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Review Article

Scaling up an Indigenous Tree (*Gmelina arborea)* Based Agroforestry Systems in India

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Abstract: Scaling up of *Ghamar (Gmelina arborea* Roxb.) based agroforestry in India has a prime concern as it is a native species which has potential to replace and act as a substitute for other exotic timber trees in the country. *Gmelina* is gaining momentum at the present time; besides fulfilling the demand of wood and timber in the current scenario of industrial agroforestry and also fulfilling other domestic needs. This fast growing woody species has got increasing attention in India because of its exemplified diverse values due to its indigenous origin, quality wood, easy and quick remunerative returns. The present paper highlights the multifaceted volume of *Gmelina* in agroforestry including carbon sequestration potential, manifold importance and desirability of under home gardens and agroforestry systems. In addition, the paper also points out the existing constraints and limitations which are responsible in fading it's the large scale production in agroforestry and farm forestry.

Keywords: *Gmelina arborea*, Homegardens, Intercrops, Agroforestry

1. Introduction

Gmelina arborea, commonly known as white Teak/Gamar/Siwan, is an indigenous fast growing tree species of India, used for timber, furniture wood, paper and pulp making and other forest based industries. It is a most promising multipurpose tree which is able to fulfill the need of fuel, fodder, wood, medicinal products, other domestic needs etc. *G. arborea* belongs to the family of Liminaceae an associate of *Tectona grandis* as it possesses equally good quality wood and native tree. *G. arborea*is light-demanding and an ideal choice for farm forestry and large-scale afforestation/ reforestation initiatives.

In India, it is found throughout greater part in Eastern sub-Himalayan tracts, Indo-Gangetic plains, Aravali Hills, Central India, Western Peninsula and Western Himalayas scattered in dry deciduous, moist deciduous forests and occasionally in evergreen forests. Presently, *G. Arborea* contributed to 0.47% of total volume of trees under Agroforestry systems the country [1]. The species grows up to 30 m in height and over 80 cm diameters and is widely grown as a component of agroforestry system in humid tropics. It performs best on fresh, well-drained, fertile alluvial soils where rainfall varies from 1200 to 4500 mm, temperature ranges from 20 to 45°C, and elevation ranges from sea level to 1000 m [2]. In the recent past, this tree species is gaining momentum in many parts of India among the farmers in the southern part of the country particularly in Tamil Nadu and preferred to be grown in agricultural lands [3]. Likewise, in Northeast India, it is extensively used for timber, industrial wood and fodder production and is grown both on government and private lands [4].

Globally, it occurs naturally in 11 countries in tropical and subtropical regions of Asia [5], [6] examined the financial feasibility of *G. arborea* plantations at small scale and found that it is an excellent small-holder's timber as it is easy to

cultivate and grow like *T. grandis*, *Swietenia macrophylla* (mahogany), *Paraserianthus falcataria* (Indonesian albizia) etc. in South Asia including Indonesia [7].

2. Importance of *G. arborea*

Adopting an economically important tree species [8] under various agroforestry systems could upsurge the productivity and contribute considerably in narrowing the gap between demand and supply of wood. The light-weighted wood is used in light construction, packaging, furniture, artificial limbs, particle board, plywood, wooden handicrafts, matches, etc. The wood is relatively light with a density of 420 to 640 kg/m^3 and a calorific value of about 4800 kcal/kg [9]. The wood creates the average yields of paper with superior properties than from other hardwood pulps. Its leaves can be used as fodder, and its flowers produce abundant nectar from which good quality honey is produced [10].

G. arborea plantations have been established and encouraged in small woodlots, home gardens and agroforestry settings in the tropics and subtropics. The enormous potential of *G. arborea* as sole plantations and farm-grown timbers (i.e. Poplar and Eucalyptus) to meet the target for the industrial demand has attracted agriculturists, forest departments and NGO and Community Based Organisations (CBOs) to take up large scale plantation programmes in extension forestry and agroforestry [11]. The growth rate for *G. arborea* has been reported to be as high as 40–50 m^3/ha/year in areas of good soils and rainfall [12]. It is also used as avenue tree and shade tree in coffee and cocoa plantations. Farmers who are facing problems in practicing unprofitable sole agriculture can raise *G. arborea* on their farm land for innumerable profits, viz. high return, less risk, etc. because of its fast growing nature, less shade effect on agricultural crops in block plantation as well in rows or peripheral bunds under agroforestry system [13]. It is also considered important medicinal and religious sacred tree which is most widely cultivated [14]. Various plant parts like root, fruit, leaf, flower, bark etc. can be used pharmaceutically and is an essential component among Dashamuala, Rasayana (rejuvenation), Medhya (Memory enhancer) and Vrishya (Aphrodisiac) [15]. Medicines prepared from the tree parts is being used traditionally as antihelmintic, antimicrobial, antidiabetic, diuretic, hepatoprotective and antiepileptic agent [15].

