Traditional Agroforestry Systems and Practices: A Review

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Abstract

Traditional agroforestry systems (TAFS) may be described as a set of age-old agroforestry systems which are generally devoid of intentional intensified cultivation of agricultural or forage crops and which have been practiced across the world with varying structure, function, socio economic attributes and ecological services. In India, TAFS are present across different regions, having different practices. Agroforestry system are most predominant in the arid and semiarid regions of the country. In the review paper agroforestry practices adopted by the highlands at Ziro valley to the humid and subhumid regions of Tamil Nadu and Karnataka, arid and semiarid regions of Central India, Rajasthan and Karnataka and the multi-tier cropping systems typical of humid tropics represented by homegardens/ homesteads in Kerala and in the Northeast India. Each of the agroforestry systems are unique to the region incorporating their native trees into the TAFS. Some of the prominent traditional agroforestry systems and practices reported in scientific literature have also been described.

Keywords: TAFS, agroforestry, homegardens, ecological services.

Introduction

'Agroforestry' in very simple terms may be referred to as the deliberate growing of woody perennials on the same area and at the same time as agricultural crops and/or fodder plants in the form of a spatial mixture and/or a temporal sequence. The National Agroforestry Policy (2014) defines Agroforestry as a land use system which integrate trees and shrubs on farmlands and rural landscapes to enhance productivity, profitability, diversity and ecosystem sustainability. It has now been recognized globally that agroforestry has the potential to achieve ecosystem sustainability while optimizing its agricultural productivity, profitability, and diversity, in addition to mitigating climate change impact.

In agroforestry parlance, there is a subtle difference between the Traditional agroforestry systems (TAFS) compared to the classical agroforestry, prominent in longevity and degree of intensification. Traditional agroforestry systems may be described as a set of age-old agroforestry systems which are generally devoid of intentional intensified cultivation of agricultural or forage crops and which have been practiced across the world with varying structure, function, socio economic attributes and ecological services. They are found all across the globe primarily in the tropics, subtropics and even temperate regions across Asia, Africa, Europe, North America, South America and Pacific islands, though less studied scientifically.

There has been immense diversity in the combinations of cultivation of tree species alongside agricultural crops globally. In Europe, for instance, the practice was to completely fell derelict forests, burn and cultivate agricultural crops (King 1968). Conversely, in tropical America, the practice was to simulate forest ecosystem in farm lands which the local communities felt, enabled them to extract the beneficial effects of forests to the food crops grown in their farm lands (Wilken 1977). In certain parts of Philippines, Asia, modified method of shifting cultivation was practiced where in few trees were left erect on purpose to provide shade and foliage to agricultural crops (Conklin 1957). Traditionally, in Africa, food crops have been grown amidst scattered trees (Forde 1937). The situation is no different locally

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in India, wherein traditional agroforestry systems in some form or other is practiced in almost all ecological and geographical regions of India.

Interestingly, there is immense diversity in agroforestry systems within the country. The systems vary enormously in their structural complexity, species diversity, productive and protective attributes and also in socio-economic dimensions. It may range from apparently simple forms of shifting cultivation to complex home-gardens: from systems involving sparse stands of trees on farmlands (e.g. *Prosopis cineraria* (Khejri)) tree in arid regions of Western India to high-density complex multi-storied homesteads of humid lowlands: from systems in which trees play predominantly 'service 'role (e.g. shelter belts) to those in which they provide main saleable products (e.g. intercropping with plantation crops).

In this review, we have explored the different agroforestry practices based on the geographical location and climatic condition of different regions. The review paper is broadly categorized into agroforestry systems in hilly zones, in humid and subhumid zones, in arid and semiarid zones and in humid tropics. Different agroforestry systems along with structure, ecological and socioeconomic significance are elaborated in Table 1.

Agroforestry systems in Subtropical Highlands

Highlands are regions located at an altitude of over 1000 m, usually having cool temperatures. One of the major issues associated with this type of land form is soil erosion due to slanting terrains. Emphasis for agroforestry arises mainly from conservation of soil (Nair 1989). Below we have listed a few agroforestry practices at Arunachal Pradesh, India, Northern Philippines and Tanzania.

