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Van Sangyan

Note to Authors:

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

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

Cover Photo: Panoramic view of Achanakmar-Amarkantak Biosphere Reserve

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From the Editor's desk

Selection is one of the important method of tree improvement and the success of this method solely depends on the extent of variability present in the base population of target species. Traditionally, selection of plus tree is based on morphometric traits such as clear bole height, girth at breast height, straightness along with well-developed balanced crown and tolerance to insect and pests. However, with the advancement of timber science and increased awareness among the end users, plus tree selection criteria should include the wood features such as wood density, fibre length, fibre width, fibril angle, cell wall thickness, etc. which are known to define the quality of wood. It is predicted that demand for high quality wood will grow, despite advancement in wood engineering and low-cost substitutes.In general, wood properties can vary in their physical and chemical properties (e.g., fiber, lignin, and cellulose properties, and basic density).It is generally accepted that rapid growth results in less-than-desirable wood properties, especially with respect to density and mechanical properties. Geographical variations also observed in the wood properties.

In line with the above this issue of Van Sangyan containsanarticle onNatural variation as a basis for tree improvement; emphasis on wood properties.There are also useful articles viz. Wood tree-based agroforestry system boon for farmer's livelihood, Agroforestry in Karnataka - A golden opportunity for green growth: Book review, Mulberry (Morus spp.) - A potential source of herbal medicine, Acrocarpus fraxinifolius Arn.: A potential indigenous multipurpose tree for agroforestry, Insights into the sustainable agroforestry system of tropics-homegardens, Dark diversity – the concept of absent species, Agroforestry: A tool for wasteland reclamation and Rapid assessment of butterfly diversity and nectar plants

I hope that readers would find maximum information in this issue relevant and valuable to the sustainable management of forests.Van Sangyan welcomesarticles, views and queries on various such issues in the field of forest science.

Looking forward to meet you allthrough forthcoming issues

Dr. Naseer Mohammad

Chief Editor

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Natural variation as a basis for tree improvement; emphasis on wood properties

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Introduction

Trees and forests constitute one of the most vital natural resources and contribute substantially to the socio-cultural and economic development of a country by providing goods and services to the people. In recent decades, wood has become one of the important raw materials for forest-based industries such as sawmills, composite and plywood, pulp and paper, and other industries.

With the rapid increase in raw material requirements for wood-based industries, a considerable amount of timber was extracted from the natural forest unscientifically (Whitmore, 1997). This overexploitation of timber has caused irreversible damage to the natural forest. National Forest Policy, 1988, brought in a policy shift towards using forests for conservation, which included preservation, maintenance, sustainable utilization, restoration, and enhancement of forest cover. Presently, the productivity of the Indian forest is at 1.36 m^3 ha^{-1} $year^{-1}$ (FSI, 2019), and the per capita forest of India is 0.064 ha. The low productivity of natural forests coupled with an increasing area under conservation network has eventually led to the failure to meet the demand for industrial wood. This scenario caused an enhanced focus on plantations and trees on private land to fulfill different wood-based purposes such as timber, fuelwood, food, etc.

The evaluation of variation in phenotypic and wood traits is necessary to delineate better provenances and conceptualize advanced breeding strategies (Yang, 2009). For initiation of any breeding program knowing the variation or variability is essential. Variability studies of wood properties are most important in selecting wood for good quality pulp and paper production (Zobel, 1981). When the exception is more, there is scope for selection. Parentage as well as the environment influences variation. Considerable anatomical, physiological, morphological, and genetic variability may be exhibited by trees in an extensive range of spreading and little influence by anthropological activities for surviving under varying environmental conditions. The differences between populations in different traits are influenced by the latitude and total site factors and the ecotype of the stand (Varghese *et al*., 2000).

Variation in wood characters

The wood characteristics are the essential features in the selection of trees for the improvement program for industrial utility, which shows Intra and inter-specific variation with change in the growing environment. Wood properties such as

basic wood density, specific gravity, fibre length, fibre width, fibre lumen width, fibre wall thickness, vessel length, vessel width, vessel lumen width, vessel wall thickness, and anatomical ratios are indicators of wood quality in hardwoods (Parthiban, 2019). The study of wood parameters is often considered a helpful step in understanding the variability, which will provide many opportunities for selecting superior genotypes and further tree improvement programs. The earlier studies on different tree species have demonstrated that wood traits across the population and radial portions show substantial variability. Hence these variations could be reliably used in further selection and tree improvement programs (Sahoo et al., 2017).

Wood physical parameters

Wood quality, strength, and durability of timber are mainly influenced by physical characteristics like density, moisture content, and specific gravity. The bark thickness is the most considered physical feature after the density of the wood. Waste material generated by the bark is a considerable loss to the industry and the farmers unless the bark has some other utility view. Site-to-site variations in bark thickness are commonly found in the tropical tree species in relation to the growing condition (Prasad and Sagheer, 2012; Chauhan and Kumar, 2014)

The change in wood density is mainly governed by the moisture content or rainfall of the region along with the various site factors such as altitudeand edaphic factors (Chauhan *et al.*, 2019; Saravana *et al.*, 2014). The basic wood density varies along the radial direction. Wood density increases from pith to periphery. The vessel and fibre parameters chiefly affect the density of the wood (Anoop *et al.*, 2014). Specific gravity is an essential factor that influences the strength and stiffness of the wood. As specific gravity increases, strength increases (Niklas, 1993). The radial variation in wood species may be because of changes in vessel parameters, *viz*, vessel frequency, vessel area, etc. Anoop *et al.* (2014) reported significant variation in specific gravity in the radial portion with an increasing pattern from pith to periphery due to its lesser vessel diameter and vessel area besides high vessel frequency.

Inter-clonal, Intra-clonal, and within tree variations are governed by clonal and site factors. The site factors have a significant effect on inter-clonal changes of wood parameters. Thus, the environment has more impact on wood quality than the inherited nature of clones.The interspecific variation reflects vertical niche differentiation (Osunkoya *et al.*, 2007). The density of the stem is lower than the density of branch wood. The density of the stem shows higher variability between the growing sites than the density of the branch (Gryc *et al.*,2011).

Srilakshmi and Rao (2017) evaluated the specific gravity of two and four-year-old *Eucalyptus tereticornis* clones grown in two different conditions of Karnataka, *viz.*, irrigated (Mandya) and rainfed (Kolar). The clones raised under rainfed conditions showed higher specific gravity than in irrigated conditions. As age increased, specific gravity increased, and specific gravity increased from pith to bark.

The wood-specific gravity of different tree species associated with *Myristica* swamps

in five swampy sites of Karnataka was investigated by Tambat *et al.*(2018). The study revealed that the specific gravity of the marshy species and co-occurring non-swampy species varied across the sites. They concluded that the non-swampy species subjected to the drier environment tend to increase their wood-specific gravity as an adaptive strategy.

Wood fibre and vessel parameter

Wood formation is chiefly controlled by genetic factors and environmental factors in which trees grow (Savidge, 2003). The anatomical features mainly affect the quality and strength of timber; it also reveals timber's suitability for end-use. Most wood fibre and vessel parameters vary with rainfall, temperature, edaphic factors, and interaction between the genotype and environment.

The wood anatomical structures were highly influenced by the sites' longitude, latitude, and precipitation. Annual rainfall in the region affects the vessel percentage and diameter, fibre length, and lumen of fibre (Moya and Fo**,** 2008; Ashwath et al., 2021). The 7-year-old 14 *Eucalyptusglobulus* clones showed variations in vessel frequency, area, coverage, fibre wall thickness, and lumen diameter. From pith to bark vessel and fibre parameters increased except for fibre wall thickness (Ramirez *et al.*,2009).

Pande (2011) studied the intra and inter-clonal variation in wood properties like density, fibre, and vessel parameters of 10 different clones of *Populus deltoides* in Rudrapur. All clones showed a significant variation for diameter at breast height. Wood traits showed considerable variation in inter and intra-clonal ramets. Fibre length and specific gravity were significantly higher in female, while male clones showed high significance in wall thickness and vessel parameters. In all ramets, fibre and specific gravity were significant in increasing trends from pith to periphery. Wood structure variation of *Acacia senegal* grown under different rainfall zones of Western Sudan was investigated by Elamin *et al.*(2015). Wood characters were examined to study the effect of rainfall on wood traits in different rainfall zones (low, medium, and high). Fibre, vessel, and parenchyma diameters have not shown any difference under varying rainfall zones in sandy soil. The study revealed that the species was well adapted to its environment without any changes in the anatomical structure.

Vessel morphology variation of Anjily**(***Artocarpushirsutus)* wood grown in three different agro-climatic zones of Thrissur, Kerala, was studied by Sahoo ***et al.***(2017). The vessel length showed a significant difference between girth classes across three agro-climatic zones. Vessel frequency, vessel area, and vessel diameter did not significantly differ across the three agro-climatic zones.

The variation of wood property in *Melia dubia* with an increase in age in Gujarat was evaluated by Sinha *et al.*(2019). Wood properties such as basic density, fibre dimensions, cellulose, and lignin content of *M. dubia* of five age gradations were tested to determine the harvesting age for pulp and paper production. All the traits considered differed with tree age. Fibre length and cell wall thickness increased while fibre width and lumen width slightly decreased with an increase in age. Studied wood properties showed significant variation from one to fifth-

year.The study showed that the species is suitable for making pulp and paper at the age of 4 and 5, compared to other ages with higher fibre and derived dimensions.

Conclusions

Understanding the variation of all tree species provides information about adapting to changing environmental conditions. Understanding geographic variation within a species is essential for developing effective tree improvement programs. It gives an idea about the species range, the amount of diversity encountered within the species in its natural range, and its variation pattern. In anatomical properties, the variation is related to age and locality factors. Further selection will be made to identify superior genotypes for mass multiplication and future breeding programs based on the variation studied.

References

Anoop, E.V., Jijeesh, C.M., Sindhumathi, C.R. And Jayasree, C.E., 2014, Wood physical, anatomical and mechanical properties of big leaf mahogany (*Swieteniamacrophylla*Roxb.) a potential exotic for South India. *Res. J. Agric. and For. Sci.*, 2(8):7-13.

Ashwath, M.N., Sathish, B.N., Deepthi, N.L., Devagiri, G.M., Hegde, R.K., Hareesh, T.S., 2021. Geographic and Within Tree Variation for Wood Properties in *Acrocarpus fraxinifolius* Wight and Arn. Populations. Journal of Scientific and Industrial Research 80(12), 1049-1055.

Chauhan, S. And Kumar, A.A., 2014, Assessment of variability in morphological and wood quality traits in *Meliadubia* Cav. for selection of superior trees. *J. Indian Acad. Wood Sci.*, **11(1):**25-32.

Chauhan, S.S., Annapurna, D., Kumar, A.A. And Joshi, G., 2019, Phenotypic assessment of wood density and stiffness in *Meliadubia* plantations from three locations using non-destructive tools. J. Indian Acad. Wood Sci., **16(2)**:87-93.

Saravanan, V., Parthiban, K.T., Thiruneraiselvan, S., Kumar, P., Vennila, S. And Kanna, S.U., 2014, Comparative study of wood physical and mechanical properties of *Meliadubia* with *Tectona grandis* at different age Gradation. *Res. J. Recent Sci.*, 3:256-263.

Elamin, E. E., Ballal, M. E. And Mahmoud, A. E., 2015, Variation in Wood Structure of *Acacia senegal* (L.) Willd. under Different Rainfall Levels in Western Sudan. *Forest Res.*, 4(141):22-29.

FSI, 2019, The State of Forest Report. Forest Survey of India, Ministry of Environment and Forests, Government of India, pp.13-43.

Gryc, V., Horacek, P., Slezingerova, J. And Vavrcik, H., 2011, Basic Density of Spruce wood, wood with bark and bark of branches in locations in the Czech Republic. *Wood Res.*, 56(1):23-32.

Moya, R. And Fo, M. T., 2008, Variation in the wood anatomical structure of *Gmelinaarborea*(Verbenaceae) trees at different ecological

conditions in Costa Rica. *Int. J. Trop. Biol.*, 56 (2):689-704.

Niklas, K. J., 1993, Influence of tissue density-specific mechanical properties on the scaling of plant height. *Ann. bot*, 72(2):173-179.

Osunkoya, O. O., Sheng, T. K., Mahmud, N. A. And Damit, N., 2007, Variation in wood density, wood water content, stem growth and mortality among twenty-seven tree species in a tropical rainforest on Borneo Island. *Austral Ecol.*, 32:191–201.

Pande, P. K., 2011, Variation in Wood Properties and Growth in Some Clones of *Populusdeltoides*Bartr. ex Marsh. *Am. J. Plant Sci.*, 2:644-649.

Parthiban, K.T., Dey, S., Krishnakumar, N. And Das, A., 2019, Wood and plywood quality characterization of new and alternate species amenable for composite wood production. *Wood and Fiber Sci.*, 51(4):1-8.

Prasad, A. G. And Sagheer, N. A., 2012, Variation in wood fibre traits among eight populations of *Dipterocarpusindicus* in Western Ghats, India. *J. Environ. Biol.*, 33:215-221.

Ramirez, M., Rodriguz, J., Peredo, M., Valenzuela, S. And Mendonc, R., 2009, Wood anatomy and biometric parameters variation of *Eucalyptus globulus* clones. *Wood Sci. Technol*., 43:131–141.

Sahoo, S., Anoop, E.V., Vidyasagaran, K., Kunhamu, T.K. And Santhoshkumar, A.V., 2017, Vessel morphology variation and Eco anatomical properties of anjily (*Artocarpushirsutus*Lam.) wood grown in different agro-climatic zones of Thrissur, Kerala. *J. Trop. Agric.*, 55 (1):40-44.

Savidge, R. A., 2003, Tree growth and wood quality, In: Barnett, J.R. and Jeronimidis, G. (eds.). Wood quality and its biological basis. Blackwell Publishing Ltd, Oxford, UK, pp.1–29.

Sinha, S. K., Chaudhari, P. A., Thakur, N. S., Jha, S. K., Patel D. P. And Dhaka R. K., 2019, *Meliadubia* Cav. wood properties vary with age and influence the pulp and paper quality. *Int. Wood Prod. J.*, 7(3):139-148.

