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Agroforestry as an option for livelihood security to farming community of INDIA

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ABSTRACT

In most of the areas especially in rainfed agricultural system in India, the management of trees in conjunction with crops and/or animals, minimizes the risks of stress period through crop diversification and efficient utilization of the resources therein. Thus, agroforestry can play crucial role in managing the risks under such stress period of most concern. Even earlier studies had revealed that, the agroforestry practices are more profitable than arable farming. But then, selection of area specific and need based agroforestry models are one of the important criteria to maximize farm output and returns. Research upgradation and management over all the prevailed agricultural and agroforestry systems are utmost important. More research efforts are needed towards identification of viable agroforestry models under rainfed condition for balancing ground water level without affecting economic crop productivity to the land holders. Intensive research efforts are required for participatory domestication of unexploited and under-exploited multipurpose trees, bushes, and grasses. Promotional research on production and supply of genetically improved agroforestry planting material using latest plant breeding and genetic tools for improved productivity, value addition and quick returns is utmost needed. Dissemination of knowledge regarding ongoing research and its scientific findings can be an effective tool for scientific cultivation practices. Marketing issues and value addition to products of agroforestry are utmost important to carry forward. Moreover, emphasis should be given on tangible benefits (*viz*., revenue generation/ cash returns) from agroforestry systems.

INTRODUCTION

Mostly the rural areas are predominantly characterized by undulating topography and rain-fed agriculture, leading to massive degradation of soil. India is having a total area of 328.72 M ha, out of which approximately 142 M ha areas are under cultivation, 69.79 M ha areas under forest cover (FSI, 2013) and approximately120 M ha areas are under degradation (FSI, 1999). All those degraded lands can be rehabilitated by means of planting trees “so called Multipurpose Tree species (MPTs)” (Shinde *et al.,* 2017; Shinde *et al.,* 2019). And hence, agroforestry is one of the best land-use management practices which provide both tangible (Das *et al.,* 2016; Das *et al.,* 2017; Das *et al.,* 2019; Sarkar *et al.,* 2017c) and non-tangible benefits (Sarkar, 2019a), helps in improving livelihood security by increasing the total productivity per unit area of land (Sarkar *et al.,* 2017c; Sarkar, 2019b), which can meet the growing demands of the people for food, fruits, fuel wood, timber, fodder, bio-fuel and bio-energy as well as provide other ecological services (Sarkar, 2019a).

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Rainfed agriculture is largely practiced in arid, dry semi-arid, wet semi-arid, and dry sub-humid regions in the country (Singh, 1999). Coarse cereals (85 %), pulses (83 %), oilseeds (70 %), and cotton (65 %) are the predominant rainfed crops grown in India (CRIDA 2007). Normally, it is considered that soils in rainfed regions are not only thirsty but also hungry (Venkateswarlu, 1986). Rainfed agricultural scenario is influenced by both biophysical and socioeconomic factors and their interaction (Das *et al.,* 2019). Management of trees in conjunction with crops in rainfed areas minimizes the risk associated with stress period (Sarkar *et al.,* 2017a; Sarkar *et al.,* 2017b; Sarkar *et al.,* 2017c) through diversified components (Kumar *et al.,* 2016) and through efficient utilization of limited natural resources (Korwar *et al.,* 2014).

Major objectives of agroforestry

Following are the major objectives of agroforestry (Korwar *et al.,* 2014) mentioned hereunder:

1. Gainful utilization of off-season precipitation
2. Income stabilization,
3. Soil and water conservation,
4. Insurance against weather aberrations and
5. Mitigation of climate change

Special conditions/ constraints under which agroforestry systems can be taken up

There are some important conditions (Nair, 1993) under which agroforestry systems can be taken up, which are mentioned here under:

- Subsistence farming
- Degraded soils
- Shortage of fuel, fodder and small timber
- Land-tenure constraints
- Low capital, high labour

Causes of land degradation

There are five main reasons of land degradation which are mentioned below:

a) **Over cultivation**- The proportion of landless and marginal farmers in India is high. Because of scarcity of land, farming of ecologically vulnerable areas is taken up resulting in erosion and associated land degradation problems.

