, N. S., Suryaprakesh and Achoth, L. 2001. Study and demand and supply of timber poles and firewood in the state of Andhrapredesh.IWST Research Report.156 pp.

Rao. M. V., Balaji, M. and Joshi, S. C. 2011. Etikoppaka: An Indian village perpetuating the joy of wood through the tradition of toy art. Paper presented in the International Conference and Exhibition on the Art and Joy of Wood, held at IWST, Bengaluru, 19-22, October 2011.

Ratnasingam, J. and Scholz, F. 2009. Rubber wood: An Industrial Perspective. World Resource Institute, Washington.

Ravikanth, G., Ganeshaiah, K. N., Uma Shaanker, R. 2001. Mapping genetic diversity of rattans in Central Western Ghats: identification of hot-spots of variability for in situ conservation. In: Uma Shaanker, R., Ganeshaiah, K.N., Bawa, K. S. (Eds.), Forest genetic Resources: Status, Threats and Conservation Strategies. Oxford and IBH Publishing Co. Pvt. Ltd Pp. 69-83.

Rehman, M. A. and Gupta, P.G. 1968. Timber for Pencil slats, its conversion, seasoning and treatment. Indian Forest Leaflet.Wood Seasoning. 188.

Saigal, S. Bose, S. 2003. Small-scale forestry enterprises in India: Overview and Key Issues. Discussion Paper.International Institute for Environment and Development, London.51 Pp.

Sapra, R. K. 2020. Rejuvenation of wood-based industries – Need of the hour. Ply Insight – December 2020. Pp. 60-61. www.plyinsight.com

Sarkar Plywood Pvt. Ltd. (n. d.). Rubber wood.http://www.sarkarplywood.com/information.php/sarkar-plywood-rubber-wood-i-18.

Sathre, R. and Gustavsson, L. 2009. Using wood products to mitigate climate change: External costs and structural change. Applied Energy 86 (2): 251–257.

Sekhar, A.C. and Gulati, A.S. 1972. Suitability Indices of Indian timbers for industrial and engineering uses. Indian Forest Records (N.S.), Timber Mechanics 2 (1), 62 Pp.

Shrivastava, S. and Saxena, A. K. 2017. Wood is Good: But is India doing enough to meet its present and future needs? A Status Report by Centre for Science and Environment (CSE), New Delhi. 45 Pp.

Shukla, S. R. and Sharma, S. K. 2020.Desirable wood properties for application in furniture. Wood is Good 1 (3): 59-64.

Singh, M. P and Singh V. 2021. Need an act to revive agro wood based sector. Wood is Good., IWST Magazine 1 (3): 9-16.

Sharma, B., Gatoo, A., Bock, M. and Ramage, M. 2015.Engineered bamboo for structural applications. Construction and Building Materials 81:66-73.

Shukla, S. R. 2021. Wood Properties for Different Applications. In: IWST Webinar on "Identification, Certification and Utilization of Timbers", 27th September 2021. Institute of Wood Science and Technology, Bengaluru.

Shukla, S. R. and Dhamodaran, T. K. 2020. Need of furniture testing and certification facilities in India. Wood is Good 1(3): 47-52.

Shukla, N.K.; Rajput, S.S. and Singh, K.R. 1991.A note on variation of density and strength properties from pith to periphery in Populus deltoides. Journal of the Indian Academy of Wood Science, 22(1): 1-6.

Singh, M. P. 2020a. Reviving wood based industries. Wood is Good 1(1):7-14.

Singh, M. P. 2020b. Indian plywood and panel industries: Their journey of raw materials from forest produce to AgriWood (Supporting Atma Nirbhar Bharat, Make in India and Vocal for Local). Wood is Good 1(2):9-13.

Singh, M. P. and Singh, V. 2020. Need an act to revive agro wood based industry sector. Wood is Good 1(3):9-16.

Singh, M. P. 2021. Timber policy to boost locally produced certified solid wood and promote furniture sector for export. Presentation made in Institute of Wood Science and Technology, Bengaluru, India.

Sinha, S. and Pasha, S. (nd). Wood based handicraft industry – Report on survey of wood based handicraft industry: Jodhpur (Rajasthan). A matter of fact: Complying with Lacey Act and the FLEGT Action Plan in India. WWF, Global Forest Trade Network & TRAFFIC.24 Pp.

