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SHORT PAPER

Timber Production Potential of Trees on Farmlands

S. Suresh Ramanan[1] · **Ayyanadar Arunachalam**[1] · **Arun Kumar Handa**[1]

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Abstract

In the efforts to protect the natural forests, the policies and regulations in India have discouraged the usage of wood or timber, especially in the construction sector. Despite all, wood usage in India is high, and the country is a net importer of wood. A glance at the wood production scenario revealed that Trees Outside Forests (TOFs) is a major source (93%) of wood in India. The Central Public Works Department, Government of India has reverted to encourage wood usage in construction by revoking the ban on wood usage in its works. This will have reverberations in the demand–supply of timber of India, and the timber resources are also skewed geographically. In this context, this paper analyzes the timber production potential of trees on farmlands, i.e. agroforestry, with existing datasets. It seems that the actual potential of timber production was 216.26 million cu.m. in 2013, which is far less than the actual wood used in construction, furniture, and agricultural implements (420.18 million cu.m). Even the projected estimates also indicate that there is a need to encourage timber-based agroforestry. Till date, fast-growing tree species were promoted in farmlands, and there is a need to shift towards longer-rotation tree species in agroforestry. Thus, it will be beneficial in the long run on both ecologically and economically. This paper details the bottlenecks involved in timber production through agroforestry and recommends the policy level changes required to facilitate the adoption of agroforestry among farmers.

Keywords Timber · Agroforestry · Tree · Wood · India

Introduction

There was increased concern for sustainable utilization of forests owing to the rampant deforestation in the 1980s. More than 16 million ha of forest area was diverted for other land-use between 1990 and 2000 (Ghosh and Sinha 2016). Many countries, however, reoriented their environmental policies to protect the natural forests.

✉ S. Suresh Ramanan
suresh.s@icar.gov.in

[1] ICAR-Central Agroforestry Research Institute, Jhansi, Uttar Pradesh 284003, India

In India, the Forest Conservation Act (1980) and National Forest Policy (1988) encouraged wood-based industries to source their raw materials outside the natural forests. The interim ban on unregulated felling in 1996 by the Supreme Court of India was the final blow to the supply of wood from natural forests (Dutta 2005). The eventual raw-material crisis led to the closure of many wood-based industries which had acute socio-economic impacts (Arunachalam and Arunachalam 2012). Subsequently, the wood import was liberalized in 1996 to meet the local needs, and it steadily increased after that thereafter (Ghosh and Sinha 2016). Subsequently, the industries established tree clusters in and around their factories to meet their requirements. Thus, many reports highlighted the role of Trees Outside Forests (TOFs) in provisioning wood and ecosystem services (FSI 2013, 2017; MOEFCC 2019). Trees on farmlands, i.e. agroforestry, holds a major share of area under TOFs. It is estimated that about 23.36 million ha of area is under agroforestry practice in India (Rizvi et al. 2019) and another study reports that about 37.4% (122.74 million ha) of the land is highly suitable for agroforestry practice (Ahmad et al. 2019; Nath et al. 2021a, b). Empirical analysis has reported that adoption of agroforestry to 30% of geographical area of the country has the potential to offset India's GHG emissions by 2050 (Nath et al. 2021a, b). As well as, counting on the agroforestry potential in provisioning both tangible and intangible benefits (Jose 2009, 2012), an analysis was done on the existing datasets to contextualize the promotion of agroforestry and tree cultivation outside forests as a way forward to meet the raw material needs of the wood-based industries, which also have attributes of employability and allied livelihood opportunity.

Demand and Supply of Wood

Wood is the major output from trees and is traditionally used for various socio-cultural ethos. Wood-based industries, like the paper and pulp industry, demand this as raw material for paper production. In ancient time, the houses did consume wood as construction material. In particular, engineers choose wood for climate amelioration in the temperate world. In our country, wood is not the first choice for construction purposes except in the mountain region. Interestingly, the Central Public Works Department (CPWD) banned the usage of wood as construction material in 1993, much before the Supreme Court Judgement imposed a ban on unregulated tree felling inside natural forests in 1996, thereby reducing the market availability of wood and eventually, wood has been substituted by other durable materials like plastics, steel etc.