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b) **Deforestation** – Tree are among the most effective preservers of land; however, at present, trees are being cut for various reasons *viz.,* fuelwood harvesting/ collection, shifting cultivation, commercial timber exploitation, clearing for permanent non forestry purpose e*tc*.

c) **Over grazing-** Over grazing is as destructive as deforestation but its effects are not immediately noticeable. According to an FAO estimate, one buffalo eats seven tones of leaves (by fresh weight) per year, and a cow two and a half tones –all these leafy material coming from forests adjoining the villages (FAO, 2014). Thus uncontrolled grazing has contributed to destruction of forests and grasslands thereby exposing the soil to wind and water erosion and consequent land degradation.

d) **Improper Irrigation practices-** The farmer is totally oblivious of the cost that improper irrigation, *viz.*, over use of water and non provision of adequate drainage, imposes on others. In most cases , especially in large plains, the water table, and capillary arising from the higher ground water level increases accumulation of salts both in ground water and the soil near the surface thus subsequently lowering soil productivity, and in extreme cases, making it unfit for crop production.

e) **Improper developmental activities-** It is seen that many of the areas which are very adjacent to industries and mining areas, are generally found degraded because of many such improper developmental activities *viz*., dumping of wastes, mine wastes *etc.* And hence, those areas are to be rehabilitated by means of taking up vegetative measures.

Multipurpose Trees species (MPTs)

Multipurpose Trees species are the species that can provide diverse benefits in various land-use systems. Nair (1993) also defined this as "those trees which are deliberately kept and managed for more than one preferred use, product, and/or service. For example Teak, Mahagony, Gamhar, Bakain, Neem, Arjuna, Siris, Shisham, Kalashisham *etc*. are timber yielding trees which are also called as insurance trees/plants generally grown under different agroforestry systems and are more accepted by the farmers (Das *et al.,* 2017; Sarkar *et al.,* 2017a; Sarkar *et al.,* 2017c). There are many other MPTs found throughout the world, among them some are *Acacia nilotica*, *Albizia lebbeck, Azadirachta indica, Dalbergia sissoo, Gliricidia sepium, Gmelina arborea, Leucaena leucocephala, Moringa oleifera, Pongamia pinnata, Prosopis juliflora, Tamarindus indica, etc.*

Choice of Species for degraded lands

a) Species should be highly drought resistant
b) Species should be of site specific
c) Should have property of fast development of fibrous root system

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d) Capable of deep vertical penetration into soil to reach lower, moisture regime of the soil
e) Should have sufficient capacity to sustain high wind velocity
f) Capable of multiple benefits

Planting Technique for Problem Soils (degraded lands)

At first, the area should be leveled either manually or by mechanical means. Then, pits of 60 cm^3 should be dug out and left it open for 10 – 15 days and then should be filled with fertile soil. Addition of farmyard manure at the rate of 0.50 kg pit^{-1} had been found more useful. In some states like Jharkhand, filling up of the open pits by addition of fertile soil along with vermicompost at the rate of 5-10 kg pit^{-1} and some Karanj cake or Neem cake are recommended and are found most suitable for healthy plantation. It is also recommended that, container raised seedlings of at least 9 to 12 months old are to be planted.

Management strategies for degraded lands

Management strategies for waterlogged and marshy lands

Proper drainage is important to reclaim these areas. Tree species suitable for the waterlogged areas are *Eucalyptus robusta, Syzygium cumini, Salix spp., Populus nigra, Terminalia arjuna, Acacia nilotica, etc.* In case of marshy areas species like *Baringtonia spp., Bischofia javania, Eucalyptus robusta, E. rudis Lagerstroemia flosreginea, Casurarina equisetifolia, etc.* are found more suitable (Das *et al.,* 2016).

a) Management strategies for Sand and desertic lands

Establishment of grasses is must. Trees are to be planted across wind direction. Cultivation of tree species like Teak, *Casuarina sp., Acacia tartalis, Prosopis sp., Eucalyptus sp., etc.* are the most common tress grown under such conditions.

b) Management strategies for degraded land under plantation crops

Plantation of suitable MPTs to the particular area where gaps created can be done for soil binding and water harvesting in root zones as an impediment to the eroded soils. Suitable MPTs like *Eucalyptus camaldulensis*, Acasia, Ailanthus, Casuarina, Prosopis, Neem, *etc*. and many economic fruit trees like Guava, Indian gooseberry, Drumstick, Ber, Mango, Cashew, *etc*. can be planted successfully (Das *et al.,* 2016).