Sjöstedt, S. I. (nd). Logging in India. Unasylva No. 82. Food and Agricultural Organization (FAO).http://www.fao.org/3/44279e/44279e02.htm

Sree Veena Mani. 2020. Traditional Toy Makers of South India Struggling to Find Enough Wood. Zenger, September 13, 2020. https://www.zenger.news/2020/09/13/traditional-toy-makers-of-south-india-struggle-to-stay-in-business/

Subramony, T.P. and Kuepper, R. 2019. Industrial and Global Market Potential of Northeast India Bamboo. Paper presented in the World Bamboo Workshop, Manipur, India. February 4-8, 2019.

Sullivan, C. C. 2018. Sustainable Envelopes with Structural Engineered Bamboo: Engineered Bamboo Products (EBPs) deliver structural, and renewable, bio-based solutions for high-performance building enclosure systems. Continuing Education.

Sumana Sarkar. 2020. Packing industry holds potential for high growth. The Hindu Business Line, August 05, 2020. <https://www.thehindubusinessline.com/opinion/packing-industry-holds-potential-for highgrowth/article32275596.ece>

Tandon, J.C. 1991. The safety match industry in India.In: Campbell, J.Y. (Ed.) Case Studies in Forest-Based Small-Scale Enterprises in India. Food and Agriculture Organisation of the United Nations (FAO), Bangkok, Thailand.

Tewari, D. N. 1992. Monograph on Bamboo. Indian Council of Forestry Research and Education (ICFRE), Dehra Dun, India.

Tewari, D.N. 1995. Marketing and Trade of Forest Produce. Dehradun: International Book Distributors, Dehra Dun, India.

Timber Trade Portal 2021. Country Profile India.https://www.timbertradeportal.com/countries/india/#legality-profile

Tluanga, L., Jha, L & Lalramnghinglova, H. 2010. Status of Research on Rattans: A Review. Science Vision. 10. 51-56.

Todoroki, C. L. and Rönnqvist, E. M. 1999. Combined Primary and Secondary Log Breakdown Optimisation. The Journal of the Operational Research Society 50 (30): 219-229.

Timber Research and Development Association (TRADA) (n. d.). Wood Species Database - Cedar.https://www.trada.co.uk/wood-species/cedar/ TRADA, UK.

Uma Shaanker, R., Ganeshaiah, K. N., Srinivasan, K., Rao, V.R. and Hong, L.T. 2004. Bamboo and Rattans of the Western Ghats: Population Biology, Socio-economics and Conservation Strategies. ATREE, Bangalore, IPGRI, Malaysia and UAS, Bangalore.

Upadhyay, V. K., Singh, M. P., Nandanwar, A., Kushwaha, P. K., Murthy, N. and Kumar, M. 2021. Statistics, trend and scenario of wood log import in India. Indian Forester 147 (1): 1-11.

Van der Lugt, P. and Vogtlander, J.G. 2015.The environmental impact of industrial bamboo products – Life cycle assessment and carbon sequestration.INBAR Technical Report No. 35.International Network for Bamboo and Rattan (INBAR), Beijing, China.53 Pp.

Van der Lugt, P. and Charlotte King. 2019. Bamboo in the Circular Economy. INBAR Policy Synthesis Report 6. International Network for Bamboo and Rattan (INBAR), Beijing, China.34 Pp.

Vanam, B. 2019. Timber trade in India – Challenges and Policies. EPRA International Journal of Multidisciplinary Research (IJMR) 5(12)119-122.

Winchester, N and Reilly, J. M. 2018.The economic and emissions benefits of engineered wood products in a low-carbon future.MIT Joint Program on the Science and Policy of Global Change.Massachusetts Institute of Technology, USA). 12Pp. https://globalchange.mit.edu/sites/default/files/MITJPSPGC_Rpt331.pdf

World Wide Fund for Nature (WWF) India. 2003. Relevance of Certification to the wood carving industry in India. WWF- India. New Delhi.

