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Agroforestry systems: Opportunities and challenges in India

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Abstract

Agroforestry, the integration of woody perennials with farming systems, has been practiced in India since time immemorial as a tradition land use system because it offers both economically and ecologically viable option to farmers and rural people community for large-scale diversification in agriculture to get supplement fuel, fodder, fruits and fibers on one hand and environment amelioration on the other hand. Despite Agroforestry's huge potential in India, the adoption rates are still low because there are several challenges that reap the benefits of agroforestry like shortage of superior planting material, insufficient research, lack of market infrastructure, cumbersome and frustrating legislation in respect of tree felling, wood transportation, processing. The adoption of National Agroforestry policy by the government of India in 2014 expected to remove these challenges as well as increases the farm productivity and the livelihood of the small and marginal farmers substantially in the future.

Keywords: agroforestry systems, challenges, opportunities, future, potential

Introduction

In the words of Lundgren and Raintree (1982) ^[10] "Agroforestry is a collective name for land use systems and technologies where woody perennials (trees, shrubs, palm, bamboos, etc.) are deliberately used on the same piece of land management units as agricultural crops and/or animals in some form of spatial arrangement or temporal sequences and there are both ecological and economical interactions between the different components". Agroforestry is not a new concept although it has been practiced in India for thousands of years (Puri and Nair, 2004) ^[13] on agricultural lands for different purposes like for food, fodder, fruit, firewood, medicinal trees, bio-fertilizer, Non-timber forest products (NTFP), shelter etc. (FSI, 2013) ^[7]. Agroforestry is a shining approach which merges century's old knowledge with modern science in a system and the concept of thinking small scale to achieve potentially big and transformative outcomes (Steiner, 2012) ^[17].

Today, Indian agriculture faces diverse challenges and constraint due to growing demographic pressure, increasing food, feed and fodder needs, natural resource degradation and climate change (Dhyani *et al.* 2013) ^[5] therefore a management system needs to be devised that is capable of producing food from marginal agricultural land and is also capable of maintaining and improving quality of producing environment (Dobriyal, 2014) ^[6]. Agroforestry is the only option because it has a tremendous potential to simultaneously offer both economically and ecologically viable option to farmers and rural people community for large-scale diversification in agriculture to get supplement fuel, fodder, fruits and fibers on one hand and stabilizing the ecosystems (increase the tree cover, production of timber and other wood products thus reduces the pressure on the forests) on the other hand (Bijalwan, 2013) ^[11].

Extent of agroforestry in India

In India, just as there is a great diversity in climate similarly there exists a large number of agroforestry systems of various forms and types (Dagar *et al.* 2014) ^[4] (Table 1). The accurate assessment of area under different agroforestry systems is quite difficult. A large number of researchers and agencies are continuously engaged to work out the accurate assessment of area under Agroforestry Systems. The current area under agroforestry in India is estimated as 25.31 million hectares or 8.2 percent of the total reporting geographical area of the country by Dhyani *et al.*, (2013) ^[5]; Dagar *et al.* (2014) ^[4] and CAFRI (2015) ^[2]. The estimation of FSI (2017) ^[8] shows lower values because it doesn't include many agroforestry systems like block plantations. The estimated physiographic zone-wise agroforestry area is given in Figure 1. Maharashtra, Gujarat and Rajasthan are the states having highest total agroforestry area as compared to other states (FSI 2017) ^[8].

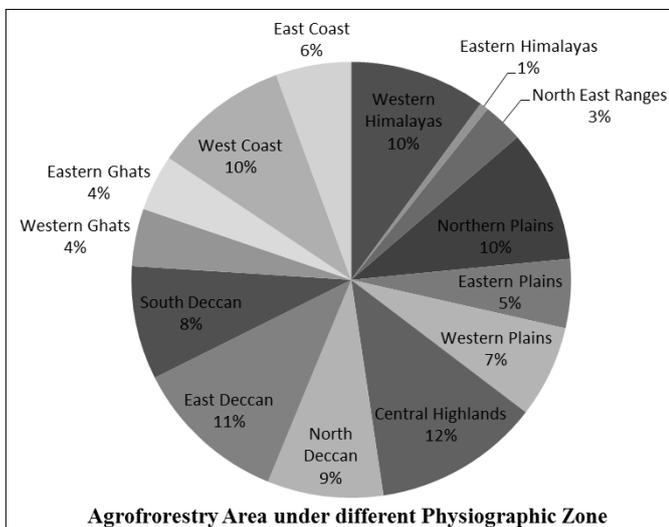
Table 1: Major Agroforestry systems followed in India (Recreated from Dagar *et al.* 2014 [4] and Puri and Nair, 2004) [13].