c) Management practices for Gullied and ravenous lands

Reducing the slopes of the gullies and diverting the surface flow are essential pre-requisites for any successful afforestation programme. Constructing gully plugs (like macro and micro check dams) in the bed of the main and branch gully are playing important role to conserve soil and

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moisture (Shinde *et al.,* 2017; Shinde *et al.,* 2019). Trees species like *Acacia nilotica, Acacia catechu, Azadirachta indica, Albizia lebbeck, Dalbergia sissoo, Prosopis juliflora, etc.* are found suitable for these areas.

d) **MPTs for salt affected areas**

In places where the ground water is saline and scarce in quantity as in arid and semi-arid regions, suitable MPTs are planted. In general, Plantations for fuel wood are rated better for saline soils than timber wood species. Many such species *viz., Prosophis juliflora, Acacia nilotica, A. catechu, A. auriculiformis, A. arabica, Tamarix articulata, Casuarina equisetifolia, Eucalyptus hybrid, Albizia lebbeck, Azadirachta indica, Terminalia arjuna, Dalbergia sissoo, Leucaena leucocephala, etc.* are found suitable for these areas. Fruit trees like Sapota, Guava, Ber, Pomegranate and Custard apple can also be selected for plantation.

e) **Management strategies for barren rocky / stony waste / Sheet rock area**

In such areas where rainfall is low to medium, many MPTs like *Ecalyptus tereticornis, Melia azaderach, Albizia lebbeck, Acacia catechu, Ailanthus excels, Hardwickia binata, Cassia siamea, Prosopis chilensis, Dalbergia sissoo, etc.* can be planted. But for area with high elevation (upto 2000 m), species like *Robinia pseudoacacia, Populus ciliate, Pinus roxburghii, etc.* can be selected for planting.

f) Management strategies for steep sloping area

Protective measures can be taken up which includes isolation of the area from man and animal. Vegetative measures like planting of various MPTs *viz*., *Alnus nepalensis, Betula alnoides, Trewia nudiflora, etc.* can be done.

g) Management strategies for mining areas

Those mining areas should immediately be rehabilitated and managed; otherwise it will degrade air quality, water quality and land productivity. Such areas should be rehabilitated through afforestaton/ reforestation/ agroforestry models. Many literatures revealed that the performances of leguminous species like *Acacia catechu, Albizia lebbeck, Dalbergia sissoo* and *Pongamia pinnata planted on mined areas are better than many other species.* Even, bamboos like *Dendrocalamus strictus* and *Bambusa sp., etc.* are also found to grow well (Sarkar *et al.,* 2019a).

Points to be considered for rehabilitation of degraded lands

Following are the points, which can be considered before rehabilitating the degraded lands:

1. Govt. departments must give importance to afforestation as a definite support for rehabilitation of degraded lands by means of planting site specific tree species of interest.
2. People's involvement can be mobilized in the line of watershed management and its successful developments.

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3. Sufficient funds should be earmarked and made available to finance various projects related to rehabilitation of degraded lands through MPTs in watershed.
4. Available technology should extensively be popularized and transferred among the people of that watershed and globally as usual.
5. Advance planning should be done for raising nursery stock of the required species of interest to avoid planting of poor quality seedling stock and consequent failure of plantation.

Agroforestry Systems/Practices

Agroforestry systems/practices of India may be classified as traditional and advanced agroforestry systems (Korwar *et al.,* 2014).

a. Traditional agroforestry systems

- Scattered trees on farm lands/Parkland systems
- Trees on farm boundaries/boundary plantations
- Farm wood lots/block plantations
- Trees on range lands
- Vegetative live hedges/live fences.

b. Improved agroforestry systems

- **Forest trees and arable crops-based systems**
- **Alley/Hedge row cropping**
- **Fruit tree-based cropping systems involving grasses and arable crops**
- **Agroforestry systems based on commercial plantations**

  Few examples like (Sarkar *et al.,* 2017c; Das *et al.,* 2017; Sarkar *et al.,* 2019b):

  - *Leucaena leucocephala*-Based systems
  - *Tectona grandis*- Based systems
  - *Swetenia mahagony*- Based systems
  - *Dalbergia sisso*-Based systems
  - Bamboo-Based systems

- **Other systems**
  - **Biofuels and bioenergy systems like**

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a) *Pongamia Pinnata*- based Systems
b) *Simarouba glauca*- based Systems
c)*Jatropha curcas*- based systems

- **Silvopastoral systems**
- **Boundary plantations/windbreaks and shelterbelts**
- **Shade trees in plantations**

Recommended Agroforestry practices

There are few suggested trees and agricultural crops which were recommended against each agro-climatic region (Table 1).