Srilakshmi, S. And Rao R.V., 2017, Clonal variation in selected wood anatomical properties and specific gravity of *Eucalyptus tereticornis*Sm. from two localities in Karnataka. *Int. J. Fundam. & Appl. Sci.*, 6:12-16.

Tambat, B., Venkatesh, C.S.,Chaithra, G.N., Murthy, N.R., Sethy, A.K., Raju, B.M. And Murthy, M., 2018, Wood Specific Gravity of *Myristica*Swamp Associated Tree Species. *Int. J. Pure Appl. Biosci.*, 6 (6):227-234.

Varghese, M., Nicodemus, A., Ramteke, P. K, Anbazhagi, G., Bennet And Subramanian, K., 2000, Variation in growth and wood traits among nine populations of teak in Peninsular India. SilvaeGenetica., 49:201-205.

Whitmore, T., 1997, Tropical forest disturbance, disappearance and species loss. In: W.F. Laurance& R.O. Bierregaard (eds.) Tropical

Forest Remnants. University of Chicago Press, Chicago, pp. 3-12.

Yang, X.Y., Fu, M.Y., Xie, J.Z. And Li, Z.C., 2009, Geographic variation and provenance selection for bamboo wood properties in *Bambusachungii*. *J. For. Res.*, 20(3):261-267.

Zobel, B., 1981, Wood quality from fast-grown plantations. *Tappi;(United States)*, 64(1):7174.

Wood tree-based agroforestry system boon for farmer's livelihood

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Abstract

India is the leading producer and consumer of wood in the Asia Pacific region, although the country produces the tropical hardwood species domestically to fulfill the increasing wood demand. The requirement and simultaneously shortage of wood are increasing day by day due to increasing population, urbanization, industrial development, etc. After the enactment of the forest conservation act (1980) and national forest policy (1952) and legal restriction, the supply of wood/wood products reduces or stopped almostand forest has been recognized more towards conservation than the timber production is also one of the causes of wood production shortage. The demand for wood and wood products increasing, but there are no Farm/Homestead plantation programs that were carried out before and this shortfall can be fulfilled by the adoption of an agroforestry system in farmer's fields. Agroforestry is the art and science of judiciously managing agricultural crops with woody perennials on the same land unit to increase the productivity and profitability for combined goods and services. Integration of trees on farms provides opportunities for improving variation and range of livelihood security for small holder farming household's andcreated a synergy between farming crops, tree species, and animal rearing on the same plot of land. Agroforestry also contributed to obtaining the national goal, as the required tree cover to 33 percent, in the country can only be attained by the planting of trees in farm fields/bunds.Agroforestry supplies nearly 72 % of the demand of fuelwood, 2/3 of the small timber, 70-80 % wood for plywood, 60-80 % raw material for paper pulp, 9-11 % of the green fodder requirement. This paper is highlighting the potential of wood-based agroforestry system for increasing the livelihoods of small and marginal farmers and the direct and indirect benefits of agroforestry to the environment.

Keywords: Agroforestry,Agri silviculture, livelihoods, Plantation, Environment, wood industry.

Introduction

In several countries, forests are the chief source of timber wood, fuelwood production, and for the livelihood of rural people and the community living besides of forest. Due to the rapid depletion of forests in numerous countries promoting wood-based industries to establish a plantation of trees for the fulfillment of the industrial needs as well as for local people and simultaneously conserving the forest wealth and environment (Jain and Singh, 2000). The fastest-growing demand for wood products is in the domestic markets of developing countries. Agroforestry offers significant economic opportunities for small and marginal farmers to sell

high-value wood/timber for the industrial buyer or by selling to intermediaries direct from their farm (Parthiban et al. 2021). In India, agriculture is an important base for rural livelihoods during the serious critical conditions and forest dwellers who are living in beside the forest area, their socio-economic status directly depends upon forest it can be either timber/timber products or non-wood forest products also. Agroforestry is a possible option for ensuring livelihood security by its multiple products and services (Quli et al. 2017). Farm trees can enhance agriculture productivity when grown as intercropping such as windbreaks, fodder banks, live fences and reduce chances to crop failure and enhance the livelihood of farmers. Thus, standing timber trees serves as a saving bank for the farmer who can sell them in the market, especially at the time of urgent need of money (Scherr, 2004). Agroforestry provides at least one product that offers a reliable source of annual income is essential if such an income flow is not provided by farming or off-farm employment (Scherr, 2004). Agroforestry has been played an important role from ancient times to satisfy the requirement of domestic needs of wood/wood products (Parthiban et al. 2017). Trees have continuously been a key role in sustainability and people often planted a higher number of trees on their land/ farm bunds to control soil erosion and helps to improve soil fertility status in many traditional farming systems from long times ago (El-Lakany, H., 2004). Agroforestry supplies almost 72 percent of the demand of fuelwood, 2/3 of the small timber, 70-80 % wood for plywood, 60-80 % raw material for paper pulp, 9-11 % of the green fodder requirement, besides meeting the subsistence needs of households for food, fodder, fruit, fiber, fuel, and medicine, etc. (Sahoo and Wani, 2019). The well-designed and managed agroforestry system generate huge potential to increase productivity on a sustainable basis in terms of both qualitative as well as quantitative production of wood, industrial raw material, grains, fodder, animal productions, etc. (Quli et al. 2017). Agroforestry deals with the cultivation and management of wood, fruits, vegetables, ornamental flowers, and other goods and their post-harvest management. There are several agroforestry tree species have been recognized which act as host plants for honey bees, in different agroforestry models to sustain round the year honey production and gum, resins form another important group of non-wood production in the agroforestry system (Handa et al. 2016)

Agroforestry systems for wood production

Farmers have been integrating a variety of components such as fruit, timber, fodder and fuel by the planting of perennial trees depending upon their need and achieving multiple components in the agroforestry system (Chauhan et al. 2012). Agroforestry offers not only sustained productivity but it's also providing sustainable production for longer times. The agroforestry focused on sustainability in terms of economics, ecology, and social issues that make it an unparallel land-use system (Pandey, 2007). Planting trees on farmland has not only benefited farmers but also generate employment in different sectors such as wood-based industries,

transportation, trading, and providing wood products at affordable prices (Chauhan et al. 2012). There are different types of agroforestry systems to maximize the production of trees and crop components such as agri-silviculture, silvi-pasture, horti-silviculture, agri-horticulture, boundary plantation which fulfil the multifunctional requirement of industries as well as local people (Bijalwan et al. 2019).Through contract farming with farmers and a minimum support price for tree species (Eucalyptus, *Casuarina, Melia dubia, Ailanthus excelsa, Neolamarkiacadamba*, etc.) wood-based companies are also promoting industrial agroforestry.The high genetic qualityand homogeneity of the clonal plants are superior and produce more yield as compared to the seed route plantation (Srinivas K., 2009).Thedemand for timber in India is expected to increase from 58 million cubic meters in 2005 to 153 million cubic meters in 2020, whereas its supply is projected to increase from 29 million cubic meters in 2000 to 60 million cubic meters in 2020(Parthiban et. al., 2021).Additionally, for increased net farm revenue in a shortened rotation period, the wood-based enterprises provide high-quality planting materials (mainly clones), specific silvicultural methods, harvest and post-harvest technology.Over the course of its more than ten-year journey, value chain-based agroforestry marketing has seen the establishment of over 80,000 ha of organized agroforestry plantations in collaboration with a several wood-based industries and other cooperation members. This has allowed the supply of more than 10 lakh tones of wood from farmers to these industries while also ensuring sustainable frameworks for the raw material availability materials and agroforestry promotion. (Parthiban et. al., 2021);According to estimates, productivity levels were often less than 10 m3/ha/annum because of poor genetic resources and a lack of implementation of precision silvicultural packages. Utilizing HYSR clones, miniclonal technology, precision silviculture, and the multifunctional agroforestry model has increased productivity levels in the value chain system from 25 m^3/ha/year to 40 m^3/ha/year depending on the species deployed in agroforestry promotion. This intervention has also reduced the felling age to the levels of 18 to 24 months for pulpwood species and 48 to 60 months in the case of plywood species, which has created a significant impact on agroforestry promotion among the farming community (Parthiban et al. 2021). Home gardens are described as a system for growing a variety of plant species that can be close to the house or a short distance away and is conveniently accessible. Woody plants have an essential role in household gardens, contributing to and enhancing the various opportunities for diversification of livelihoods (Yakub et al. 2014).

The participation of wood-based industries is become more beneficial for agroforestry by providing quality planting material (clones), good silvicultural techniques, and also found positive for procurement of raw materials obtained from agroforestry farms (Saravanan and Berry, 2021).

Table 1. Traditional and commercial Agroforestry system in India (Chavan et al., 2015)

Types of AFS	State	Area (in ha.)	Species
Traditional agroforestry			
Alder-cardamom	North East India	34	*Alnus nepalensis*
Kangayam Agroforestry	Tamil nadu	384	*Acacia leucophloea*
Homegarden	Kerla	1330	Mix tree species
Khejri based agroforestry system	Rajsthan	1586	Prosopis cineraria
Commercial Agroforestry			
Pulpwood agroforestry (Paper)	Punjab, Haryana, UP, Andhra Pradesh, Gujrat, TN	657	Eucalyptus, poplar, casuarina and subabool
Timber based agroforestry	Kerla, Maharashtra, TN, and MP	1700	*Tectona grandis*
Willow based agroforestry	J&K, Himanchal Pradesh, Uttarakhand and Punjab	137	Salix Species

Silvipastoral system

The agroforestry in which, grasses and fodder tree/ timber trees are grown simultaneously in same piece of land at a particular time is known as silvo-pastoral system. Tree (fodder/timber) is the main primary component of this system while, grass is secondary. This system has been practiced at the livelihood and promoting agriculture and animal husbandry also (FRTC, 2019). Suitable tree species should be planted according to climatic and edaphic factor with together grass for moisture conservation and, tree should also supply adequate fodder/timber such as *Darbergia sissoo, Leucaena leucocephala, Gmelina arborea, ficus*species etc. whereas, grass species such asNepier, molasses, khus, agave etc (Quli et al. 2017).Production in arid, semi-arid, and hilly areas, trees and shrubs frequently give significant volumes of leaf fodder during the lean season by tree lopping/pruning, also known as top feed. (Handa et al. 2016) and is usually also rich in protein, vitamins and mineral like calcium.

Agri silviculture

This one is the traditional system where locally multipurpose trees and crops are grown in this system simultaneously in the same land unit at various temporal and spatial arrangements (Deshmukh et al 2016; FRTC 2019). This system provides a favorable growing condition for the undergrowth crops as well as yield like fodder and wood etc, in this environment crops performed better than the sole cropping system. The multipurpose tree includes *Mangifera indiaca, Tectona grandish, Azadicrecta indica, Butea monosperma, Eucalyptus Spp.*etc, whereas

agriculture crops like Soybean, Groundnut, Black gram, Cotton, etc. can be grown in the field for self-consumption (Pathak, 1993; Bhoyar et al. 2016). Fodder from trees obtained from leaves, and pods. The Local environment conditions, initial age of the tree, looping intensity, and species of tree are mainly responsible for forage yield (Handa et al. 2016).

Agri-silvi-pastoral system

This system is a modified system of silvipastoral system (Quli et al. 2017) in which some agriculture crops intercrops with tree and pasture. In this system trees, crops, pasture, and animal husbandry is practiced in the same land unit simultaneously and sequentially (FRTC, 2019). This system promotes agriculture, pasture cultivation, and rearing of goats, cows, and other farm animal and provides fuel wood as well as timber woods. For the agri-silvi-pasture system, the selection of crops and trees should be as farmers choice depends upon the agroclimatic zones and local market demand (Bijalwan et al. 2019). The use of tree species encourages some local varieties with exotics species, should not be allelopathic effects on crops (Quli et al. 2017). The planting of trees on farmers land timber, fruit, fuelwood were the most important products while other hands fodder and live fencings also provided (Aalbaek, 2004).

Similarly, several other agroforestry systems can be practiced as wood production as well as livelihood security of farmers in which tree produce wood and fruit tree, and helps to animal husbandry, apiculture, fisheries, piggery and other lots of activities. The agroforestry namely such as horti-silviculture, home garden, horti-agriculture, agri-silvi-horticulture, silvofishery,agro-horti-silvi-pastoral system etc.Numerous small-scale industries that work with wood and wood-based productssupported agroforestry, enhances farmland forested areas, and increase employment opportunities (Handa et al. 2016).