Agroforestry Systems	Agroecological region adaptations
Agrisilvicultural Systems	
Shifting Cultivation	In Tropical forest areas
Taungya	In all regions
Plantation-based cropping system	Mainly humid tropical regions
Scattered trees on farms, parklands	All regions, especially semiarid and arid regions
Shelterbelts and windbreaks	In wind-prone areas, especially coastal, arid, and alpine regions
Boundary Planting and live hedges	In all regions
Woodlots for soil conservation	In hilly areas, along sea coast and ravine lands
Industrial plantations with crops	Intensively cropped area in northern India.
Silvo-pastoral systems	
1. Silvopastures	Sub tropics and tropics with bio-edaphic sub-climaxes
Horti-pastoral	In hilly orchards for soil conservation
Tree on rangelands	In all regions
Plantation crops with pastures	Mostly humid & Sub-humid regions of south regions of south East Asia and South with less grazing pressure on plantation lands
Seasonal Forestry Grazing	Semi-arid and mountainous ecosystem
Agro-silvo-pastoral systems	
Home gardens	Mainly tropical region
Others	
Aqua forestry	Low Lands
Apiculture with trees	In all regions

79.42 million hectare which is 24.39 % of the total geographical area, but as per the National Forest Policy (1988) one third of country's geographical area must be under forest and tree cover. However, unfortunately, we have still a shortage of approximately 9% and, there is an urgent need for large-scale afforestation activities in the non-forest areas but it is very tough task for the developing countries like India. Perhaps, agroforestry is the only viable option to achieve the forest and tree cover to 33 percent of total geographical area of country. According to CAFRI (2015) [2] by 2050, there is a scope of increasing the area under agroforestry by another 28.0 M ha and thus a total of 53.23 M ha or 17.5 percent of country reported area under agroforestry. Most of this area will come from fallows, cultivable fallows, groves, degraded and wasteland and have the potential to change fortunes of small and marginal farmers and rural people by providing the resources to meet livelihood and food security along with the economic growth in the region (Singh and Dhyani, 2014) [15].

Table 2: Estimated area under different agroforestry systems in India (Dagar *et al.* 2014) [4].

Category	Area (million ha)	Remarks
Agroforestry in irrigated areas		
Agrisilviculture	2.63	Industrial use
Agrihorticulture	2.79	Fruit orchards/fruit tree based cropping systems
Tree on field boundary or bunds	1.58	Social forestry, live fences, etc.
Sub-total (A)	7.00	
Agroforestry in rainfed areas		
Agrisilviculture	2.40	Scattered trees on fields, bunds, boundaries
Agrihorticulture	1.86	Fruit orchards/fruit tree based cropping systems
Tree on field boundary or bunds	0.74	Social forestry, deliberate live fences, etc.
Silvo-pastoral	5.58	Trees on grazing/range lands
Sub-total (B)	10.58	
Other land uses		
Home gardens	2.42	Mostly in coastal areas and N-E states
Shifting cultivation	2.27	Mostly in NEH States, Orissa, Andhra Pradesh
Afforestation of problem soils	2.12	Plantations on salty soils, mine areas, etc.
Trees on community/common lands	0.92	On Panchayat lands, along roads, railways, etc.
Sub-total (C)	7.73	
Total Agroforestry area (A+B+C)	25.31	
Agroforestry as % of Total Reporting Geographical Area	8.28	

**Fig 1:** Physiographic Zone-wise Agroforestry area (Adapted from FSI 2017) [8]

Agroforestry opportunities in India

Agroforestry systems in India include both traditional and modern land use systems and have significant potential and use in many aspects like provides employment to rural as well as urban population through production, processing and value addition. According to an estimate, one hectare of the plantation in wood-based industries create about 450 man employment, thus, 30 million ha has the potential to create approximately 15,000 million man-days of employment besides creating job opportunities in wood based value chain (Singh and Dhyani, 2014) [15]. According to Forest survey of India (2017) [8]; current forest and tree cover in country is

Furthermore, agroforestry systems have potential to produce 100 million cubic meter timber/pulpwood for industrial and domestic use (Chavan *et al.* 2015) [3], which fulfills the 65 percent of the country's timber demand, 2/3 of small timber demand, 70–80 percent of plywood demand and 60 percent raw material demand for paper pulp. In addition, it produces 150 million tonnes of firewood which fulfill half of country's firewood demand. Likewise, 9–11 per cent of the green fodder requirements are met from the trees grown on the farms i.e. through agroforestry (Singh and Pandey 2011, CAFRI 2015) [16, 2].