The CPWD vide F.No.45/SE(TAS)/TAD/New Product/2020/265 dated 01.07.2020 has revoked its ban on the usage of wood as construction material, stating that wood is a versatile renewable construction material and also an alternative to steel or plastics that have high carbon footprint than wood vis-a-vis longer recycle period. A multi-disciplinary team from the Yale University (USA) systematically proved that using wood as a construction material instead of steel and cement could prevent 14–31% of CO_2 emissions (Churkina et al. 2020). The researchers logically argued that the exponential growth in the global population and concurrent

requirements of construction materials like cement and steel would further increase GHG emissions. Evidently, they suggested utilizing wood in building construction, including engineered wood products like Glulam and Cross Laminated Lumber. Many countries, including the U.K., encourage the use of more wood in construction due to its low carbon footprint. In India, current usage of wood as such construction material is minimal, but the country is a net importer of wood and its products, about 18.01 million cu.m of timber, pulpwood and allied products (Shrivastava and Saxena 2017). We believe that the recent revoke of the ban on timber usage in construction shall give a flip to our timber demand and supply, also keeping the country's global commitments on climate change and carbon mitigation. This calls for bringing more area under tree plantations outside forests and/or agroforestry. Evidently, the carbon absorption capacity of Indian forests (Table 1) had an increase of 42.6 million tons in 2019 (7124.6 million tons) compared to 2017 (7082 million tons).

On average, India's annual wood demand for construction purposes is 56.4 million cu.m., including the wood demand in rural areas for agricultural implements. However, the annual production of wood is 44.34 million cu.m. and bamboo are 5.38 million cu.m. (Table 2). Bamboo is majorly used for construction and furniture making after due pre-treatment and processing. However, the India State of Forest Report (ISFR-2017) reports annual wood production from the Trees Outside Forests (TOFs) as 69.04 million cu.m. in 2011 that increased by 7.9% to 74.51 million cu.m. in 2017 (FSI 2013, 2017).

Despite inconsistency in the production estimates, it is becoming increasingly evident that much of the wood demand is met from the TOFs (44.34 million cu.m) as the wood extraction from the natural forests did significantly decline after the ban on timber felling in 1996. An Expert Committee constituted by the Ministry of Environment, Forests & Climate Change, Government of India, in the year 2018 recorded agroforestry as the most viable option to promote tree cover outside the forests (MOEFCC 2019). In this regard, the revoke of the ban on wood as a

Table 1 Temporal trends of forest, tree cover and carbon stock of India. *Sources*: ISFR (FSI 2013, 2015, 2017, 2019)

	2013	2015	2017	2019
Forest cover (km^2)	697,898 (21.23%)	701,673 (21.34%)	708,273 (21.54%)	712,249 (21.67%)
Very dense forest (km^2)	83,502 (2.54%)	85,904 (2.61%)	98,158 (2.99%)	99,278 (3.02%)
Moderately dense forest (km^2)	318,745 (9.70%)	315,374 (9.59%)	308,318 (9.38%)	308,472 (9.39%)
Open forest (km^2)	295,651 (8.99%)	300,395 (9.14%)	301,797 (9.18%)	304,499 (9.26%)
ToFs (km^2)	91,266 (92.78%)	92,572 (2.82%)	93,815 (2.85%)	95,027 (2.89%)
Growing stock (m cu.m)	5658.046	5768.387	5822.377	5915.760
Forest (m cu.m)	4173.362	4195.047	4218.380	4273.470
Tof (m cu.m)	1484.684	1573.340	1603.997	1642.290
Carbon stock (million tonnes)	6941	7044	7082	7124.60

Values in parentheses are percentage of the total geographical area of India

Table 2 Wood demand and supply for construction purposes (2011–16). *Source*: Based on CSE report—Wood is Good (Shrivastava and Saxena 2017)

Wood Consumption	Wood Consumed (million cu.m)	Wood Production	Wood Produced (million cu.m)
Construction, furniture, and agricultural implements	48	Trees Outside Forests (ToF)	44.34
Plywood and panel	8.4	Bamboo	5.38
Total	56.4	Total	49.72

construction material would expectedly boost tree farming, and increase wood availability, and create employment opportunities. This warrants an inclusive assessment of the timber production potential of agroforestry and/or trees from the farmlands.