Other benefits from the agroforestry system:

Fruit and medicinal through agroforestry

Agroforestry is an important source for fruit and medicinal plant conservation. There is much agroforestry system by nature of components, which helps to the production of fruit and medicinal plant cultivation and simultaneously provides wood for small farmers households such as horti-medicinal, silvi-horticulture model, agri horticulture, etc.In home gardens, rural people manage a small garden in which they grow fruits and vegetables and medicinal and aromatic plants (B.N. Ragmi, 2003). The sustainable production of fruit, fodder and fuelwood are obtained by horti-silviculture system and it also helps to extend profits from other secondary sources like lack cultivation in *Ziziphus* plant, sericulture in *Morus alba*, and honey production (Quli et al. 2017)

Agroforestry for fodder and firewood/fuelwood production

For improving livestock productivity and supply of fodder and food security agroforestry is a viable option. In the agroforestry system, a woody tree species can also subsidizefodder requirements through leaf and fruits such as *Darbergia sissoo, Leucaena leucocephala, Gmelina arborea and Salix spp.*, etc.and gives fuelwood (Pathak, 1993). Trees grown in

Case Study

Table 2.Some important case study on agroforestry research review

Researchers	Agroforestry component	Outcome of research	Study Area
Subrahmanyam M.V.R., Bheemaiah G., and Ismail S.	Dalbergia Sissoo with Sunflower and Castor	Mean seed yields of sunflower and castor (438 and 486 kg/ha) were not influenced by the growth of sissoo when compared with seed yields of respective sole crops (448 and 477 kg/ha) and Tree growth determined by height and girth was greater in association with intercrops during the entire experimentation period. During the first year, the height increment of sissoo in intercropping was almost double that of sole sissoo.	Hyderabad
Pandey C.B., Pandya K.S., Pandey D., and Sharma R.V.	*Acacia nilotica* and Paddy	The Maximum yield of paddy (606 g/m^2) at 25 m and was lowest (339 g/m^2) at 2m distance from the tree trunk.	Bilaspur (C.G.)
PhimmavongSomvang, Maraseni T.N., Keenan R.J.,	Eucalyptus with Rice and Casava	All Agroforestry models were highly profitable with positive NPV under a 12% interest rate, and Internal Rates of Return (IRR) ranging from 17% to 20%. The Eucalyptus-rice model generated the highest returns, with 21% of the NPV going to the local rice farmer.	Lao PDR
Chand Subhash, Sikka A.K., Singh D.V., Ragupathy and Sundrambal P.	Eucalyptus, Acacia, Potato, Geranium based agroforestry system	The net return was ranges from Rs. 1.95 to 3.15 lakhs per ha. from different treatments in eucalyptus-based agroforestry system and it was highest in the case of potato with eucalyptus. Since raising livestock helps sustain livelihoods in hilly locations, growing grass and legumes as an intercrop can be	Tamil Nadu

		another way to supply the demand for fodder in agroforestry systems.	
Chavan S.B. and Dhillon R.S.	Poplar, sorghum-berseem and cowpea–wheat	The study resulted in 10 × 2 m spacing of poplar with sorghum–berseem crop rotation exhibiting the highest net returns (Rs 1,191,241 ha^{-1}), NPV @ 12% discounting (Rs 409,673 ha^{-1}), B: C ratio (1: 2.22), IRR (70%), highest land equivalent ratio (2.28) and land expectation value (Rs 2,242,372 ha^{-1}).	Hisar, Haryana
Nautiyal S., Maikhyuri R.K., Semwal R.L., Rao K.S. and Saxena K.G.	Three types of agroforestry system	In monetary terms, highest per ha annual output was obtained from simultaneous agroforestry (Rs 25370, Rs 35 = US$1) followed by home garden (Rs 18200) and sequential agroforestry (Rs 9426).	Garhwal Himalayan
Dwivedi R.P., Kareemulla K., Singh R., Rizvi R.H., and Chauhan J.	*Acacia Nilotica, Populasdeltoides, Eucalyptus, And Azdirechtaindiac*	The net return from tree produce ha-1 per annum in traditional system was Rs. 989, 541 and 440 for marginal, small and medium farmers, respectively. In commercial region, B:C ratio has been found higher (3.00) for poplar based agrisilviculture than poplar (2.84) and eucalyptus (2.68) based bund system.	Uttar Pradesh
Vishwanath S., Chetan K., Shrivastav A., Joshi G., Sowmya C., Joshi S.C.	*Bamboo Brandisii and Ginger*	Bamboo at 6 m x 6 m spacing intercropped with ginger had the highest NPV (Rs. 497,517.94 at 10% and Rs. 146,927.09 at 15%) and LEV (Rs. 206,194.12 at 10% and Rs.147,477.66 at 15%).	Karnataka
Saravanan S., Buvaneswaran C., Veeramani T., and Jayraj R.S.C.	Casuarina And Cotton	Casuarina and Cotton-based agroforestry system yielded 40t/ha pulpwood and 10 t/ha fuelwood resulting economic return of Rs 75,000 which was higher than the pure casuarina or	Tamil Nadu

		pure cotton yield.	

contour strips follow or scattered cropland can yield a large quantity of wood/ fuelwood and provide products and services that have economic, social, and environmental values (Akinnifesi et al. 2008).

Agroforestry for biodiversity conservation

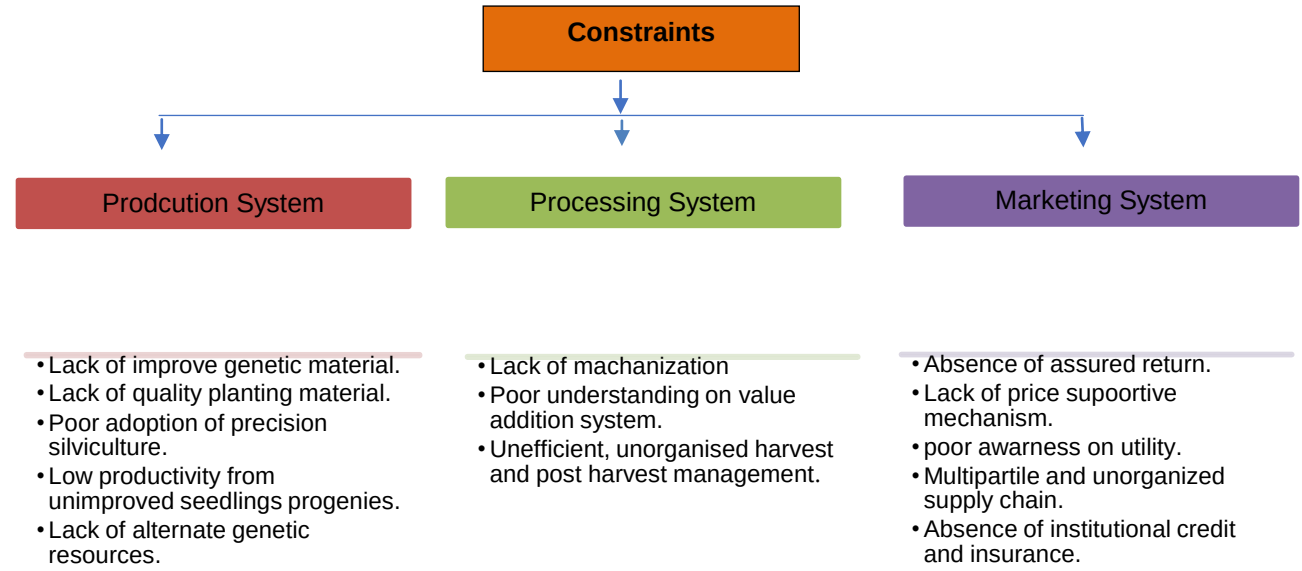
Agroforestry biodiversity is an approachable land-use system that plays a good approach to preserve biodiversity and provides multiple benefits to the farmers (FRTC, 2019). Generally, the agroforestry system is closer to the natural forest system helps to improve soil fertility, conserve from erosion, and enhance micro-climate properties. It helps to conserve biodiversity by providing habitat, germplasm preservation, and by providing other ecosystem services (Sahoo and wani, 2019). The agroforestry practices mitigate biodiversity loss and provide more chances for improving diversification and livelihood option for rural households (Kalaba et al. 2010)

Agroforestry for carbon sequestration

Agroforestry play a significant role in carbon sequestration because of its carbon storage potential through multiple plant species and their proper design and management can make the more effective source of carbon sink.Agroforestry systems can function as both sources and sinks of carbon. The average sequestration of carbon through agroforestry has been estimated as 9, 21, 50, and 63 Mg C per hectare in the semiarid, subhumid, humid, and temperate regions (Montagnini and Nair, 2004). The carbon sequestration potential or amount of carbon storage is depending upon the structure and function of various components within the systems put into practices such as species, locality, and climatic factors also (Sahoo and Wani, 2019).

Conservation of soil and water and efficiency of their use

Maintenance and enhancement of soil fertility play important role in food production as well as the sustainability of the environment. In small farmers farmland agroforestry contributes to the enhancement of soil fertility and food production by simultaneous cultivation of crops and trees, in which crops ensure food security and the tree produces biomass for future demand (Sahoo and Wani, 2019). In the agroforestry system, soil and water relationship are better compared to sole crops for water use efficiency, nutrient uptake, soil conservation, and Soil amelioration (Bijalwan et al. 2019). Several agroforestry systemshelp to maintain and enhancement of fertility and conservation of soil by acting as a physical barrier by the stem, upper and lower branchy root, and leaf litter against runoff of surface water and also increase water use efficiency by rapid infiltration of water through roots (Puri and Nair, 2004). Agro-silvipasture, horti-silviculture, silvopastoral, and other agroforestry systems, these types of alternative land use system are very effective for restoration of soil organic carbon and also regain the nutrient loss in shifting cultivation land through suitable species (Sahoo and wani, 2019). The principal management strategies in the home garden to increase



Source: Parthiban et. al. 2021

Fig. 1: Constraints in adoption of agroforestry system.

the soil fertility condition of the home gardens were widespread application of organic matter and manure application (Yakob et. al, 2014).

Major constraints to adopting wood-based agroforestry

The production of food, fodder, fuelwood, timber, mitigation of adverse impact climate change and livelihoods improvement supports through agroforestry system. Despite research and extension efforts during the last few decades, many farmers have still not adopted agroforestry technologies due to several difficulties, particularly lack of agroforestry extension works among the farmers (Dagar et al. 2012).

Conclusion

The continuously increasing population and decreasing availability of landholding in Famers and irregular weather conditions created huge pressure on sole cropping. To mitigate this situation appropriate institutional approach, research, and extension activities need to create awareness of rural peoples towards economic and environmental benefits ofthe agroforestry system.There are several highly valuable crops and trees which can be integrated into the agroforestry system to increase the livelihood of the rural communities. In this system, trees are preferred for obtaining fodder, fuel, as well as timber without affecting the income of farmers, and arable crops generate income from the very first season. The promotion of agroforestry by wood-based industries to reduce forest dependency is also the right direction towards forest conservation. These initiatives not only fulfill the domestic and economic requirements of rural peoples but also provide environmental benefits.

References

Aalbaek, A. Farmers' tree planting and access to germplasm in the southern highlands of Tanzania. *Southern African Forestry Journal*, *2001*; 191, 75-88.

Akinnifesi, F. K., Sileshi, G., Ajayi, O. C., Chirwa, P. W., Kwesiga, F. R.,

&Harawa, R. Contributions of agroforestry research and development to livelihood of smallholder farmers in Southern Africa: 2. Fruit, medicinal, fuelwood and fodder tree systems. *Agricultural Journal*. 2008; *3*(1): 76-88.

Bhoyar, S., Deshmukh, H., Mahajan, R., Sharma, N., Bohra, B., &Nalgel, D. N., Traditional agroforestry systems practiced in lower hills of Melghat region, Chikhaldara tehsil, Maharashtra, India. (2016).

Bijalwan, A., Verma, P., Dobriyal, M. J., Patil, A. K., Thakur, T. K., & Sharma, C. M. Trends and insights of agroforestry practices in Madhya Pradesh, India. *Current Science*. 2019; *117*(4): 597.

Brodt, S. B. Interactions of formal and informal knowledge systems in village-based tree management in central India. *Agriculture and Human Values*. 1999; *16*(4): 355-363.

Chand, S., Sikka, A., Singh, D., Ragupathy, R., &Sundrambal, P. Comparison of acacia and eucalyptus agroforestry system for hills: Tamil Nadu, India. (2015).

Chauhan, S. K., Sharma, R., &Dhillon, W. S. Status of intercropping in poplar-based agroforestry in India. *ENVIS Forest Bull.* 2012; *12*(1): 49-67.

Chavan, S. B., &Dhillon, R. S. Doubling farmers' income through *Populus deltoides*-based agroforestry systems in north-western India: an economic analysis. *Current Science*. 2019; *117*(2): 219-227.

Dagar, J. C. Utilization of degraded lands/habitats and poor-quality water for livelihood security and mitigating climate change. *Indian Journal of Agroforestry*. 2012; 14(1).

Dwivedi, R. P., Kareemulla, K., Singh, R., Rizvi, R. H., & Chauhan, J. Socio-economic analysis of agroforestry systems in Western Uttar Pradesh. *Indian Research Journal of Extension Education*. 2016; *7*(3): 18-22.

El-Lakany, H. Improvement of Rural Livelihoods: the role of Agroforestry. In *first world agroforestry congress*. 2004, June; Vol. 27: 1-4.

FRTC, Agroforestry System and Practices in Terai and Mid-hills of Nepal, Forest Research and Training Centre (FRTC), Ministry of Forests and Environment, Kathmandu, Nepal. 2019.

Handa, A. K., Toky, O. P., Dhyani, S. K., Chavan, S. B., Toky, O., & Dean, E. Innovative agroforestry for livelihood security in India. *World Agriculture*. 2016; *7*: 7-16.

Jain, S. K., & Singh, P. Economic analysis of industrial agroforestry: poplar (Populus deltoides) in Uttar Pradesh (India). *Agroforestry systems*. 2000; *49*(3): 255-273.

Kumar, B. M. Agroforestry's Potential for Meet Industrial Wood Requirement. *YOJANA*. (1997).

Nautiyal, S., Maikhuri, R. K., Semwal, R. L., Rao, K. S., & Saxena, K. G. Agroforestry systems in the rural landscape–a case study in Garhwal

Himalaya, India. *Agroforestry Systems*. 1998; *41*(2): 151-165.

Pandey, D.N. Multifunctional agroforestry systems in India. *Current Science*. 2007; 92: 455-463.

Parthiban, K. T., &Fernandaz, C. C. Industrial agroforestry-status and developments in Tamil Nadu. *Indian journal of Agroforestry*. 2017; *19*(1): 1-11.

Parthiban, K. T., Fernandaz, C. C., Sudhagar, R. J., Sekar, I., Kanna, S. U., Rajendran, P., and Kumar, N. K. Industrial Agroforestry—A Sustainable Value Chain Innovation through a Consortium Approach. *Sustainability*. 2021; 13(13): 7126.

Phimmavong, S., Maraseni, T. N., Keenan, R. J., & Cockfield, G. Financial returns from collaborative investment models of Eucalyptus agroforestry plantations in Lao PDR. *Land Use Policy*. 2019; *87*: 104060.

Puri, S., & Nair, P. K. R. Agroforestry research for development in India: 25 years of experiences of a national program. *Agroforestry Systems*. 2004; *61*(1): 437-452.

Quli, S. M. S., Islam, M. A., & Singh, P. K. Mitigating livelihood crisis through agroforestry interventions in rural India. *Jharkhand Journal of Development and Management Studies.* 2017; *15*(1): 7159-7178.