Wood Technologist Association: a Catalyst for Building a Robust Industry-institution Partnership Ecosystem

The wood technologist association (WTA)promotes an efficient industry-institution partnership ecosystem by building long-term links to promote education, research, employment generation and entrepreneurship by sharing technical knowledge and facilities and the over-all success of its role is evident from the achievements of the recent interactive programmes. This article presents a full account of a two-day interactive programme conducted in July, 2021 jointly by WTA and Forest Research Institute, Dehradun.

A robust industry-institute interaction promotes education, research, employment generation and entrepreneurship and is the most preferred activity for mutual benefit and growth of industries as well as institutions. The partnership provides the best platform for showcasing the best practices, latest technological advancements, and their implementation and impact on the industries involved in the programme. The industry and institution are interdependent on each other for new inventions and discoveries to meet the demands of the present problems of the society.

Wood Technologist Association (WTA) is a non-government organisation of plywood and other wood-based industries in India. It isa dynamic, vibrant, credible and respected business association that unites industrialists, technologists and other stakeholders and it acts a strong catalyst for co-operation between scientists, wood technologists and industry professionals. It promotes new solutions and improved processes that benefit the entire industry by combining the technical knowledge gained from decades of research and field work by the scientists at FRI, IPIRTI and IWST with the association members. WTA under the leadership of Shri Subhash Jolly Saheb, also participates in the planning and implementation of new research projects in the institutes and industries, in all the major thrust areas of forestry and wood technology and is constantly striving for collaborative programmes such as the recent' Research Outreach Programme for Wood Industry' organised jointly by Forest Research Institute, Dehradun, Uttarakhand and Wood Technologist Association, Yamuna Nagar on 22-23 July 2021. The

WTA acts as a catalyst for wood industry-institution interactions in the country

participants of this programme were WTA members including the plywood industry owners, Shri Rajesh Goel, Hari Om Timbers, Shri Kamal Jain, Arihant Wood Products, Shri Ashwani Kaushik, Grassim Plywood, Shri Shyam Sunder Aggrawal, Haploos Plyboards, Shri Subhash Jolly, President Wood Technologist Association, Shri Baheri, Ply Insight, Shri Manoj Thakur, Journalist.

All guests from Yamuna Nagar interacted with heads of department and researchers of Forest Products Division, Division of Genetics and Tree Improvement, Silviculture and Forest Management Division and Forest Extension Division. Scientists of FRI had all opportunity to explain and show their work and capacity on trees specially tree outside forest. The industrialists who were developing various plywood products shared their wisdom, also explained the current issues in industry and solicited help from FRI. Dr. N K Upreti explained the ongoing research on Melia, Corymbia, Poplars and extension activities of agroforestry models and training to farmers. Dr Charan Singh and Dr Devendra elaborated their agroforestry work on poplars during 90's, agroforestry models of different species and training programmes.

This was followed by visit to trial plots of tissue culture raised Corymbia hybrids of 3, 4 years and 15 years old and also some products made from Corymbia wood. During this, tree improvement programmeof Corymbia hybrids was explained to guests. There was a discussion with Shri Arun Singh Rawat, Director General of ICFRE on training where he emphasized the need of on-site and institutional training, demonstration and also testing in collaboration with Yamuna Nagar wood industries, wood technologists, tree growers and farmers. Later the team visited workshop of plywood and composite disciplines. Shri Khali, Scientist G showed the working of new press and explained the ongoing research by Ph.D and M.Sc. Wood Science and Technology students and other activities such as the trainings provided specially to next generation of entrepreneurs. Guests were pleased to see the facilities and also impressed with the education, research and training provided by FRI exclusively to the wood sector. They discussed technical details, shared their insights and promised for future collaboration with researchers of FRI. This was followed by field visit of first and second generation gene bank of Melia. Selection and genetic testing of the species was explained to the visitors and they were happy in knowing that this facility at FRI sells more than 25 lakhs seedlings of released varieties of Melia annually.