For the first time, the India State Forest Report (ISFR-2013) estimated the total area under agroforestry in the country as 11.15 million ha, i.e. 3.39% of total geographical area (FSI 2013), and the recorded total volume of wood available from agroforestry is 1124.10 million cu.m. However, this is an estimate based on the total volume of standing trees without accounting for felling and/or conversion loss. Furthermore, all the trees growing on farmlands may not be suitable for timber purposes. Thus, the authors sorted out trees suitable for timber utility based on their wood density and size. Accordingly, the available Roundwood Equivalent (RWE) with 60% conversion efficiency is 216.26 million cu.m. (Pandey and Rangaraju 2008) (Table 3). Even if the conversion efficiency is raised to 70%, the production will still be 252.28 million cu.m., which is far less than the actual demand. Further, the report also states that the total wood demand in 2013 for construction, furniture and agricultural implements was 420.18 million cu.m. (FSI 2013). Using this information as a benchmark, we calculated the projected value for 2017 using it annual wood consumption that recorded ca. 600 million cu.m., which is again much lower than the wood production as calculated for 2017 (375.66 million cu.m) (Fig. 1). These analyses call for upscaling timber-based agroforestry in the country.

Essentially, there is a demand–supply gap in both annual as well as total wood estimates. Although there are 55,731 sawmills in our country as of 2013, the percentage of the sawn-wood import doubled from 3.1% (2009–14) to 6.8% (2014–19). Simultaneously, round-wood/log import percentage decreased from 44.5% (2009–14) to 25.4% (2014–19), respectively. Notwithstanding, future wood (timber) imports may still increase. According to ITTO's recent report titled "Biennial review and assessment of the world timber situation 2017–2018", India is one of the top producers and consumers of tropical wood. The report recorded that India could still manage to export semi-finished wood items and, most importantly, wood handicraft items (Sood 2019; ITTO 2021). Srinivasan et al. (2018) predicted that the compound annual growth rate of import and consumption would be 0.10% and 0.09%, respectively and estimated an increase in the demand for round-wood by 0.07 million cu. m. with a rise of one unit of GDP per capita from the current mean value. Despite the huge demand–supply gap, the TOF area is increasing together

Table 3 Species-wise volume of prominent timber species under agroforestry systems in India. *Source*: ISFR (FSI, 2013)

Species	Volume (million cu.m)		Total Volume (million cu.m)
	30–50 DBH class	> 50 DBH class	
Acacia nilotica (Acacia arabica)	11.074	2.072	13.146
Albizia spp.	7.309	2.253	9.562
Artocarpus heterophyllus	9.534	3.947	13.481
Azadirachta indica	28.734	14.449	43.183
Butea monosperma	12.016	4.38	16.396
Dalbergia sissoo	5.672	1.394	7.066
Gmelina arborea	1.119	0.603	1.722
Holoptelea integrifolia	1.894	0.933	2.827
Madhuca longifolia	5.752	57.046	62.798
Mangifera indica	35.585	95.484	131.069
Pinus kesiya	0.458	0	0.458
Pinus roxburghii (Pinus longifolia)	14.924	7.488	22.412
Prosopis cineraria	4.924	1.413	6.337
Quercus leucotrichophora (Q. incana)	1.766	0.599	2.365
Shorea robusta	5.928	9.048	14.976
Tectona grandis	1.998	0.488	2.486
Terminalia arjuna	2.755	1.633	4.388
Terminalia crenulata	1.781	1.369	3.15
Toona ciliata (Cedrela toona)	2.098	0.484	2.582
Total	155.321	205.083	360.404

Total wood volume (including felling and conversion loss at 40%)—216.26 million cu.m. (RWE)

Total wood volume (including felling and conversion loss at 30%)—252.28 million cu.m. (RWE)