Sahoo, G., &Wani, A. M. Multifunctional agroforestry systems in India for livelihoods. *Annals of Horticulture*. 2019; *12*(2): 139-149.

Saravanan, S., & Berry, N. Agroforestry practices in Tamil Nadu, India–a boon for farmers for livelihood security. *Current Science*. 2021; *120*(4): 644.

Scherr, S. J. Building opportunities for small-farm agroforestry to supply domestic wood markets in developing countries. *Agroforestry Systems*. 2004; *61*(1): 357-370.

Srinivas, K. Eucalyptus based agroforestry system for improving the productivity of arable lands. *Ind. J. of Dryland, Agri. Res. and Dev*. 2009; *22*(2): 173-181.

Subrahmanyam, M. V. R., Bheemaiah, G., & Ismail, S. Potential Role of Dalbergia sissoo in Agroforestry Systems for Sustainable Rainfed Agriculture. *in India*, 58.

Yakob, G., Asfaw, Z., &Zewdie, S. Wood production and management of woody species in home gardens agroforestry: the case of smallholder farmers in Gimbo district, south west Ethiopia. International Journal of Natural Sciences Research. 2014; 2(10): 165-175.

Agroforestry in Karnataka - A golden opportunity for green growth: Book review

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Sri DipakSarmah, IFS (Retd.), is a well-known forest officer and very good writer on subjects related to forestry. The book "Agroforestry in Karnataka: A Golden Opportunity for Green Growth" is a great resource for learning about many agroforestry topics, especially because it describes how agroforestry has developed in the Indian state of Karnataka and the advancements that have been made there recently. The difficulties faced by many stakeholder groups, including farmers and foresters, as well as many other insights, are skillfully organized into fifteen chapters and eight annexures.

In this book's preface, it is stated that after years of learning from a forester, the trees in the kitchen garden that his father had grown to know via his childhood memories of Shillong took on new dimensions.The first five chapters are general in nature and connect agroforestry with basic forestry aspects. The first chapter introduces basic concepts such as agroforestry, farm forestry, and the benefits of agroforestry, but the second chapter is more focused on the evolution of agroforestry in Karnataka and describes major tree planting programmes outside of forests. World Bank-funded social forestry projects (1983–1992), Raising of seedlings for public distribution (RSPD), Eastern Plains Forestry and Enviornment Project (EPFEP), VanasamvardhaneYojane, Karnataka Sustainable Forest Management and Biodiversity Conservation Project (KSFMBC), and Krishi Aranya ProtsahaYojane (KAPY) are some of them. It also mentions the basics of the National Agroforestry Policy, 2014, and the Submission on Agroforestry (SMAF).

Chapter three and four tries to explain the relationship between forestry and agroforestry. In the third chapter titled on role of agroforestry in forest conservation pointing the conservation aspects along with the statics of forest cover in Karnataka and progress of raising plantations by the Karnataka Forest Department. It emphasis agoforestry and farm forestry can play a vital role by making available most of the biomass needs of the population including firewood, fodder, small timber and NTFPs.Forest cover, tree cover, and agroforestry are the major discussion topics in the fourth chapter, and the author provides forest cover and tree cover statistics from 2001 to 2019 in a chronological manner. Added to that, land use and land cover classification by the Karnataka State Remote Sensing Application Center (KSRSAC) are also mentioned. It provides valuable background information to various stakeholders interested in tree planting and agroforestry.

Chapters 5, 7, 8, 11, and 12 attempt to establish a healthy relationship between agroforestry and agriculture development in Karnataka, with a special focus on various allied branches of agriculture such as horticulture, sericulture, animal husbandry practices, and apiculture.

With relation to agroforestry, particularly in the interior of Karnataka and the eastern plains, chapter six discusses the significance and implications of water conservation. The author also offers some appropriate trees and shrubs for planting strips along the natural water courses because he might broaden the perception that a tree cover ensures protective environmental functions like soil fertility maintenance and restoration, erosion control, soil and moisture conservation, and maintenance of biodiversity.

Agroforestry is portrayed in Chapters 9 and 10 within the Karnataka state's geographical background. In the ninth chapter, a description of the Malanad region and the statistics of recorded forest area, forest cover, crop land, and horticultural and agricultural/agroforestry plantations were mentioned cover, crop land, and horticultural and agricultural/agroforestry plantations were mentioned. It provides an excellent overview of the region's potential and constraints for further agroforestry expansion. The author also indicated some suitable models and tree species for the Malanad region. However, he kept some interesting information about the introduction of cocoa in the Dakshina Kannada district in the same chapter for curious readers. In a similar spirit, chapter ten was offered, but it discusses the interior of Karnataka and the eastern plains, as well as the GI-tagged Devanhallipomelo and the superfood *Moringaoleifera* (Nugge), all of which are explained in straightforward terms for the common person to understand.

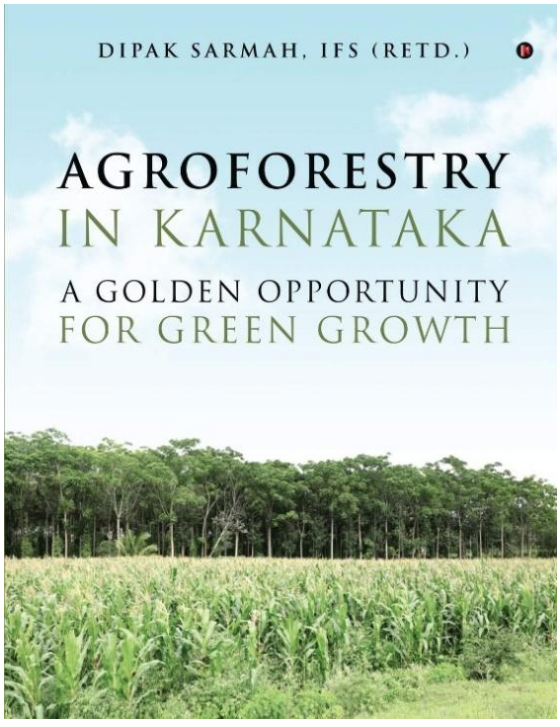
Agroforestry needs to become a farmer-centric activity, and various stakeholders like the Forest Department, Agriculture Department, and Watershed Development Department need to promote agroforestry through proper interventions. In this regard, the author explains the legal hurdles to the promotion of agroforestry in the thirteenth chapter. Felling permission and transit requirements were mentioned in the light of the Karnataka Preservation of Trees Act (KPTA), 1976, and he also pointed out some critical comments. This chapter piques the interest of every reader because the prosperity of trees on farmlands is ultimately dependent on tree harvesting and marketing. In the concluding paragraph of this chapter, the author mentioned similar farmer-friendly and practical acts like the Kerala Promotion of Tree Growth in Non-Forest Areas Act, 2005, and also suggested that the Karnataka Forest Department may have a look at it.

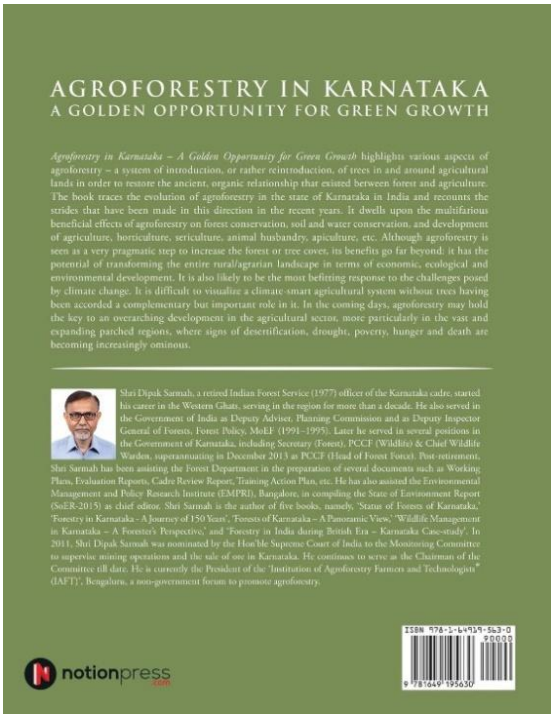
Chapter 14 gives an overarching idea regarding the marketing of agroforestry products. The author briefly discussed wood and non-wood forest products, as well as their marketing aspects. Marketing information for economically important trees such as rosewood and sandalwood is of great interest to medium- and large-sized farmers. The suggestions from the author for solving the marketing issues are very pragmatic and innovative.Chapter fifteen summarizes all of the chapters and

provides a very nice conclusion indicating the importance of promoting agroforestry throughout the state of Karnataka.

Eight annexures pertaining to the book's main topic are included by the author after the conclusion; these annexures are also quite helpful. The first annexure is a general piece by Mr. Michael A. Gold, while the second one sheds some insight on the accomplishments of the prestigious KrishiArantaProtsahaYojane tree planting initiative of the Karnataka Forest Department (KAPY). It is highly helpful for those who are new to the agroforestry field. The forest cover change matrix from 2005 to 2019 is provided in chronological order in Annexure 3. Knowing the state's historical tendencies is essential for putting good programmes in place going forward. The most significant annexure in light of the interests of farmers and foresters is Annexure 5, which provides information on tree species that are exempt from both felling and transit. Major agroforestry models used and suitable in Karnataka, such as block plantations, row/line planting, strip planting, alley cropping, cluster planting, random planting, and bund planting, were mentioned in Annexure four. Good pictures of various agroforestry practices and information on farmers are provided in Annexures 7 and 8. Those who are interested in agroforestry may find this useful because they can get in touch with the relevant farmers to learn more about agroforestry.

“Agroforestry in Karnataka: A Golden Opportunity for Green Growth” provides comprehensive, first-hand information on agroforestry practices and systems in Karnataka. The geographical and historical perspectives on the development of agroforestry in Malnad, Karnataka's interior, and its eastern plain region are thoroughly discussed, and also provide insight into the many statistics related to agroforestry. In a few of the chapters, the author explains why agroforestry is the offspring of forestry and agriculture and demonstrates how these two sectors can coexist harmoniously for the benefit of all people. From the viewpoint of a farmer, only the simplest explanations are provided for matters like marketing and policy concerns relating to the harvesting of tree crops.The annexes also offer some crucial details for those who are truly interested in agroforestry. In general, it's a great resource for understanding the fundamentals of agroforestry in the state of Karnataka.





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Mulberry (*Morus* spp.) - A potential source of herbal medicine

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In recent years, plants have become increasingly popular as sources of physiologically active chemicals with anti-inflammatory, anti-oxidant, anti-diabetic, anti-cancer, and weight-loss properties. Mulberry (*Morus* spp., Moraceae) is a multipurpose tree farmed for its fresh fruits, silkworm-rearing foliage, and animal food in times of famine. There are about 68 species of the genus *Morus*, while the most well-known species are the red mulberry (*Morusrubra*), black mulberry (*Morus nigra*), and white mulberry (*Morus alba*). Mulberry species can be found in tropical, subtropical, and temperate climates all around the world. On the other hand, the majority of the plants are found in Asian countries, including China, Japan, Korea, and India. Mulberry is a well-known plant for its therapeutic properties. Leaves, flowers, fruits, stems, bark, and roots are all utilized in herbal therapy to treat a variety of ailments. Mulberry has long been used in Asia as a traditional medicine for the treatment of a variety of infections and internal disorders. It contains a high concentration of bioactive chemicals that can benefit human health.

Figure 1 : Health benefits products of mulberry plant

Many scientists have studied the pharmaceutical properties of mulberry plants, reporting that many biochemical compounds such as hydroxymoricin, kuwanol, albafuran, albanol, calystegine, moranoline, and morusin are isolated from mulberry plants and play an important role in the pharmaceutical industry. Mulberry plants' therapeutic characteristics have been discovered for their lucrative medicinal worth, attracting the attention of pharmaceutical research and industry. However, due to a lack of an established and defined technique for its examination, it has yet to be formally or scientifically recognized. Numerous studies have been conducted using modern biotechnological tools to investigate the relationship between the active ingredients in mulberry and their biological activities in order to resolve ambiguities in their mechanisms of action, potentially opening a new horizon in traditional Chinese medicine with the potential for modernization in the near future. Mulberry's potential nutritional and medicinal properties have piqued researchers' interest since the ancient Chinese Material Medica lists many of the fruit's medicinal virtues. Mulberry consumption has been shown to provide nutritional value and health advantages in recent studies. Mulberry's functional components, primarily polysaccharides, anthocyanins, alkaloids, phenols, and flavonoids, have been well investigated. These bioactive chemicals frequently have a diverse variety of physiological effects. Mulberry is thus a medicinal and nutritional plant that poses no risk to the consumer's health (Wen et al., 2019).

Mulberry leaves have been used in antibacterial, antiviral, antiobesity, antidiabetic, and antioxidant treatments for a long time in Chinese medicine to treat fevers, protect the liver, strengthen joints, improve eyesight, and modulate endritic cell maturation. Sugars, quercetin, rutin, amino acids, vitamins, volatile oils, and microelements found in mulberry leaves have a wide range of pharmacological effects, including lowering blood glucose, anti-hyperlipidemia, hypertension, bacteriostatic properties, and antiviral properties. Mulberry leaf-derived powders, extracts, and capsules are now available commercially as functional foods and nutritional supplements for weight management and blood glucose control (Ramesh et al., 2014). Mulberry leaf water-alcohol extracts have been shown to have the strongest antiviral activity against human coronaviruses and contain components that are beneficial in the treatment of diabetes. Furthermore, they include chemicals that can lower SARS-CoV-2 infection and potentially delay the disease's progression toward severity or death in individuals. Among these, flavonoids stand out (Thabti et al., 2020). Mulberry leaf tea is also high in antioxidants and has been shown to lower cholesterol and triglycerides, as well as inflammation (Kim et al., 2010).