The second day was dedicated to a special session on field launching of end result of FRI research on timber,e specially tree growing outside forest. Shri Arun Singh Rawat, Director General of ICFRE along with Shri Jolly addressed the session in presence of representatives of media, plywood industry and agroforestry led by Shri. Bahety of Ply Insight and national correspondent Shri Manoj Thakur, Dr. NK Upreti, Shri DP Khali, Dr Ashok Kumar, Dr. Ajay Thakur and Dr. P S Rawat. Shri Rawat emphasized that Melia is the future of face veneer which can save billions worth of foreign exchange. He informed that FRI has an ongoing programme on other timbers species like *Corymbia hybrids, Toonaciliata* and *Grevillearobusta*. After *Melia, Corymbia* hybrids are in advance stage to be launched in field and after 3-4 years good genetic material of Toona, *Grevillea* and native poplars (*Populusgamblei)* will be available for farmers and industry.

In the final technical session an elaborated discussion was held on different strategies to develop face veneer and other products of Melia. During the two-day programme, realizing that demonstrating the peeling of Meliaand other species with an extremely high efficiency and the pilot-scale resin preparation to the students of FRI have been crippled due to lack of modern equipment, Shri Subhash Jolly approached four industrialists of Yamuna Nagar with his request to generously donate the required machinery as a token of gratitude to the Institute for their support in various ways and the same was readily accepted by all. An exclusive meeting of Shri Amarjeet Singh, Guru Amar Industries, a prominent peeling machine manufacturer based in Yamuna Nagar (they supplied machinery to 28 countries) with DG ICFRE, Shri Subhash Jolly, Dr Upreti and others was also held during this session, where Shri Singh announced the decision to help FRI by his

Double head wide-belt sanding machine donated to FRI By Shri Sunil Shrivasthava, Founder & Managing Director, M/s Kumar Engineering Co.

Shri Amarjeet Singh and other WTA members interact with the FRI Scientists

Shri Arun Singh Rawat,IFS, Director General,ICFRE, Dehradun handing over the appreciation letter to Shri Subhash Jolly for arranging the donation of a Double head wide-belt sanding machine by M/s Kumar Engineering Co. to FRI

contribution of any suitable machine for education and demonstration lands for trials. He also shared his vast experience of developing plywood machine with the gathering.

In the closing ceremony, Shri Arun Singh Rawat, IFS, Director General, ICFRE, appreciated Shri Jolly for facilitating the donation of a Double head wide-belt sanding machine by M/s Kumar Engineering Company and also for arranging the gifts of a resin kettle by M/s Om Engineers and peeling machines by four industrialists to FRI. He also thanked Sardar Amarjeet Singh for his willingness to donate a peeling machine to the Institute for R&D purpose. Thanking all guests who came on their own by strictly following all norms of restrictions due to Covid-19, FRI team conveyed that their insights were really valuable and innovative ideas they shared were priceless. WTA congratulated FRI team led by Dr Upreti for making this event a grand success.

Short term Courses offered by the Advanced Woodworking Training Centre (AWTC)

The Advanced Woodworking Training Center (AWTC) is a premier training Centre is located in the heart of Bangalore city. It was established by the Institute of Wood Science & Technology (IWST) as the first Training Center in India with an aim to enhance skillset of manpower working in wood-based industries. So far AWTC has trained more than 2500 professionals. The courses are designed to give first-hand experience in handling advanced machines and tools to work on various wood and wood products that meet the global standards.

Conventional Woodworking and Finishing (4 Weeks)

Admission Eligibility	:	10th Class Pass.
Course Fee	:	Rs.15,000/- for entire course
Extra	:	Rs.1,650/- towards Accommodation Charges , Food Charges (as per actual)
Security Deposit	:	Rs.5,000/- (Refundable) : Maximum 5 Candidates per Batch
Intake	:	Maximum 20 Candidates per Batch

Product Designing and Development on CNC Router (4 Weeks)

Eligibility	:	Completion of Conventional Woodworking and Finishing course at AWTC
Course Fee	:	Rs.20,000/- for entire course
Extra	:	Rs.1,650/- towards Accommodation Charges Food charges (as per actual)
Security Deposit	:	Rs.5,000/- (Refundable)
Intake	:	Maximum 5 Candidates per Batch

Product Designing and Development on PYTHA 3D (2 Weeks)

Eligibility	:	Completion of Product Designing and Development on CNC Router at AWTC.
Course Fee	:	Rs.10, 000/- for entire course
Extra	:	Rs.1, 650/- towards Accommodation Charges, Food Charges: Extra (as per actual)
Intake	:	Maximum 5 Candidates per Batch.