As the population of India is increasing at a very fast rate; the

land-holding size of farmers shrink at a very fast rate and agroforestry is the only way to optimize the farm productivity (National Agroforestry Policy, 2014) ^[11]. Gross productivity under the agroforestry systems is higher as compared to mono cropping and this gives farmers higher financial returns. A comprehensive study reveals that economic viability with internal rate of return ranging from 25 to 68 and B:C ratio of 1.01 to 4.17 for 24 agroforestry systems from different agro-climatic regions of country (Chavan *et al.* 2015) ^[3]. Thus, agroforestry practices can be an important tool to achieve the 4 per cent sustainable growth in agriculture (National Agroforestry Policy, 2014) ^[11]. It is noteworthy that as per IPCC reports, agroforestry is one of the important tools to fight climate change and built resilience of farmers against threats of climate change and natural calamities because agroforestry gives services like microclimate moderation, biodiversity conservation, carbon sequestration, protecting water resources, soil erosion and pollution (Chavon *et al.* 2015) ^[3]. Agroforestry systems have potential to sequester up to 10 t C ha⁻¹ y⁻¹ (Chavon *et al.* 2015) ^[3] with average sequestration potential of 25 t C ha⁻¹ (Singh and Pandey, 2011) ^[16].

Apart from these, by adopting the much awaited National Agroforestry Policy, 2014 ^[11]; India becomes the first nation to adopt a comprehensive policy on agroforestry, which is path breaker in making agroforestry as an instrument for transforming lives of rural farming population, protecting ecosystem and ensuring food security through sustainable means. The new policy shows a major shift in opinion towards the agroforestry because previously, agroforestry was seen as a part of forestry but now policy views it as the part of agriculture. The major highlights of the policy are establishment of Institutional setup at National level to promote Agroforestry under the mandate of Ministry of Agriculture; simplify regulations related to harvesting, felling and transportation of twenty identified trees grown on farmlands; ensuring security of land tenure and creating a sound base of land records and data for developing an Market Information System (MIS) for agro forestry; fund investment in research, capacity building and extension related services; access to certified and quality planting material; institutional finance and insurance coverage to agroforestry practitioners; increased participation of industries dealing with agroforestry produce; strengthening marketing information system for tree products (CAFRI, 2015, Chavan *et al.* 2015) ^[2, 3].

Agroforestry Challenges in India

Agroforestry system is one of the best known traditional practices and has an important role in reducing vulnerability, increasing resilience of farming systems and buffering households against climate related risks (CAFRI, 2015) ^[2] but there are several challenges that reap the benefits of agroforestry in India. There is shortage of superior planting material and improved seed varieties (Verma *et al.* 2017) ^[18]. Only about 10% of planting material is of high quality, the rest without any guarantee for quality standard. There is insufficient research on agroforestry models suitable for the diverse agro-climatic regions; for the indigenous and multi-purpose species (*viz.* *Prosopis cineraria*) or on domestication

of species, resulting in over emphasis on few species like Poplar, Eucalyptus, Kadam etc. (National Agroforestry Policy, 2014) ^[11]. Another disturbing aspect is that in India, agroforestry research has mostly been conducted on research stations in relatively small plots or/and laboratories. Little or no research has been done on an ecosystem or landscape level and most of studies are of relative short-term nature (Puri and Nair, 2004) ^[13].

The marketing infrastructures for agroforestry produce are unavailable in the country except in the few states. As a result, it is largely a buyer's market and middlemen get major share in profit. Institutional finance and insurance coverage in agroforestry has not been at par with its potential due to lack of awareness of technical and economic data on different agroforestry models (National Agroforestry Policy, 2014, Planning Commission, 2001) ^[11, 12]. Also, there is cumbersome, costly and frustrating legislation in respect of tree felling, wood transportation, processing and marketing (Planning Commission, 2001) ^[12] which play a significant role in the minds of the farmer looking to adopt agroforestry (Chavan *et al.* 2014) ^[3]. Similarly, tax is imposed at various stages of processing by multiple agencies. As a result, the domestic agroforestry produce is increasingly losing grounds against the imported material. So there is an urgent need to remove these regulatory restrictions.