Mulberry fruit that has reached full ripeness has a delectable, tempting flavour as well as a pleasing aroma and flavor. It is prized for both direct consumption and the development of value-added products. Mulberry fruits are noted for having a high nutritional value, making them healthy for humans. Mulberry fruits also include a variety of nutritional components that are important to human metabolism. Carbohydrates, fats, proteins, vitamins,

minerals, and fibers are all abundant in M. alba fruit. Mulberry fruit has been utilized in Chinese traditional medicine for many years, and it is also eaten as a cuisine in many Asian and African countries. Mulberry fruit includes various bioactive phytochemicals that have health advantages and can combat a variety of ailments, in addition to their high nutritional content. Mulberry fruit's bioactive polysaccharides, anthocyanins, flavonols, phenolic acids, alkaloids, and melatonins have drawn the attention of many researchers. These chemicals have antioxidant capabilities, and as a result, they have direct or indirect curative activity on diabetes, inflammation, cancers, hepatic disorders, immunomodulation, hyperlipidemia, brain damage, and chronic diseases, either synergistically or in their pure form. The high bioactivity of mulberry fruit extract may open up new opportunities in the culinary and pharmaceutical industries (Zhang et al., 2018).

Flavonoids, mulberrofuran, betulinic acid, umbelliferone, scopoletin, α-amyrin, ß-sitosterol, essential oils, tannins, and other compounds are found in the bark of the mulberry root as well as the stem. Mulberrin, mulberrochromene, cyclomulberrin, cyclomulberrochromene, morusin, cyclomorusin, and oxydihydromomsin are examples of flavonoids. According to the People's Republic of China's Pharmacopoeia (2000 edition), bark has therapeutic properties such as reducing heat from the lungs, alleviating asthma, and causing dieresis. Mulberry bark extracts have been shown to be anti-hyperlipidemic, anti-inflammatory, and anti-mobility (Chan et al., 2016).

Despite these numerous uses for mulberry, the international community's recognition of mulberry as an herbal medicine for natural or alternative remedies remains low. The information available about mulberry is insufficient to justify its widespread use. The lack of these study data is due to a lack of sufficient or approved research techniques for evaluating mulberry as well as national health care policies. As a result, using current science and technology to standardize and manage the quality of mulberry and its components is vital. It is critical to educate scientists about the therapeutic properties of mulberry.

References

Chan, E., Lye, P. and Wong, S. (2016). Phytochemistry, pharmacology, and clinical trials of *Morus alba* L. *Chinese Journal of Natural Medicines*,**14**:17-30.

Kim D, Man-Jin I, Hee-Jeong C. (2010). Preparation of Mulberry Leaves Tea and Its Quality Characteristics. *Journal of Applied Biological Chemistry*,**53**:56-59.

Ramesh, H., Venkataramegowda, S. and Murthy. (2014). Antioxidant and medicinal properties of mulberry (*Morus* sp.): A Review. *World Journal of Pharmaceutical Research*,**3**:320-343.

Thabti, I. Albert Q, Philippot S, Dupire F, Westerhuis B, Fontanay S, Risler A, Kassab T, Elfalleh W, Aferchichi A and Varbanov M. (2020) Advances on antiviral activity of *Morus*spp. plant extracts: human coronavirus and

virus-related respiratory tract infections in the spotlight. *Molecules*, **25**(8):1876.

Wen P, Hu TG, Linhardt R J, Liao ST, Wu H. and Zou Y X, (2019). Mulberry: A review of bioactive compounds and advanced processing technology.*Trends in Food Science & Technology*, **83**:138-158.

Zhang, H. Feei M Z, Xiaoqin L. and Xinli L (2018). Effects of mulberry fruit (*Morus alba* L.) consumption on health outcomes: A Mini-Review. *Antioxidants (Basel, Switzerland)*,**7**(5):69.

Acrocarpus fraxinifolius Arn.: A potential indigenous multipurpose tree for agroforestry

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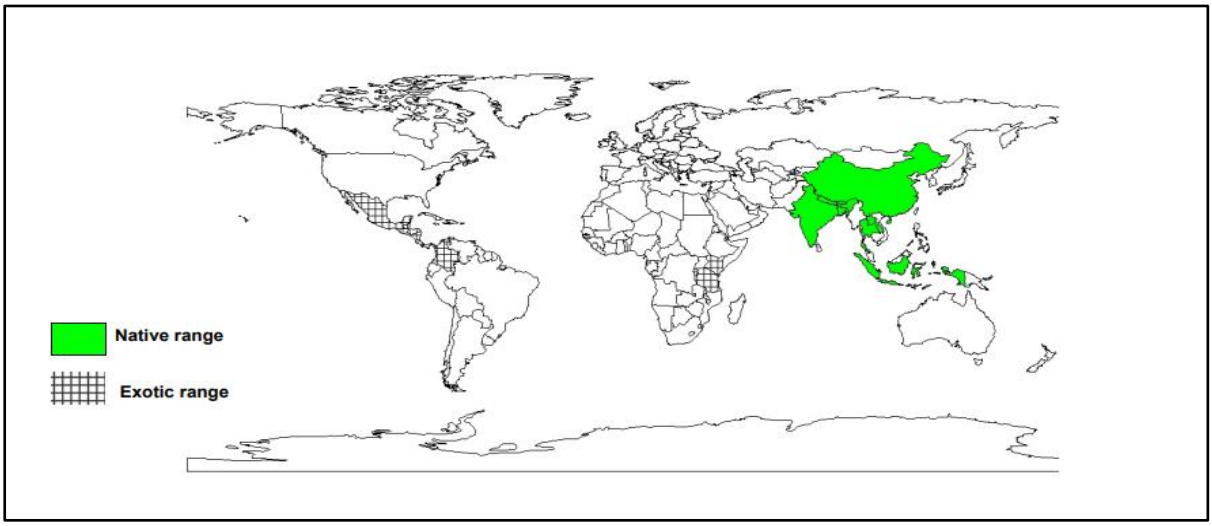
Introduction

Acrocarpus fraxinifolius Arn. is a large deciduous tree with buttresses that can grow up to 40 metres tall in the wild. It is a leguminous tree and belongs to the Fabaceae family (Das et al., 2022). Pink cedar, Indian ash, Mundani (Hindi), Tokphal (Marathi), malai-k0konrai (Tamil), Karangadi (Malayalam), and Hantage (Kannada) are some of its common names. Its synonyms are *Acrocarpus combretiflorus*and *Acrocarpus grandis*. The circular crown has ascending branches, whereas the straight trunk has spurs. The leaves are bipinnate and about 30 cm long, with 3–4 compound leaflets made up of 5–6 pairs of elliptical, lance-shaped leaflets that are each 7–10 cm long. The leaves are bright red when they are young, giving the tree its distinct appearance. The wood is strong and hard, with a low to medium economic value, and is used to make furniture, build homes, manufacture furniture, create packing cases, planks, rafters, and so on (Nath et al. 2011). When compared favourably to exotics such as Silver Oak, it generally sprouts naturally from seeds or coppices within coffee plantations under appropriate ecological conditions (Vishwanath et al., 2018).

Species distribution

The species is native to the tropical regions of Asia and is distributed in countries like Bangladesh, Bhutan, China, India, Indonesia, Laos, Myanmar, Nepal, and Thailand. It is introduced to a few countries, such as Colombia, Guatemala, Honduras, Kenya, Malawi, Mexico, Nicaragua, Panama, Taiwan, the Province of China, Tanzania, Uganda, and Zimbabwe (Orwa et al., 2009). In India, it grows in Assam, Meghalaya, Arunachal Pradesh, Sikkim, Uttarakhand, West Bengal, Tamil Nadu, Karnataka, Kerala, and Odisha; it was also introduced to Punjab and Andhra Pradesh. Acrocarpus fraxinifolius is the only species of the genus Acrocarpus in India and grows well in sub montane areas in the sub humid and humid regions, and it grows naturally in evergreen forests of the western Ghats on hill slopes until 1220 m. Regeneration happens primarily in very small, open patches where fresh soil is exposed and through newly constructed roads. It is a pioneer, frost-sensitive, and light-demanding, but in its younger stage, it can tolerate slight shade. It grows well in moderate-altitude regions with red soil and a moist climate (Kumar et al., 2013).



(Reference: http://apps.worldagroforestry.org/treedb2/AFTPDFS/Acrocarpus_fraxinifolius)

Characteristics of *Acrocarpusfraxinifolius* for agroforestry

Acrocarpusfraxinifolius is widely used as a naturally grown shade tree among the various tree species in coffee plantations in evergreen forest patches (Manjunatha et al., 2017). *A. fraxinifolius* is chosen for plantations in highly degraded soils overexploited with cattle grazing for better establishment. It doesn't contain nitrogen-fixing nodules, even though it is a leguminous tree and a deep-rooted plant.

The criteria of the Multipurpose trees(Owino, 1992)

Aspects of Agroforestry systems

(a.) It should be Compatible with alternate crops (both below and above the ground)

(b.) Special products and services (e.g., fodder, fuelwood, fruits, nitrogen fixation)

(c.) Tree management requirements in specific agroforestry systems

(d.) Species should be Free from pathogens (including those of alternate crops)

Adaptability considerations

(a.) Species has to be adaptable and show good growth performance in broad agro ecological zones

(b.) Species can be adaptable to specific soil conditions (e.g., Acidic soils) and constraining soil water regimes (e.g., drought resistance in arid lands)

Cultivation practices of species

Soil requirements

It grows in light to medium-textured soils with slightly acidic to neutral soils.

Propagation

In India, wildlings are used for the growth of *Acrocarpus fraxinifolius*, as it is propagated through seedlings, direct sowing in sight, and cuttings. Direct sowing in lines or patches up to 900 metres of elevation in West Bengal was successful, with plants growing to 3.6–6.1 metres in 2.5 years. To ensure successful natural regeneration of this light-demanding species, the forest floor is raked to clear weeds, and then the canopy is gradually evacuated as young trees are being established. This species regenerates quickly in burned areas and areas where

Major Agroforestry systems and practices involves *Acrocarpusfraxinifolius*

Major Agroforestry systems and practices	*Description*	Reference
Silvipasture	*Acrocarpusfraxinifolius*with *Leucaena leucocephala* and *Cassia siamea*.	Neil, 1990
Agri-horti-silviculture	Banana and Bean are intercropped between *Grevillea robusta, Acrocarpusfraxinifolius, Calliandracalothyrsus, Leucaena diversifolia, Cedrela serrata, Albizia chinensis*	Akyeampong et al. 1995
Traditional Agroforestry System	*Syzygiumcumini, Acrocarpusfraxinifolius,Grevillea robusta*, and *Aporosalindleyana* along with coffee plantations	Manjunatha et al. 2017
Traditional Agroforestry System	*Erythrinasuberosa, Dalbergia latifolia, Ficus racemosa, Grevillea robusta*along with coffee plantations	Manjunatha et al. 2017
(Agri-silviculture) Traditional Agroforestry System	Coffee under traditionally managed fast growing native trees in Coorg, Karnataka	Vishwanath S et al. 2018
Agri-silviculture	Coffee under *Dalbergia latifolia*, *Ficus racemosa* and *Acrocarpusfraxinifolius*	Maheswarappa et al. 2022

soil has recently been exposed. Coppicing easily and expanding very quickly (1.3–3 m per year), coppices produce a high quantity of seeds, many of which germinate under parent canopies to form substantial monospecific stands at the expense of native plant and animal species.**Seeds**

The seeds show orthodox storage behaviour, as seeds must be stored at low temperatures, as they lose viability easily. Only a few seeds survive 7 years of storage at room temperature. The number of seeds per kilogram is about 13000–47000. At the time of the establishment of seed orchards, patch budding is used, and 80% success is being recorded. Germination is sporadic, that is, after 10–30 days of good pre-treatment.

Pre-sowing treatment

Seeds should be pre-treated with sulphuric acid or hot water and vinegar for 10 minutes.24 hours of soaking were followed by sowing in a shaded bed. After the pre-treatment, 80–95% germination is attained in a period of 2–7 days. Under natural circumstances, some seeds can germinate in as little as a week, while others must first remain dormant for a year. In full sunlight, three-month-old seedlings that are between 30 and 45 cm tall are planted. It coppices vigorously and has a rotation period of 8–10 years for fuel wood and 30–40 years for timber. Until

the young tree's crown closes, regular tending operations are carried out. They are well developed despite the fact that they need to be weeded frequently up until sapling stage; thinning is a necessary procedure for its optimal growth because it needs a large crown; it is initially carried out 3–4 years after plantation; and it is thought to be a very good species for the restoration of open sites (Orwa et al., 2009).

(Source: https://www.google.com/search?q=acrocarpus+fraxinifolius)

(A) Mature Tree (B) Flowers (C) Pods (D) Plantation *of Acrocarpus fraxinifolius*

Tending operations

Acrocarpusfraxinifolius is avery fast-growing tree species, as it acquires rotation at the ages of 8–10 years for fuel wood and 30–40 years for timber. Pollarding is only possible when the plant is young. The species requires little weeding and clearing because it tolerates shade well in its early stages and can quickly push through weeds. However, fencing is recommended to prevent sambar and deer damage and browsing. Climbers can be cut, which is good for the crop. The first thinning must be done when the trees are between 3 and 5 years old. Regular thinning must continue until the stand is completely mature since the trees need a broad crown for optimal development.

Uses

The sapwood and heartwood are very decorative, as they are whitish and bright red to brownish red, respectively, with dark veins. Due to its ease of use, it is excellent for turning, carving, and polishing. The wood is used for furniture, cabinetry work, interior panelling, and trim. In the native range of this species, it is used for shingles, general construction, floors, stairways, doors, tea crates, beehive frames, and, after being impregnated, for railway ties. When these trees are felled, their wood releases a gum-like resin (Orwa et al. 2009). It is a kind of tree that makes good fodder, provides nectar, and is a good forager for bees. By reinforcing riverbanks and stabilising terraces, it can prevent soil erosion. In South India, it is a perfect species for coffee and tea plantations as a shade tree and is also used as a windbreak. The tree's wood is often used to make furniture, cabinets, and tea boxes. Despite being used to make paper pulp; the wood is thought to be inadequate for that usage. Due to its vibrant, fresh foliage and wonderful flower arrangement, in the tropics, the tree is sometimes planted as an attractive plant when its leaves are absent. Fast-growing and naturally colonising, the species is chosen for reclaiming and replanting disturbed and degraded ecosystems (Dasetal., 2022).