Advanced Woodworking Training Centre

INSTITUTE OF WOOD SCIENCE AND TECHNOLOGY

(Indian Council of Forestry Research and Education)

An Autonomous Body of Ministry of Environment, Forest and Climate Change, Govt. of India

P.O. Malleswaram, Bengaluru – 560 003, India Website: http://iwst.icfre.gov.in/awwtc/awwtc.htm

Ph: 080-22190148, 150Fax: 080-23340529 E-Mail: awtc_iwst@icfre.org,dir_iwst@icfre.org

FEDERATION OF INDIAN PLYWOOD & PANEL INDUSTRY (FIPPI)

REGISTERED UNDER THE SOCIETIES REGISTRATION ACT XXI OF 1860, REGN. NO. S/2985/1968-69 DT. 4.1.1969

Part of FIPPI Achievements

With great efforts of Federation of Indian Plywood & Panel Industry (FIPPI), an Apex representative body of Plywood / Panel / Other Allied products including Furniture and Wood / Bamboo Working Machinery Manufacturers in India alongwith close cooperation with various Ministries and Premier Institutes through Agro and Farm Forestry and other Captive Plantation programme, the dying woodbased industry is again reviving in the country to produce various standard products like Veneer, Plywood, Panelboard, Particleboard, MDF, Laminates etc. which are internationally accepted. Further with great pursuance of the President and Senior Executive members of FIPPI we are highlighting and representing the crucial issues confronting the Plywood & Panel Industry. FIPPI also publishes quarterly Journal Indian Wood & Allied Products highlighting the development taking place in India and abroad, market profile, world timber market report, statistics, international exhibition and conferences, articles, write-ups etc.

FIPPI is cordially inviting all plywood / panel / bamboo / Laminates and other allied products manufacturers to become active member for the strengthening the platform of FIPPI and working for the development of the industry which is Internationally recognized by ITTO, FAO, European Union, IWPA, BIS, MoEFCC, Ministry of Commerce & Industry, BIS, FICCI, CII and other renowned Organizations.

FEDERATION OF INDIAN PLYWOOD & PANEL INDUSTRY (FIPPI)

404, Vikrant Tower, 4, Rajendra Place, New Delhi110 008, India
Ph.: (Direct) +91-11-25755649, Other Nos. +91-11-25862301
Fax: +91-11-25768639, E-mail : fippi@fippi.org

Website : www.fippi.org

A lifelong touch of endurance

With footprints in national as well as international shores, Greenply Industries Limited is one of the nation's leading interior infrastructure companies, with a wide range of products like plywood, blockboards, flush doors, decorative veneers and PVC products to match every aspiration. We also offer lifetime warranty on all our premium offerings.

We are an ever-growing family of industrious individuals and concern for environmental welfare lies at the heart of all our endeavours. Our journey has always been towards sustainability and good health. This is why we ensure the products we offer, conform to negligible formaldehyde emissions, offering safe and clean indoor air quality. We hope to add to our already diverse portfolio of E-0 grade products in the days to come. After all, everyone deserves a wholesome living space.

PLYWOOD | BLOCKBOARD | DOORS | VENEERS | PVC/WPC BOARDS & uPVC DOORS

Toll Free No.: 1800 103 4050

wood is good
GROW MORE, USE MORE

Published by:

Institute of Wood Science and Technology, Bengaluru
Indian Council of Forestry Research & Education
(An Autonomous body under Ministry of Environment, Forest & Climate Change)
P.O. Malleshwaram, Bengaluru - 560 003, Karnataka, India
E-mail: dir_iwst@icfre.org | Website: https://iwst.icfre.gov.in

For copies, write to:
Head, Extension Division,
Institute of Wood Science & Technology, Bengaluru
P.O. Malleshwaram, Bengaluru - 560 003.
E-mail: extension_iwst@icfre.org

Designed by: **Samvida Communications (OPC) Pvt. Ltd.**
Contact: Meghana S Belavadi, meghana@samvida.biz, +91 9886201993