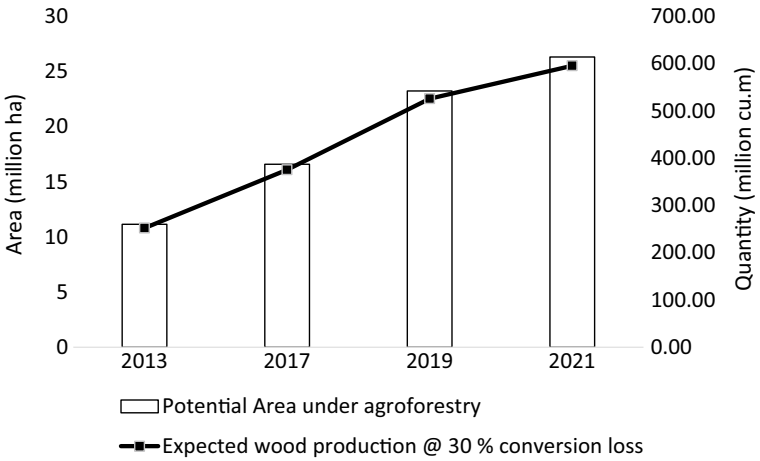

Fig. 1 Potential agroforestry area and expected wood (timber) production across the timescale (30% conversion loss is based on the average conversion efficiency reported (Pandey and Rangaraju 2008))

with wood consumption and imports. Likewise, the trees grown outside forests and/or in farmlands are essentially required to enable our sawmill or any other wood-based industry to operate at its full potential and generate employment. For instance, a study on the socio-economic impact of a ban on unregulated felling recorded a 78% decline in employability due to a 76.86% decline in the number of wood-based industries in 2009 compared to pre-ban situations in 1996 (Arunachalam and Arunachalam 2012).

Meanwhile, the furniture industry recorded an annual growth rate of 12.19%, despite timber scarcity for furniture purposes leading to an increased usage of engineered wood products like MDF, plywood and particleboard. (Kedia 2020). Culturally, every Indian household shall have more than one piece of wooden article (TET 2019; Norman and Canby 2020). All these add as drops in the ocean and raise the demand for timber, which calls for transparency and institutionalization of timber governance, including export and import.

Agroforestry to Augment Wood Production in India

As the timber wood production in India is not distributed equally among the ecological regions, we need to augment the wood production geographically. For instance, trees like *Pinus kesiya, Pinus roxburghii, Quercus leucotrichophora* and *Toona ciliata* are confined to selected Himalayan states contributing significantly to the overall timber production. The geographic disparity also creates variability in local level demand and supply gap reflecting the differential market pricing. To have comprehensive utilization of wood, we shall have to.

(i) create inter-state clusters to facilitate easy transportation of timber and wood,
(ii) institutionalize timber trade and transportation with adequate data banking and transparency,
(iii) encourage timber-based industries to have assured buy-back assurance with farmers for timber trees as they have long gestation periods,
(iv) need to have a gradual increase in import duty as a measure to discourage timber imports, thus aligning the industries to support local tree growers and. in the process,
(v) disseminate adequate information to popularize timber-based agroforestry models (Table 4) for adoption by the stakeholders through bankable projects.

For instance, agroforestry is today widespread in few states like Gujarat, Karnataka, Uttar Pradesh and Tamil Nadu, Karnataka alone has 1.293 million ha of land under agroforestry (Rizvi et al. 2019). If we presume that the entire State adopts a teak-based agroforestry system, then the State's timber production shall be approximately 17.40 million cu.m. Nonetheless, there are caveats in augmenting timber production through agroforestry. For example, the rotation age mostly depends on the farmers' needs, and without assured buy-back, the trees may be felled earlier. The

Table 4 Timber-based agroforestry models. *Source*: Successful Agroforestry Models for Different Agro-ecological regions of India (Handa et al., 2019)