3. *Gmelina arborea* Based Agroforestry

Tree based land use systems or agroforestry marked a valuable contribution to improve the productivity, sequester carbon and offers alternative source of income generation. It is considered as the most dynamic and suitable system which broadens the profitability prospects and enhances production for increased socio-economic, ecological and environmental benefits. Several crops were found compatible with Ghamar trees viz, soybean, yam, cowpea, wheat, maize, mustard, rice, cowpea, groundnut and black gram etc.

In India, amongst other multipurpose trees raised in the farm fields, bund plantation of *G. arborea* was most acceptable to the agrarians which revealed highest survival rate in three of the five target districts i.e. Koraput and Bhawanipatna (Odisha) and Jagdalpur (Chhattisgarh) [16]. The tree in the farmland sequesters carbon and act as a climate resilient agro-ecosystem besides providing wood and timber. The net biomass accumulation in Gmelina was assessed in 10-year age old of plantations to be 371.54 tonne ha-1 over 279.89 tonne ha-1, in T. grandis [17]. Another study indicates that the biomass of *G. arborea* and *Ceiba pentandra* based agroforestry system was 9.9 Mg ha^{-1} to 21.4 Mg ha^{-1} and 12.9 Mg ha^{-1} to 25.1 Mg ha^{-1} respectively. Further, it revealed higher stem biomass in *G. arborea* (1.57 Mg ha^{-1}) as compared to *C. pentandra* (0.86 Mg ha^{-1}) and also added average 6.8-11.9% carbon content to the soil [18]. *G. arborea* has been well recognized among farming community under agroforestry systems in India as presented in the following table 1.

Globally, it is also grown in association with yam or cassava in southern Nigeria [19]. A study under *G. arborea* - Zea mays hedgerow agroforestry system in Philippines revealed that tree spacing greatly affected the nutrient dynamics of hedgerow agroforestry systems [20].

Table 1. *Prominent Gmelina based agroforesty in India.*

Agroforestry combination/systems	Region	Major Finding	References
G. arborea with soybean and cowpea in rainy season; wheat and mustard in winter season	Chhattisgarh	Total C storage in agricultural land before planting was 26.3 Mg ha^{-1}, which increased to 33.7 Mg ha^{-1} in plantation and 45.8 Mg ha^{-1} C in agrisilviculture system after 5 years	[21]
G. arborea plantation	Tripura	Average tree density (452 stems/ha), diameter (25.4 cm), height (20.9 m) and mean annual increment was 10.483 m^3 /ha; Total aboveground biomass was 164.436 t/ha with annual productivity of 8.2 t/ha	[22]
G. arborea with Rice, cowpea, groundnut and black gram	West Bengal	Yields of Rice, cowpea, groundnut and black gram intercrops were 1.97, 1.03, 0.69 and 0.46 t ha^{-1} respectively; the return from the crop was highest (Rs. 13,800.00 ha^{-1} year^{-1}) with blackgram/ groundnut and lowest in cowpea (Rs 6,180.00 ha^{-1} year^{-1})	[23]
G. arborea withwheat, linseed, mustard and urd crops	Chhattisgarh	Total biomass ranged from 6.96 to 13.75 Mg ha^{-1} after5 years; The yields of all crops decreased under *G. arborea* stands in comparison to their sole crops after 4 years of its planting	[24]
Gmelia with soyabean crop	Central India	Total biomass varied from 10.89 Mg ha^{-1} to 3.65 Mg ha^{-1}; Soybean yield varied between 1.5 Mg ha^{-1} to 2.1 Mg ha^{-1}	[25]

4. *G. arborea* in Homegardens

Home garden agroforestry, one of the oldest forms of managed land use system, is supposed to be more diverse and deliver numerous services than other mono cropping system and this is due to the amalgamation of crops, trees and livestock production systems [26]. *G. arborea* is an important plant species grown under home gardens. It is mostly grown and present in the home gardens of north-east India, Northern West Bengal and South India. It supports local community in contributing to their daily domestic needs as well as assist in livelihood security. Many studies have been done in the home gardens which are listed in Table 2 with its major findings.