Medium-density particleboard (MDP) for dry use applications can be made using *Acrocarpusfraxinifolius* along with Pinus wood, or even just *Acrocarpusfraxinifolius* wood (Reis, 2020). The leaves of *Acrocarpusfraxinifolius*exhibit an anti-inflammatory effect due to presence of lipoidal content (AbouZeid et al., 2011). Due to its robust taproot, it has been suggested for use in preventing erosion. Mulching is a good use for leaves. When a tree is cut or felled, it emits a resinous substance like gum (Ashwath et al., 2020).

References

AbouZeid A.H., Soliman S.M., Mohammed R.S., Sleem A.A., and DakroryElY.M., (2011). Anti-inflammatory effect and lipoidal content of *Acrocarpusfraxinifolius* Wight &Arn leaves. Planta Med 2011; 77 - PL8.

Akyeampong, E., Hitimana, L., Franzel, S. *et al.* The agronomic and economic performance of banana, bean and tree intercropping in the highlands of Burundi: an interim assessment. *Agroforest Syst* **31**, 199–210 (1995).

Ashwath, M. N., B. N. Satish, G. M. Devagiri, R. K. Hegde and Hareesh, T. S. 2020. Variation in Growth Traits of *Acrocarpusfraxinifolius* Wight

&Arn Populations in Southern Karnataka, India. Int.J.Curr.Microbiol.App.Sci. 9(08): 1838-1843.

Das PK, Sahoo T, Kamila PK, Panda PC. *Acrocarpusfraxinifolius*Arn. (Leguminosae-Caesalpinioideae), a tree species new to flora of Odisha. Species, 2022, 23(71), 161-164

Kumar, S., Gupta, N. K. & Mahajan, P. K. (2013) Effect of diameter and plant spacing on growth of *Acrocarpusfraxinifolius* under mid hill conditions of Himachal Pradesh, Indian Journal of Agricultural Sciences; 84 (2): 218-23.

Maheswarappa, V., Vasudeva, R. & Hegde, R. *Circa situm* conservation of coffee

Neil, P. E. (1990). Notes on *Acrocarpusfraxinifolius*. *BankoJan akari*, *2*(4), 391-394.

Orwa, C., Mutua, A., Kindt, R., Jamnadass, R., Anthony, S., (2009) Agroforestree Database: a tree reference and selection guide version 4.0. World Agroforestry Centre, Kenya

Owino, F. Improving multipurpose tree and shrub species for agroforestry systems. *Agroforest Syst* **19**, 131–137 (1992).

agroforests: farmer's perception in Kodagu landscape of Karnataka, India. *Trop Ecol* **63**, 104–112 (2022).

Manjunatha, M., Devakumar, A. S., Nivedita, M. & Kushalappa, C. G. (2017) carbon stock present in dominant tree species of coffee-based agroforestry system, International Journal of Agroforestry and Silviculture; Vol. 5 (5), pp. 311-314.

Nath, C. D., Pélissier, R., Ramesh, B. R., & Garcia, C. (2011). Promoting native trees in shade coffee plantations of southern India: comparison of growth rates with the exotic *Grevillea robusta*. *Agroforestry Systems*, *83*, 107-119.

Reis, A.H.S.; Silva, D.W.; Scatolino, M.V.; Mendes, R.F.; Mendes, L.M. Technological features of medium density particleboards produced with *Acrocarpusfraxinifolius* in association with *Pinus oocarpa*. Mat Int 2020, 2, 0465-0471

Vishwanath, S., Lubina, P. A., Subbana, S. & Sandhya, M. C. (2018) Traditional Agroforestry Systems and Practices: A Review, Advanced Agricultural Research and Technology Journal; Vol II, Issue I.

Insights into the sustainable agroforestry system of tropics-homegardens

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Introduction

Ever since the human life began on earth his major aim was to fulfil his stomach hence, in the initial days he used to hunt and gather the food. Later on, he started to cultivate the crops nearby his settlements. As the human civilization got evolved, simultaneously agriculture also got improved. It witnessed its booming success during the golden era of 1960s i.e., green revolution. World's hunger crisis was solved with the advent of new hybrid crops developed during green revolution. However, this success came out with a huge price – underground water depletion, loss of nutrients, increased use of pesticides, insecticides resulted in polluting soil, water, crops, etc. Thus came a very need of crop diversification and agroforestry is one such solution. Agroforestry is a collective name for land-use systems involving trees combined with arable crops and/or animals, where woody perennials are deliberately used on the same land management system as agricultural crops and/or animals, in a spatial or temporal sequence, there being both ecological and economic interaction between the components (Kumar, 2016). In 1987, P.K. Nair classified the agroforestry system on the basis of structural, functional, socio-economic and ecological aspects and homegardens are one such sustainable agroforestry practice which comes under Agri-silvi-pastoral system. They are the intimate, multi-storey combinations of various trees and crops, sometimes in association with domestic animals, around homesteads (Kumar, B. M. 2008).It is known by various names across the world - Puriyada Krishi (Kerala), Baree (Assam), Kandyans (Sri Lanka), Chaggas (East Africa – Mt. Kilimanjaro), Pekarangans, Talun-kebun (Indonesia), etc.

Distribution of homegardens

Homegardens are usually practiced in the areas of warm humid climate with high rainfall. They are spread across the tropics from America in the west to Indonesia in the east.Countries of South and South-East Asia i.e., Philippines, Thailand, Sri Lanka, India and Bangladesh practice homegardens. Sudan, Ethiopia, Nigeria, Kenya, Tanzania, Mt. Kilimanjaro etc. are those prominent regions of African continent where homestead practices are followed.While coming to American continents, Peruvian-Amazon homegardens, Brazilian homegardens, Mexican, Guatemala, Honduras, Nicaraguan and Costa Rican homegarden make an important part around homesteads. However, due to the lack of boundaries between homegardens and the

Structures of some prominent Homegardens across the globe

S.No.	Homegarden	Number of Strata	Species in each stratum
1	Kerala Homegarden	3-4	**Lower strata (<1.5m):** Herbaceous food crops, forage, medicinal crops E.g., Tomato, Cauliflower etc. **Middle strata (1.5m-5m):** Fruit trees and spice crops. E.g., Banana, Guava etc. **Upper strata (>5m):**Tall trees/Palms E.g., Coconut, Teak, Mahogany, Cashew etc.
2	Andaman Homegarden	5	**Lowest strata (<2m):** E.g., *Curcuma longa, Zingiber officinalis, Manihotesculenta*, Pineapple etc. **Second strata (2-5m):**E.g., Cinnamon, Nutmeg and Clove **Third strata (5-10m):**E.g., Mango, Cashew nut and Tamarind **Fourth strata (10-15m):**E.g., Arecanut and Jackfruit **Fifth strata (15-20m):**E.g., Coconut
3	Javanese Homegarden	4-5	**Lowest strata (<1m):**Vegetables and Medicinal crops. E.g., Cabbage, Sweet potato etc. **Second strata (1-2m):**Food plants. E.g., Cassava, Banana, Papaya, Yam etc. **Third strata (2-5m):**Fruit trees. E.g., Guava, rambutan, mango, and mangosteen etc. **Fourth strata (5-10m):**Medium sized trees such as *Moringa oleifera and Sesbania grandiflora.* **Fifth strata (>10m):**fully grown timber and fruit trees.E.g., *Anacardiumoccidentale, Artocarpus hirsutus, Psidiumguajava, Mangifera indica,*
4	Brazilian Homegarden	3	**Lowest strata (1-3m):**Medicinal and Fruit trees E.g., *Psidiumgujava, Annona squamosa, Jatropha molissima* etc. **Middle strata (3-7m):**Combination of species with multiple uses. E.g., *Tabebuia sps, Myracroduronurundeuva*etc. **Upper strata (7-12m):** Fruit and timbers. E.g., *Prosposis juliflora, Anacardiumoccidentale, Erythrinavelutina, Schinopsisbrasiliensis, Anadenantheracolubrina*etc.
5	Thailand	4	**Shrubs and ground cover (<1m):**Different species of

Homegarden	shrubs and grasses. **Understorey layer (1-5m):**Diverse fruit trees. **Canopy layer (5-10m):**E.g., Mango, tamarind, jack fruit, coral tree, Indian trumpet flower and plum mango **Emergent layer (>10m):**E.g., Coconut, arecanut, bamboo and teak.

Source: (Kunhamu, T. K. 2018)

adjoining agricultural fields it is difficult to determine the exact extent of homegardens. Yet some efforts have been made across the world to understand the distribution of homegardens. Kerala has around 4.32 million HGs equivalent to 1.33 Mha. In Sri Lanka around 60% of the land holdingsand in Philippines, 70% of all households maintain homegardens (Sangakkaraet al., 2016).Extentof some important homegardens across the globe are: Indonesia-5.13 Mha; Java-1.74 Mha; Bangladesh-0.54Mha; Srilanka-1.05 Mha; India- 1.44 Mha; Africa- 1,20,000 ha (Kumar et al., 2017).

Carbon sequestration under homegardens

As we all know that trees absorb CO_2 from the atmosphere through the process of photosynthesis and eventually store in biomass and soil as organic matter. Natural forests which act as the prominent potential sink for the carbon are under extreme pressure. Thus, agroforestry is one such solution to tackle this problem. It is estimated that under different ecological conditions, an agroforestry system has the potential of accumulating 0.29 to 15.21 Mg ha^{-1} $year^{-1}$ of carbon above ground and 30-300 Mg C ha^{-1} $year^{-1}$up to 1 meter depth in the soil (Kumar, B. M. 2006). Agroforestry can reduce CO_2 via three main mechanisms i.e., carbon sequestration, carbon conservation and carbon substitution. Homegardens are among those unique agroforestry practices in which above all 3 mechanisms are relevant when compared to other practices. On a comparative scale homegardens sequester C much better than intensively managed crop lands. For example, cropped land after slash and burn showed CS values 39 to 52 Mg C $ha^{-1}year^{-1}$while that of Javanese and Sumatran homegardens sequestered 55.8 to 162.7 Mg C ha^{-1} $year^{-1}$(Kumar, B. M. 2006). The C stocks of landscape increased on an average of 10 Mg C ha^{-1} during a period of 20 years, when all sun-coffee systems were converted to shade-coffee systems. Homegardens are similar to young secondary forests in terms of carbon storage.

Benefits of homegardens

Tropical Homegardens are known as epitome of sustainability**.** Plant products harvested from homegardens improve the family's nutritional status, health, and food security**.** A large number of fruit-producing trees are an integral part of many tropical HGs. They act as the daily source of carbohydrates, proteins, vitamins, minerals etc. to households. Eg: Banana (Vit-C); Guava (Vit-C); Mango (Vit-A, E, C) etc. Root vegetables like that of potato, sweet potato, taro, cassava, yam etc. provide carbohydrates in fair amount. Beans, seeds and nuts are the rich source of protein and oils.They are the source of income for poor rural and urban

households around the world. E.g.: In South and Southeast Asia, from 6 to 54% of the total household income come from homegardens**.** HG also serves an important role in the conservation of rare and endemic species. E.g.: *Brugmansia arborea* and *Platycladus orentalis* which are near threatened species were found in the tribal homegardens of Kerala (George et al 2020).They also play a prominent role in providing ecosystem services like that of carbon sequestration, improvement of water quality, recreation, climate amelioration, biodiversity conservation, enhancement of soil fertility etc. Homegardens also make a substantial contribution to the supply of medicinal plants, which may be traded or consumed locally by the family or community. For e.g.: 95 medicinal plant species were observed in the homegardens of four ethnic groups in Thailand (Panyadee et al.,2019).

Role of women in homegardens

Women play an important role in introducing many crops, particularly in HG.The role of women in home garden management depends on several factors like their occupation, size of the Homegardens, opportunities for off-farm jobs and socio-economic condition of the family. Since this is an unpaid labor, it is not given due value, and is not included in any statistics and thus become invisible.Almost 50% of the rural households in the hills were headed by women as the men folk migrated to augment the farm income in Bhimtal block of Nainital District, Uttarakhand, India (Gariya et al., 2016). While in Garhwal region of Uttarakhand, primary roles of women were crop management (74.8% of households) and harvesting (55.7%), with smaller role in marketing (36.6%) (Kumar et al., 2017).

Carbon stocks of some prominent land use systems in the tropics

S. No	Land use practice	Duration (years)	Carbon stock(Mg C ha^{-1})
1.	Pastures	4 to 12	27 to 31
2.	Cropping after slash and burn	2	39 to 52
3.	Secondary forests, Sumatra	30	86
4.	Panama Teak plantation	20	120.2
5.	Sumatran homegarden	13.4	55.8 to 162.7
6.	Natural forests, Indonesia	120	500

Source: (Kumar, B. M. 2006)

Threats to homegardens

Present status of homegardens across the globe is under vulnerable situation. They are facing several threats and their extent is declining every year. Commercialisation and Urbanisation is one of the major threats affecting homegardens worldwide. E.g., highest number of ornamental species was found in the homegardens of Hassan district of Karnataka (Kumar et al, 2022). In another example, *Aquilariamalaccensis* which is a commercial species dominated the homegardens of Assam (Saikia et al, 2012). Some of the other threats which are posing to homegardens include: fragmentation of land holdings, change in

the food habits, dependence on modern medicines, climate change and outbreak of pests & diseases, introduction of exotics etc.

Conclusion and suggestions

Homegardens agroforestry system is playing a key role in reducing pressure on natural forests and acting as a source of livelihood.However, during the past few years there has been a decline of HG's due to several factors. Thus, they need to be studied much in detail for the purpose of their conservation and development. Government should launch some policies in favour of HG's.Autecological and synecological properties of plant components, plant-plant interactions, economics of homestead farming, resources management and utilization and other aspects are yet to be studied systematically.Homegardens are testing grounds of many innovations of the gardeners, and today's gardens of long standing are a result of such continuous innovation and improvement.

References

Bargali, K. (2015). Comparative participation of rural women in agroforestry home gardens in Kumaun Himalaya, Uttarakhand, India. *Asian Journal of Agricultural Extension, Economics & Sociology*, *6*(1), 16-22.