Extension services are important for smooth dissemination of research results on the different aspect of agroforestry but research results on agroforestry, available in the public and private domain do not regularly reach the farmers due to lack of a proper or dedicated extension system. Also, Farmers with major land holdings will get more benefit by the agroforestry related schemes than the small and marginal farmers. So there is need to introduce special programs on agroforestry models for marginal and small farmers (Verma *et al.* 2012) ^[18] because 2/3rd farmers of Indian farmers are small and marginal farmers (Kumar *et al.* 2017) ^[9].

By Adopting the National Agroforestry policy, 2014 ^[11]; an attempt is made to eliminate most of the challenges but the major challenge is to move the policy from paper to ground level. (Chavan *et al.* 2015) ^[3]. Also there are some gaps in the policy like there is lack of information on the selected trees (No Agroforestry tree manual for farmers); no mechanism for certification of nurseries and planting material; no proposal for biofuel blending in diesel and establishment of dedicated agroforestry extension system; and less emphasis on unique and hi-tech agroforestry systems like aqua forestry (Kumar *et al.* 2017) ^[9].

Future of Agroforestry in India

Agroforestry is bound to play a major role in future, not only for its importance in food and livelihood security, but also for its role in combating the environmental challenges because country's land area cannot be stretched (CAFRI 2015) ^[2]. According to CAFRI 2015 ^[2], in 2050, requirement of fodder increases by 1.5 times; food grain and fuel wood by two times; and timber by three times. Agroforestry has the potential to meet the demand for food, fodder, firewood and timber, against

Table 3: Total Domestic demand for various commodities and Agroforestry Contribution in 2050 (CAFRI 2015) ^[2].

Items	2010-2011	Projected for 2025	Projected for 2050	Contribution from Agroforestry in 2050
Food grains (millions t)	218.20	320.00	457.1	41.14*
Fruits (millions t)	71.20	106.00	305.3	47.74*
Fodder (millions t)	1061.00	1170.00	1545	154.50
Fuel wood (millions t)	308.00	479.00	629	308.00
Timber (millions t)	120.00	171.00	347	295.00
Biodiesel (millions t) required for 20 % blending of diesel	12.94	22.21	37.92	30.34
Area (millions ha) required for TBOS	12.32	15.86	21.67	17.34
Agroforestry (millions ha)	25.32		53.32	

*Food-grains/fruits production from systematic agroforestry systems viz. agri-silviculture/ agri-horticulture only considered.

The continuously shrinkage of land and water resources and the threat of changing climate in future as shown in table 3. To achieve this, the major focus of research in the future will be on developing agroforestry technologies for critical areas like arid and semi-arid zones and other fragile ecosystems such as Himalayan region and coastal ecosystem to sustain these areas for higher productivity and natural resource management. Apart from these researches should also focus on development and demonstration for the adoption of agroforestry models linked with market for enhancing productivity and profitability for small holding farmers. The state government should evolve a state agroforestry policy in consonance with the National Agroforestry policy 2014 ^[11], to plan, prioritize and develop agroforestry action plan suitable for each agro climatic zone and focus on strengthening research and activities through public-private partnership mode for developing profitable, ecologically and socio-economically viable agroforestry models for all farmers (Verma *et al.* 2017) ^[18]. The future goals in the agroforestry should be toward to enhance biomass productivity per unit area and time through agroforestry interventions; Tree improvement, post-harvest & value addition; environmental amelioration, resource conservation, mitigation of climate change effects and management of stresses; and Participatory development of agroforestry models, HRD, refinement and transfer of technology (CAFRI, 2015) ^[2]. The promotion of sustainable agroforestry practices on a large scale in future only possible through amalgamation of proactive farmer policies of government, involvement of the industries, support services from NGOs and willingness of farmers (Verma *et al.* 2017) ^[18]. A major role for agroforestry in the near future will be to give environmental service such as climate change mitigation (carbon sequestration), phytoremediation, watershed protection and biodiversity conservation. However, this will need the development of mechanism to reward the rural poor for the environmental services that they provide to society (CAFRI 2015) ^[2].

Conclusion

Agroforestry is the key path to prosperity for farmers and rural people, leading to the generation of employment and revenue; food and nutritional security; meeting the other basic human needs on the sustainable basis and cushioning farmers from the harshness of climate change. Agroforestry creates more integrated, diverse, productive, profitable, healthy, sustainable land use systems and only option to increase the country's forest and tree cover to the 33%. The opportunities and benefit offered by agroforestry can only be getting with the help of substantial investments and coordinated efforts in research, education, extension services and appropriate national policies. National Agroforestry Policy, 2014 has written a new chapter in the development of the agroforestry in India by addressing most of the challenges faced by

farmers and rural people but the major challenge left is to move forward the National agroforestry policy from paper to the ground level.

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