S. No	Agroforestry System	Recommended States	Age	Yield	Number of Trees/ha	Spacing	Crops
1	Three-tier agroforestry system for paddy growing area	Eastern Maharashtra (Vidarbha), Konkan and Chhattisgarh	Initial planting 6th (50% thinning) 12th (25% thinning) 20 (final harvesting)	– 250 poles 125 poles + 7.03 cu.m/ha 125 poles + 13.62 cu.m/ha	500 250 100 100	2 m in a single row on paddy bunds and 10 m spacing between bunds	Kharif: Paddy; Rabi: Gram, Black gram,Linseed
2	Teak based agri-silvicultural System	Karnataka, Maharashtra	22nd	24.35 cu.m /ha 13.46 cu.m /ha	100 (10 × 10 m) 50 (20 × 10 m)	10 m alleys 20 m alleys	Sorghum and groundnut
3	Jackfruit and Acacia based silvi-horticultural system	Kerala and Karnataka > 2000 mm rainfall	20nd	0.9–1.09 cu.m/ha	1111	3 × 3 m	Pineapple, Black Pepper
4	Shisham (*Dalbergia sissoo*) based agri-silvicultural system	Bundelkhand region of Uttar Pradesh and Madhya Pradesh	10th 20th 30th 40th 50th	10 cu.m/ha 100 cu.m/ha 210 cu.m/ha 280 cu.m/ha 370 cu.m/ha	277 (6 × 6 m) 208 (6 × 8 m) 156 (8 × 8 m)	6–8 m	1. Wheat, mustard, barley, lentil (Rabi) and greengram, blackgram, sesame (Kharif) 2. Napier in silvi-pastoral system
5	*Melia dubia* based agri-silvicultural system	Maharashtra, Karnataka, Andhra Pradesh and Tamil Nadu	10th	0.3–0.4 cu.m per tree 120–160 cu.m/ha	400 (5 × 5 m)	Bund: 2–2.5 m × 2–2.5 m Boundary: 3–4.5 m × 3–5 m Block: 5 m × 5 m	Kharif: blackgram, cowpea, greengram, okra and groundnut Rabi: sorghum, vegetables

intercropping possibility declines with the age of trees, especially in closely planted areas. In the absence of uncertain intermittent revenue from the timber-based agroforestry system, the farmers would remain skeptical. Moreover, the law of the land, rules and regulations involved in the felling, transportation and marketing of trees grown in farmlands needs more clarity between the intent and implementation (Ghosh and Sinha 2018; Vanam 2019). The list of trees exempted from transit rules varies with state and often gets changed. To sort out this issue, the Bansal Committee gave its recommendation in the form of guidelines on felling and transit regulations for tree species grown on non-forest/private lands (vide Ministry's Notification: F. No. 8-14/2004-FP (Vol. 2) dated 18.11.2014) which is also subscribed in the proposed agricultural reforms by the NITI Ayog, Government of India. The Committee recommended centralized exemptions and clearances for timber transit rules and underlined the need for promoting trees on farmlands and beyond through flexible policies. Nevertheless, different states have their own transit rules, which is a major hurdle in marketing timber produce from agroforestry. Another extreme situation is being experienced in the Union Territory of Chandigarh that has a very meagre forest cover, including the TOF's and so, no inter-state permit is issued for transportation of timber. The existing centralized National Transit Pass System (https://ntps.nic.in/Index.aspx) is a genial initiative yet tumbles for want of a validated and robust database for decision making about exemption or permitting trade of a given tree species under timber transit rules.

With this volatile situation, implementing the National Agroforestry Policy (2014) objectives through the Sub-mission of Agroforestry (SMAF) by the Department of Agricultural Cooperation and Farmers' Welfare, the Government of India comes as a ventilator to subside the existing bottlenecks. As of today, the scheme is implemented in 27 states and union territories of the Indian Union which have made relaxation in timber transit rules by exempting transit permits for selected agroforestry species like Eucalyptus, Poplar, Casuarina, Salix, *Leucaena leucocephala, Prosopis cineraria, Melia dubia, Acacia mangium, Grevillea robusta* and *Gmelina arborea.* Few more challenges need to be addressed, like the certification of quality planting material for agroforestry tree species, creation and updating of the database on the area of agroforestry tree species planted across the States and uniform implementation agency for SMAF in all the States for effective facilitation and monitoring. With this, there is no denial that agroforestry practices could resurrect tree cover, maintain biodiversity, and provide an opportunity to enhance timber production and associated livelihood opportunities to the people at large, farmers in particular. The SMAF is promoting fast-growing tree species in short-rotation in farmlands; this, however, needs a shift towards longer-rotation to emphasize timber implications of TOFs. In the whole process of timber governance, either from forests or outside the forest, block-chain technology can be an effective tool to ensure/assure the source and enable transparency and traceability in the timber value chain. This, if developed, the technology can become a boon to the farmer who grows trees on their farmlands and contribute to meet the timber/wood requirements in the country and shall deduce the recent revoke of the ban on wood being used as a construction material.

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Declarations

Conflict of interest The authors declare no conflicts of interest.

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