Gariya, K., Dwivedi, G. K., Kumar, V., Kumar, A., & Tewari, S. K. (2016). Socio-economic Characteristics of Homegardens in Bhimtal block of Nainital District, Uttarakhand, India. *International Journal of Agriculture, Environment and Biotechnology*, *9*(6), 1001-1013.

George, M. V., & Christopher, G. (2020). Structure, diversity and utilization of plant species in tribal homegardens of Kerala, India. *Agroforestry Systems*, *94*(1), 297-307.

Kumar, B. M. (2006). Carbon sequestration potential of tropical homegardens. *Tropical homegardens: A time-tested example of sustainable agroforestry*, 185-204.

Kumar, B. M., & Nair, P. K. R. (2006). *Tropical homegardens* (p. 377). Dordrecht: Springer.

Kumar, B. M. (2008). Homegarden-based indigenous fruit tree production in Peninsular India. In *Indigenous fruit trees in the tropics: Domestication, utilization and commercialization* (pp. 84-99). Wallingford UK: CABI.

Kumar, V., & Tiwari, A. (2017). Importance of tropical homegardens agroforestry system. *International Journal of Current microbiology and applied sciences*, *6*(9), 1002-1019.

Kunhamu, T. K. (2018). Tropical homegardens. *Agroforestry Theory and Practices; Raj, AJ, Lal, SB, Eds*, 365-375.

Kunhamu, T. K. (2021). Homegardens as sustainable land use practice: Prospects and Challenges.

Kumar, G. M., &Shiddamallayya, N. (2022). Documentation of Plant Species in Homegardens of Three Physiographic Regions of Hassan District, Karnataka. *Indian Journal of Ecology*, *49*(2), 570-581.

Panyadee, P., Balslev, H., Wangpakapattanawong, P., &Inta, A. (2019). Medicinal plants in homegardens of four ethnic groups in Thailand. *Journal of ethnopharmacology*, *239*, 111927.

SAIKIA1a, P., Choudhury, B. I., & KHAN1b, M. L. (2012). Floristic composition and plant utilization pattern in homegardens of Upper Assam, India. *Tropical Ecology*, *53*(1), 105-118.

Sagar, A., Kademani, B., &Bhanumurthy, K. (2013). Research trends in agricultural science: A global perspective. *Journal of Scientometric Research*, *2*(3), 185-185.

Sangakkara, U. R., &Frossard, E. (2016). Characteristics of South Asian rural households and associated home gardens-A case study from Sri Lanka. *Tropical Ecology*, *57*(4).

Dark diversity – the concept of absent species

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The study of interactions between animals and their environment forms the basis of ecology. Observed species richness, which historically relies on field surveys to tally the individual species, is the most often used measurement. Although observed diversity can provide valuable insights into the richness of species within a given site, it does not account for the absent part of the species pool that could potentially inhabit that site considering suitable environmental conditions and biogeographic history, that is, the dark diversity (Pärtel, Szava-Kovats, & Zobel, 2011; Fløjgaard et al., 2020)

Because dark matter serves as its inspiration, the phrase "dark diversity" was particularly chosen. Like dark matter, dark diversity cannot be directly seen or measured. Three researchers from the University of Tartu first coined the phrase in 2011, and according to their definition, "dark diversity" refers to species in the area that may theoretically live in specific ecological conditions in a local community but are not present in that community (PärtelSzava-Kovats, & Zobel, 2011). Dark diversity is part of the species pool concept, which is defined as a set of all species that are able to inhabit a particular site and that are present in the surrounding region or landscape. It has to do with the "filtered" or "habitat-specific" species pool, which only contains species that may propagate to and perhaps inhabit the research location. Similar to light diversity, dark diversity cannot be immediately seen when only the sample is seen, but it is there if a greater scale is considered. When appropriate data are available, its existence and properties can be estimated.

The importance of conceptualizing absent species in addition to observable species is emphasized by the recently formed notion of dark diversity, which places absences within the framework of the species-pool. The current understanding of ecology's absent species, particularly dark diversity, and how including both absent and observable species has a significant potential to further knowledge of how biological diversity is controlled and preserved (Lewis, R et al., 2017).

Applications of dark diversity

The idea of dark diversity can strengthen and supplement current strategies for prioritizing conservation efforts and making management decisions. Knowledge of dark variety can also be used to spot potential dangers to the effectiveness of restoration (Lewis, R et al., 2017). Understanding a region's dark diversity can help us predict the likelihood of the restoration's success. There is a chance that the extinct species will reappear if dark diversity in a region continues to be high. According to the theory, dark diversity species may have existed in an ecosystem and may do in the case that the restoration trajectory deviates from the plan, monitoring dark diversity

can aid in the initiation of preplanner adaptive management actions (Lewis, R et al., 2017).

It can be helpful to identify the most complete locations in various regions when prioritizing environmental conservation. Dark diversity of alien species, weeds and pathogens can be useful to prepare for future invasions in time.

Researchers can better understand the mechanisms and processes affecting specific populations or entire communities by quantifying dark diversity patterns and combining them with observed diversity patterns (Fløjgaard et al., 2020).

Numerous ecological processes are still poorly understood or cannot be predicted by observable patterns of species distribution;thus, it is important to identify which species are in the dark diversity, understand why they are absent, and consider the effects on community activities. It can be used to forecast future distributions of threatened species in a scenario of climate change, better understand species distributions assess the likelihood of successful species invasions, restore damaged habitats, and more (Fernandes et al., 2019).

Completeness index

Partel et al., (2013) recently formulated a "completeness index" (i.e., the completeness of a habitat or region relative to its respective species pool; completeness = log(observed diversity/dark diversity) (Lewis, R et al., 2017). Dark diversity is a useful tool for facilitating biodiversity comparisons across regions, ecosystems, and taxonomic groups. Community completeness, a relativized biodiversity indicator, can be derived from dark diversity. The proportion of species from the regional species pool that have dispersed to and established at a location following abiotic and biotic filtration is the broad definition of the community completeness index. Since community completeness takes into account the variation in species pool size and expresses biodiversity on a relative scale (Partel et al., 2013), it can provide a different aspect of biodiversity since patterns in observed species richness may mimic patterns in dark diversity e.g., exhibit a strong latitudinal gradient; For fungi plants and birds completeness showed no correlations to latitudinal gradients but strong relations to anthropogenic disturbance, greater completeness in areas with lower disturbance (Fløjgaard et al., 2020)

High completeness (i.e., high observed diversity and low dark diversity) within an ecoregion coupled with high irreplaceability and vulnerability indicate an area should have a high conservation priority (Lewis, R et al., 2017)

Estimation of dark diversity

Despite being challenging, estimating dark diversity is nevertheless possible (Lewis et al., 2016). A significant area of ecological research nowadays is modelling species distributions, which originated in conceptual models based on expert opinion. The constraints of static niche models can be partially overcome by emerging methodologies for dynamic mechanistic species distribution models.The models offer just as much information on species absences even though they are frequently viewed in terms of species occurrences. However, there are even more comprehensive methods for

anticipating species absences. Lewis et al., (2016) show that species co-occurrence patterns can be used to estimate dark diversity with a respectable level of accuracy. The species pool was determined by patterns of co-occurrence across taxa with similar evolutionary relationships. Therefore, if a missing species often co-occurs with an observable species that is present in the community, it is considered to be a member of the species pool (Lewis et al., 2016; Fernandes et al., 2019).

Assuming that species with similar ecological needs and biogeographic histories will have similar likelihoods of being present at a particular site, the species pool is typically estimated using species co-occurrence patterns with Beal's smoothing (Fløjgaard et al., 2020). There are several techniques that can be used to separate environmentally acceptable species. Environmental niche modelling is applicable to a wide range of species. You can employ professional judgement. Information about species' preferred habitats, such as bird nesting areas, is available in literature. According to Ellenberg, this may also be quantitative, as in the case of plant species indicator values.

Reference

Fernandes, C. S., Batalha, M. A., &Bichuette, M. E. (2019). Dark diversity in the dark: a new approach to subterranean conservation. Subterranean Biology, 32, 69.

Fløjgaard, C., Valdez, J. W., Dalby, L., Moeslund, J. E., Clausen, K. K., Ejrnæs, R., ... &Brunbjerg, A. K. (2020). Dark diversity reveals importance of biotic resources and competition for plant diversity across habitats. Ecology and Evolution, 10(12), 6078-6088.

Lewis, R. J., de Bello, F., Bennett, J. A., Fibich, P., Finerty, G. E., Götzenberger, L., &Pärtel, M. (2017). Applying the dark diversity concept to nature conservation. Conservation Biology, 31(1), 40-47.

Lewis, R. J., Szava-Kovats, R., &Pärtel, M. (2016). Estimating dark diversity and species pools: an empirical assessment of two methods. Methods in Ecology and Evolution, 7(1), 104-113.

Pärtel, M., Szava-Kovats, R., & Zobel, M. (2011). Dark diversity: shedding light on absent species. Trends in ecology & evolution, 26(3), 124-128.

Pärtel, M., Szava-Kovats, R., & Zobel, M. (2013). Community completeness: linking local and dark diversity within the species pool concept. Folia Geobotanica, 48(3), 307-317.

https://en.wikipedia.org/wiki/Dark_diversity

https://envirobites.org

Agroforestry: A tool for wasteland reclamation

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Introduction

The wasteland designates degraded, underused, uncultivated, and common land as (a) areas not suitable for agriculture, barren wastes; (b) other uncultivated land other than fallow; (c) culturable waste; and (d) fallows beneath wastelands. According to different patterns of land usage, many departments describe the wasteland. Wasteland is defined by the National Wasteland Development Board (NWDB) as "Land that is degrading owing to poor water and soil management, on account of natural causes, and degraded fields that might fairly be brought under vegetative cover and that are now underutilized." The reclamation of wasteland includes a variety of development measures, including clearing land, conserving soil and water, improving nutrient status, installing irrigation systems, and more. The existing state of wastelands, however, displays great geographical variability in terms of their potential for agriculture. Therefore, in order to develop a workablereclamation-cum-development plan for the wastelands, it is imperative to conduct a scientific assessment of the current status of the waste lands dispersed across various agro-climatic zones of the state, including fertility, erosion levels, soilconditions, water potential, suitable cropping systems, etc. Therefore, rehabilitating wastelands via sustainable management benefits soil by providing a better cover and promotes the growth of new trees (Kumar et al., 2015).

Extent and distribution of wastelands

According to the Wasteland Atlas of India 2015, India's wastelands cover around 63.85 million hectares of land. The National Remote Sensing Agency of the Department of Space estimates that 16% of India's geographical area is considered to be wastelands. Thirteen types of wastelands are classified as follows: gullied and/or ravenous land, underutilized/degraded notified forest land, mining/industrial waste land, barren rocky/stony waste/sheet rock area, land with or without scrub, steep sloping area, snow covered and/or glacial area, degraded pastures/grazing land, degraded land under plantation crops, sands inland/coastal, waterlogged and marshy land, land affected. There are 114.01 million hectares (ha) of degraded and wastelands in India as a whole. The area affected by water erosion is 23.62 M ha, whereas the area affected by wind erosion is 8.89 M ha.

Causes of Wasteland

Fig1: Causes of wasteland

Method of wasteland reclamation

Integrated Wasteland Development Project (IWDP) follows up some activities which help in reclamation of wastelands.

- Afforestation of degraded forest and non-forest wasteland.
- In situ soil and moisture conservation measures like terracing, bunding, trenching, vegetative barriers and drainage line treatment.
- Planting and sowing of multi-purpose trees, shrubs, grasses, legumes and pasture land development.
- Encouraging natural regeneration.
- Promotion of agro-forestry & horticulture.
- Wood substitution and fuel wood conservation measures.
- Encouraging people's participation through community organization and capacity building.
- Drainage Line treatment by vegetative and engineering structures
- Development of small water Harvesting Structures.
- Development and conservation of common Property Resources.

Waste land development schemes

Till the sixth five-year plan, no specific programme of wasteland development was taken up. It is only in1985 with establishment of NWDB that the problem of wasteland development received a new thrust. With the setting up of NWDB, a number of new schemes were initiated to secure people‘s participation, besides

continuation of ongoing afforestation schemes.

- Decentralized People's nurseries
- Silvipasture farms
- Seed development
- Area oriented fuel wood and fodder projects
- Ariel seeding programme
- Plantation of minor forest produce
- Margin money schemes
- Rural employment scheme

Role of agroforestry in wasteland reclamation

Either Agroforestry is the deliberate integration of woody perennials with arable crops and/or livestock simultaneously or sequentially.Agroforestry systems are biodiverse and have a great deal of promise for reclaiming abandoned land thanks to the varied tasks carried out by system's many parts. Agroforestry activities can ease resource-use strain on natural conservation areas and are potential means of mitigating deforestation, Carbon sequestration, forest degradation. Leguminous multifunctional trees that can withstand poor soil conditions are planted in agroforestry systems as a management strategy for restoring degraded land. Throughthe addition of organic carbon, nitrogen enrichment by nitrogen fixation through nitrogen-fixing tree and shrubs, and improvement of physical conditions of soil such as water holding capacity, permeability, drainage, etc., agroforestry has the potential to improve the physical, chemical, and biological conditions of soils (Kumar et al., 2021).Release and recycling of nutrients through biochemical nutrient cycling, increased microbial associations, and the addition of root biomass, moderate effects on extreme soil acidity and alkalinity conditions, the creation of a more favorable microclimate through the effect of windbreaks and shelterbelts, and a lowering of the water table in areas with high water tables. In order to meet the demands of low-resource farmers by restoring and boosting land productivity, agroforestry techniques such

Fig 2: Ravine's restoration through agroforestry

Climate change (Nasamet al., 2022) and the use of Multi-Purpose Tree Species

(MPTs), relay-cropping, terracing and contour cultivation, strip and alley cropping are applicable.