Table 1: Recommended agroforestry practices for different agro-climatic region

Agro-climatic region	Suggested trees	Crops
Eastern plateau and hill region (Maharashtra, Uttar Pradesh, Orissa and West Bengal)	*Acacia nilotica, Borassus flabellifer, Tectona grandis, Gmelina arborea*	Coarse cereals, pulses, oil seeds, soybean, lentil, mustard
Central plateau and hill region (Madhya Pradesh, Rajasthan and Uttar Pradesh)	*Azadirachta indica, Acacia nilotica, Hardwickia binata, Dalbergia sissoo*	Ground nut, sorghum, pigeon pea, gram, lentil, mustard, soyabean, paddy, sesamum
Western plateau and hill region (Maharashtra, Madhya Pradesh and Rajasthan)	*Azadirachta indica, Acacia nilotica, Hardwickia binata, Dalbergia sissoo, Leucaena leucocephala*	Groundnut, sorghum, pigeon pea, gram, lentil, mustard, soyabean, paddy, sesamum
Southern plateau and hill region (Andhra Pradesh, Karnataka and Tamil Nadu)	*Tamarindus indica*	Tomato, chili, curry leaf
	Ailanthus excelsa	Cowpea, sesamum, sorghum, pearl millet
	Albizia lebbeck	Cowpea, sesamum, sorghum, pearl millet
East coast plains and hill region (Orissa, Andhra Pradesh, Tamil Nadu and Pondicherry)	*Acacia nilotica, Gmelina arborea, Dalbergia sissoo, Anogeissus acuminata, Prosopis juliflora*	Paddy/pulse, ground nut, sesamum

(Korwar *et al.,* 2014)

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Suitable inter crops for important horticultural crops

Important intercrops against different fruit trees are being listed in Table 2.

Table 2: Suitable inter crops for important horticultural crops

Crop	Age	Inter crop
Mango	Up to 7 years	Leguminous vegetables, papaya (filler)
Grapes	Up to 8 months	Snake gourd, bitter gourd on pandal
Apple, Pears	Up to 5 years	Potato, cabbage
Banana	Up to 4 months	Sunhemp, onion
Areca nut	Up to 10 years	Pineapple
Coconut	Up to 3 years	Banana, tapioca, vegetables

(Kumar, 1997)

Benefit–cost ratios of different alternate land use systems

Benefit–cost ratios of different alternate land use systems had been tabulated in Table 3. The Benefit : Cost ratio was reported higher in case of Fruit trees + Arable crops (5.53), followed by Forest trees + grasses (2.45). The least was reported in case of arable farming (1.34).

Table 3: Benefit–cost ratios of different alternate land use systems (CRIDA, 1993 & 1996)

Systems	Period (Years)	Benefits: Cost ratio
Arable farming	1	1.34
Forest tree + Sorghum + Pigeon pea	10	1.65
Fruit trees + Arable crops	30	5.53
Forest trees (with Castor intercrops)	10	1.99
Forest trees + grasses	10	2.45

CONCLUSION

Research upgradation and management over all the prevailed agricultural and agroforestry systems are utmost important. More research efforts are needed towards identification of viable agroforestry models under rainfed condition for balancing ground water level without affecting economic crop productivity to the land holders. Intensive research efforts are required for participatory domestication of unexploited and under-exploited multipurpose trees, bushes, and grasses. Promotional research on production and supply of genetically improved agroforestry

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planting material using latest plant breeding and genetic tools for improved productivity, value addition and quick returns is needed. Dissemination of knowledge regarding ongoing research and its scientific findings which can be an effective tool for scientific cultivation practices. Marketing issues and value addition to products of agroforestry are utmost important to carry forward. Moreover, emphasis should be given on tangible benefits (*viz*., revenue generation/ cash returns) from agroforestry systems.

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