Table 2. *Major findings related to G. arborea in homegardens in India.*

Studies on Home garden having *G. arborea*	Regions/states	Major findings	References
Social cultural significance	Baramura ranges in Tripura	The forest harbours a rich biodiversity and it supports local people in contributing to their daily needs	[27]
Inventory of flora in home gardens	Foot hills plains area of Himalayas, Northern part of West Bengal	Subsistence of local households and significantly contribute to conservation of native biodiversity	[28]
Plant species composition of homegardens of Kani tribe	Home gardens of Kanya Kumari Wildlife Sanctuary, Southern Western Ghats	Provide medicine, timber, fodder, fuel wood and edibles for household consumption and for sale as well	[29]
Floristic analysis and Functional diversity	Urban and peri-urban homegardens of Kerala	*G. arborea* present in urban home gardens and study finds out depletion in functional diversity in urban home gardens	[30], [31]
Medicinal plants used by tribal population	Coochbehar district, West Bengal	Commonly cultivated for timber, Root extract used in stomach disorder	[32]

5. Limitations in Expansion of *G. arborea* in Agroforestry

In India, *G. arborea* being such a wonder substitute of Teakwood, it has not scaled up in plantations as well as in agroforestry in various regions due to several reasons including dearth of proper tree improvement, silvicultural practices and inappropriate knowledge of insect pest management. Tree has negligible effect on intercrops in physical and biological spheres. Allelopathic inference also been tested in relation to under-storey weed density in home gardens of North East India [33]. The major hitches faced by the farming community/growers are non-availability of quality planting material, costly seedling, unfledged marketing linkages, etc. [13]. [34] recommended a silvicultural practice for pruning of branches in *G. arborea* to be done at 5 mm distance away from main stem and for regulating stem borer apply a paste with formulation of 2ml of Monocrotophas + 100 ml Cholorpyriphos + 100 ml of Copper sulphate + 250 gm of clay soil with 100 ml of water on the cut portion for producing better quality timber. The management aspects of *G. arborea* especially for pruning, thinning and harvesting regime and their impact on productivity of agricultural inter crops are poorly understood which need to be suitably researched [5].

Recently one monopahgus coleopteran insect *Craspedonta leayana* defoliating is reported from North-Eastern region of India [35]. It has the tendency to develop heavy branches and forks, with a crooked and tapered stem [36], therefore, stem quality is an important property to be considered in forest management and tree improvement programs. There is also need to make some better clones of the tree as the tree species is vulnerable to insect attacks and disease which is limiting plantation expansion and acceptance. It also has low wood density than most commercial species of Eucalyptus and Acacia which limits pulp yields and product strength of the wood which should be overcome with the aid of technologies and science [5].

6. Conclusion

Scaling up of *G. arborea* trees in agricultural landscape under agroforestry is not much challenging task provided agricultural extension efforts are directed with suitable agroforestry model including all package and practices. Although, *G. arborea* is mainly recommended under agroforestry for humid and sub humid tropics but it is wide spread in other parts of India from Himalayan foothills to central Indian coastal plains. The framers/ growers should have the understanding about the importance and multi-benefits of *G. arborea* before introducing in their farmlands. Acquiring proper understanding, training and assistance regarding management and silvicultural practices for higher economic returns is essential for its expansion. In spite of few constraints, *G. arborea* should not be getting unnoticed, since it is one of the fast growing tree having less shade on agricultural crops and consistent market demand for timber, wood, etc. under agroforestry system. We hope in future with concerns of climate change and doubling farmer income from agricultural landscape *G. arborea* like fast growing indigenous tree species need to be encouraged as adaptation / mitigation measures under ongoing agroforestry submission to sustain the national agriculture scenario.

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