Agroforestry for soil fertility improvement

The fertility of the soil is crucially maintained through agroforestry (Garima et al., 2021). Trees utilize a component of the biosphere that annual crops or animals often do not, which increases the creation of aggregate biomass. The soil's physical qualities, such as structure, porosity, and water holding capacity, can all be improved by trees' significant additions of organic matter and nutrients. Trees can also change the soil's temperature through shadowing and litter cover. Because tree roots penetrate parts of the soil profile (B and C layers) and collect nutrients that may not be available to annual crop root systems, agroforestry encourages a more effective cycling of nutrients. After that, these nutrients go to the sections of the plant that are above ground (i.e., leaves, branches, stem etc.).In an agroforestry system, leaf litter increases soil fertility by adding organic matter, slows down the raindrops as they fall, and aids in water infiltration into the soil's bottom layers. Leguminous tree species have the ability to increase soil fertility and save soil water because nitrogen fixation, biomass transfer, and long- or short-term fallow periods are all effective ways to increase soil fertility.

Agroforestry for erosion control

In agroforestry, trees and shrubs serve as both primary and secondary erosion control measures. By littering and pruning, increasing soil cover is one of the direct functions. Other direct functions include providing partially permeable hedge grow barriers, facilitating the gradual development of terraces through soil accumulation upslope of hedge grows, and enhancing soil resistance to erosion through the preservation of organic matter. The other roles include using the area that conservation projects occupy for productive purposes and supporting earth constructions through root systems. The country's dry and semi-arid regions are particularly susceptible to wind erosion, which is remedied by agroforestry systems like Windbreaks and shelterbelts. The protection area created by a wind breakis on both leeward (about 15-20 time of height of windbreak) and windward sides (about 2-5 times), where the wind speed is reduced by 20 percent below the incident wind speed.

Agroforestry forsoil moisture conservation

Through mulching, trees in an agroforestry system can reduce soil moisture loss and boost crop productivity. Under trees, soil moisture availability is higher than in open regions, and the agroforestry system improves the soil's infiltration properties, trapping more water and raising the soil's water content (Sharma et al., 2022). It is undeniably true that the agroforestry system enhances groundwater quality in comparison to cropping systems, where the majority of applied nutrients drain away and contaminate the groundwater. Agroforestry plants with deep roots eat extra nutrients sprayed to agriculture fields. Consequently, it serves as a filter, discharges water that contains fewer nutrients, and lowers groundwater contamination.

Selection of Species in Restoration of mined areas

Criteria	Tree species	Grasses
Native species Fast growing Ecologically viable Deep rooted Nitrogen fixing trees. Drought tolerant.	*Eucalyptus spp* *Grevillea pteridifolia* *Pongamia pinnata,* *Dalbergia sissoo,* *Erythrinasuberosa* *Bauhinia retusa* *Agave americana* *Leucaena leucocephala* *Acacia spp*	*Eulaliopsisbinata* *Pennisetum purpureum* *Saccharum spontaneum* Cenchruscillaris Cynodondactylon

Systems followed in ravine lands are:

- Agrisilviculture
- Agrihorticulture
- Silvo pastoral

Choice of Species in Restoration of Ravine areas

Agricultural Crops	Tree species	Fruit species	Grasses
pigeon pea (Cajanus cajan) Black gram (Vigna mungo)	*Eucalyptus tereticornis,* *Dendrocalamus strictus* *Leuceanaleucocephala*	lemon(*Citrus limon),* *Mango (Mangifera indica)* *ber(Ziziphus mauritiana)* *Amla(Emblica officinalis)*	*Dicanthiumannulatum,* *Cenchrus spp* *Panicum spp* *Pannisetum purpureum,* *Brachiariamutica*

Choice of Species in Salt affected soils.

Tree species	fruit species	grasses
Eucalyptus tereticornis, *Acacia nilotica,* *Albizia lebbeck,* *Terminalia arjuna,* *Prosopis juliflora* *Casuarina equisetifolia* *Tamarix articulata,* *Pongamia pinnata*	*Zizyphus mauritiana* *Punica granatum,* *Syzygium cumini,* *Emblica officinalis* *Tamarindus indica* *Aegel marmelos*	*Leptochloa fusca,* *Chloris gayana,* *Brachiaria mutica,* *Sporobolus spp*

Agroforestry for amelioration of salt-affected soil

The best management practices are agroforestry systems, which may considerably improve both the efficient use of soil salinity and the prevention of its spread. Since vegetation prevents water from evaporating, the region beneath it has less salinity. By lowering pH, EC, and ESP and raising CEC, organic carbon, and the soil's availability of nutrients including nitrogen, phosphate, and potassium, tree species physiologically improve the salty soil. Alkali soils may be prevented from further degradation and their health can be maintained by planting trees and grasses there. The pH and EC are reduced, the organic matter and fertility are increased, and the growth of trees on alkali soils is improved.Due to the accumulation of organic matter and the recycling of vital nutrients, nitrogen-fixing plants improve alkaline soils more quickly (Sharma et al., 2021). Excess soluble salts that are capable of alkaline hydrolysis can be found in alkali soils, which hinder agricultural plant development. Plantations that are 20–36 years old improved the alkali soils by decomposing their litter and roots, which resulted in a reduction of the soil pH and an increase in organic carbon and other readily available nutrients.

References

Nasam, M. K., Bheemareeddyvalla, V. R., Vainala, V., Bathula, J., &Bodiga, S. (2022). Influence of Assisted Natural Regeneration in Increasing Carbon Stocks of Tropical Deciduous Forests. *Environmentand Ecology*, *40*(1), 82-92.

Kumar, A., Kumar, V., Bisht, H. and Kumar, R. (2015). Reclamation of wasteland through different vegetative interventions.*Indian Forester*, 141(5): 538-548.

Garima, Bhardwaj DR, Thakur CL, Kaushal R, Sharma P, Kumar D, Kumari Y. Bamboo-based agroforestry system effects on soil fertility: Ginger performance in the bamboo subcanopy in the Himalayas (India). Agronomy Journal. 2021; 113(3): 2832-2845.

Sharma P, Singh MK, Tiwari P. Agroforestry: a land degradation control and mitigation approach. Bulletin of Environment, Pharmacology and Life Sciences. 2017; 6: 312-317.

Sharma P, Singh M, Verma K, Prasad SK. Soil weed seedbank under different cropping systems of middle Indo-Gangetic Plains. Plant, Soil and Environment. 2022; 68(11): 542-551.

Kumar R, Singh, J.K., Singh A.K., Minz S.D. and Kumar N.M. Boron management in green gram (*Vigna radiata* L. Wilczek) underCustard Apple (*Annona squamosa* L.) based agri-horti system in semi-arid region. Annals of Arid Zone. 2021; 60(3 & 4): 79–83.

Rapid assessment of butterfly diversity and nectar plants

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Introduction

Butterflies are the most underrated creatures we find around us. Documentation of theirvariety, numbers, behavior, feeding biology and life cycle has reached a stagnating halt. Despitethe average lifespan of a butterfly being merely 2-3 weeks, it provides a multitude of services tothe ecosystem in this short period. They are known to be an effective pollinators and indicators of a healthyecosystem. There are substantial evidences to suggest that tracking their migration are reliableindicators of climate catastrophes and regional-scale anomalies in weather. However, due to the sheer lack of knowledge on their conservation status and population dynamics, we may lose many species of butterflies from our ecosystem. Keeping this in mind, Forest College and Research Institute (FCRI), Hyderabad has initiated a "Butterfly Garden" in FCRI to protect, conserve and to create awareness about the importance of butterflies.

Fig 1: Butterfly Garden at FCRI, Hyderabad

The newly established butterfly (Fig 1) garden is located within the vast campus of Forest College and Research Institute (FCRI) Hyderabad. This butterfly garden has been meticulously designed after taking suggestions from various experts and analysis of the management of a few well-known butterfly gardens in the city

such as the ones within Sanjeevaiah Parkand Nehru Zoological Park. Keeping these functional butterfly gardens as models, host and nectar plants for different kinds of butterflies were deducedto fit for the Central Telangana conditions. The 2019 batch undergraduate students of FCRI laid all the groundwork for the garden preparation like the pilot enumeration of the butterflies in the campus and the related hostspecies.

The FCRI Butterfly Garden has been designed in a shape of a flower, wherein each petal has a different flowering nectar species. Nectar yielding plants such as *Duranta erecta, Stachytarpheta indica, Wedelia chinensis, Lantana camara, Jatropa integrifloria, Crotolaria juncea,* and *Plumbago zeylanicum* etc. are well known for attracting butterflies withtheir vibrant colour and plentiful amount of nectar. Besides this nectar yielding species, thereare a few important larval host species like *Murraya koenigii* (curry leaf), *Citrus limon* (Lemon), and *Saraca asoca* (Ashoka), which have been planted to facilitate egg laying and larval development of some major butterfly species in the area. Moreover, the path leading to the Butterfly Garden is covered with many nectar-yielding plants such as *Nerium oleander, Ixora coccinea, Galphimia speciosa, Catharanthus roseus, Bougainvillea spectabilis, Annona squamosa, Santalum album, Hamelia patens, Wrightia tinctoria, Tridax procumbens* and *Tagetes erecta*. The related figures are displayed from the figure 1-15. The center of thegarden (from where the petals radiate) was specially designed for mud puddling so that the butterflies get the necessary nutrients (Sodium and Potassium).

The butterfly garden has been built in an area where maximum amount of sunlight is available. This allows for the butterfly basking (Butterflies are ectotherms: they rely on external sources for body heat. So, they expose their wings to sunlight to absorb heat energy to maintain their body temperature). This newly established Butterfly Garden can be seen thriving with many Butterflies.

There is regular visitation of many butterflies from dawn to dusk as this butterfly garden (Fig 16-24) efficiently satisfies all the three major requirements *viz*., nectar, host, nutrients. It hosts a wide variety of butter flies including **Hesperidae** (Skippers): *Pelopidas mathis* (Variable Swift), *Spialia galba* (Indian Skipper); **Lycaenidae** (Blues): *Castalius rosimon* (Common Pierrot)- schedule-1(part-4), *Catochrysops Strabo* (Forget-me-not), *Talicada nyseus* (RedPierrot), *Zizeeria karsandra* (Dark Grass Blue) ; **Nymphalidae**: *Tirumala limniace* (Blue Tiger), *Danaus genutia* (Striped Tiger), *Danaus chrysippus* (Plain Tiger), *Acrea terpsicore* (Twany coaster), *Phalanta phalantha* (Common Leopard), *Euploea core* (Common Crow)-schedule-4, *Hemiargus ceraunus* (Ceraunus Blue) *Junonia lemonias* (LemonPansy), *Junonia almanac* (Peacock Pansy), *Junonia atlites*

Fig 2: *Nerium oleander*

Fig 3: *Ixoracoccinea*

Fig 4: *Ruspoliaseticalyx*

Fig 5: *Bougain villea*

Fig 6: *Tageteserecta*

Fig 7: *Catharanthus roseus*

Fig 8: *Catharanthus roseus*

Fig 9: *Lantana camara*

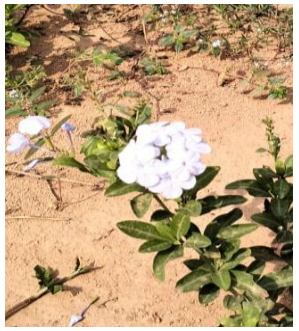

Fig 10: *Plumbago zeylanicum*

Fig 11: *Jatropha integerrima*

Fig 12: *Lantana camara*

Fig 13: *Galphimia speciosa*

Fig 14*: Stachytarpheta indica*

Fig 15: *Crotalaria retusa*

Fig 16: *Delias eucharis* (Common Jezebel)

Fig 17: *Danaus chrysippus* (Plain Tiger)

Fig 18: *Tirumala limniace* (Blue Tiger)

Fig 19: *Catochrysops Strabo* (Forget-me-not)

Fig 20: *Tirumala limniace* (Blue Tiger)

Fig 21: *Danaus chrysippus* (Plain Tiger)

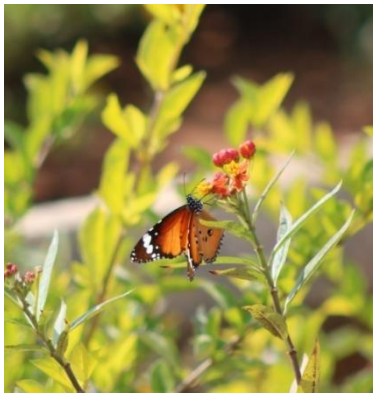

Fig 22: *Danaus chrysippus* (Plain Tiger)

Fig 23: *Pachliopta aristolochiae* (Common Rose)

Fig 24: *Catopsilia pomona* (Common Emigrant)

(Grey Pansy), *Junonia orithya* (BluePansy), *Junonia iphita* (Chocolate Pansy), *Melantis leda* (Common Evening Brown), *Melantis phedima* (Dark Evening Brown), *Hypolimnas misippus* (Danaid Eggfly)-schedule-1 (part-2), *Hypolimnas bolina* (Great Eggfly) ; Papilionidae (Swallow tails): *Papilio demoleus* (Common Lime), *Papilio polytes* (Common Mormon), *Pachliopta aristolochiae* (Common Rose), *Pachliopta hector* (Crimson Rose); Pieridae (Whitesand Yellows): *Delias eucharis* (Common Jezebel), *Cepora Nerissa* (Common Gull)-schedule-2 (part-2), *Catopsilia pomona* (Common Emigrant), *Catopsilia pyranthe* (Mottled Emigrant), *Eurema hecabe* (Common Grass Yellow), *Colotis danae* (Crimsontip), *Hebomia glaucippe* (Great Orange Tip), *Ixias Marianne* (White Orange Tip), *Ixias pyrene* (Yellow Orange Tip). Visitation sofavifauna (Purple Sunbird, Purple-rumped Sunbird, Green Bee-eater), Bees (Bumblebee, Honeybee) and Wasps have also been observed. Moreover, many ectotherms reach butterfly garden to bask in the sun.

In conclusion, a butterfly garden is a wonderful addition to any outdoor space. Not only it is a beautiful and relaxing area to enjoy, but it also plays an important role in supporting the butterfly population and the ecosystem as a whole. By providing food and shelter for butterflies, and creating a beautiful and inviting environment, a butterfly garden is a wonderful way to give back to nature.

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