Bamboo in rice paddies in Ziro valley, Arunachal Pradesh, India

Over the last half a century or so, the indigenous Apatani tribe of Ziro Valley in Arunachal Pradesh in the Eastern Himalayan region of India have developed a unique land-use system of growing rice (*Oryza sativa* L.) and fish together in homesteads as a viable alternative to shifting cultivation (slash and burn system) and as an answer to persistent shortages of food grains in the area (Figure 1). The 32 km^2 of cultivable land of the Ziro valley situated at an elevation of 1,500 m a.s.l. is surrounded by undulating hills of eastern Himalayas. The average farm size per family is only about 1.5 ha. In the bamboo + pine framework, the farmers fuse two essential types of woody perennials, bamboo (*Phyllostachys bambusoides*) and pine (*Pinus wallichiana*) (Tangjang and Nair 2015).

The system consists of growing two crops of rice per year (March–July and July–October) and rearing fish in paddy fields especially during the first crop of rice. Other agriculture crops include millets cultivated on bunds between rice plots, and domestic animals including the domesticated bison 'mithun' (*Bos frontalis*) besides pigs, and poultry. Only crop residues and animal waste are used to fertilize crops. Over the years, rice yield has stabilized at about 3.7 Mg $ha^{-1}y^{-1}$ (two crops per year). Recently, UNESCO has added the Ziro Valley to its list of "World Heritage Sites" in recognition of its "extremely high productivity" and "unique" way of preserving the ecology. The resilience and the sustainability of the system could be attributed to efficient nutrient cycling and high nutrient input in through water seeping in from surrounding hills which is used to grow rice paddies (Tangjang and Nair 2015).

Agroforestry systems in humid and subhumid zones

Humid and subhumid zones are regions having high rainfall. Because of excessive rainfall there is high level

Figure 1. Prominent Agroforestry Systems in Highlands: Integrated rice + fish farming at Ziro Valley, Arunachal Pradesh. (Photo: Tangjang S.)

of erosivity in these regions. With agroforestry systems in the region, there is reduced erosion thereby enhancing soil conservation and fertility. Below we have detailed out traditional agroforestry systems in Tamil Nadu, Karnataka and Konkan region.

Foliage forests "Soppinabettas"of Malnad, Karnataka

"Soppinabetta" (Figure 2), also known as foliage forests, are minor forests allowed by Karnataka state for the Arecanut farmer/grower's use as organic support in the Western Ghats area of Karnataka, South India (Nayak *et al.* 2000). These community-managed forests are examples of minimally managed economically valuable, high yielding forests. Soppinabetta forests appear to be a distinct land use system that can be categorized as neither regular forests nor farmlands. The species occurring in these intensely used and managed forests are a subset of those occurring in the "natural"forests nearby.

Rice grown on rainfed upland fields is the major food crop of this area, where a good number of farmers still follow traditional agricultural methods. Land preparation is completed by May, before the beginning of the South West monsoon and the upland rice seedlings are transplanted to the fields in June after the onset of the monsoon. Many traditional varieties are cultivated. Harvest takes place in December and an average rice yield of around 5-6 Mg ha^{-1} can be expected. Cultivation in this area largely depends on organic materials collected from adjacent Soppinabetta forests in the form of green foliage and leaf litter for compost production and certain herbs as pesticides in *Areca catechu* (betel nut) cultivation. The compost made of foliage and leaf litter from the Sopinabetta or 'foliage forests' is mixed with cow dung to produce an organic fertilizer. This locally prepared compost is used extensively to fertilize the betel nut farms in a completely organic venture (Purushothaman and Dharmarajan 2005).

Coffee under native shade trees in Coorg, Karnataka

Traditionally managed shaded coffee plantations of Coorg or Kodagu district in Karnataka contain a high proportion of native species. The high density and diversity of native trees in coffee plantations of Kodagu has been attributed to the existence of high indigenous diversity of adjacent natural forests as well as the tough forest protection laws in the district. However, farmers in Kodagu are restricted from direct marketing of their native timber by laws and public policies. As a result, many farmers prefer to plant exotic trees rather than native ones (Ambinakudige and Satish 2009).

Most dominant species in coffee plantations of Kodagu is an exotic Australian species, *Grevillea robusta*, which commonly known as 'silver oak'. *G. robusta* in agroforestry plantations are preferred mainly because of its fast growth rate and minimal competition with robusta coffee (*Coffea robusta*). A study on growth rates of four common native timber species viz., A*crocarpus fraxinifolius, Dalbergia latifolia*, *Lagerstroemia microcarpa* and *Syzygium cumini* in comparison with the common exotic shade tree Silver oak (*Grevillea robusta*) revealed some interesting statistics. *A. fraxinifolius*, as a fast-growing potential native species could compare favourably with exotics such as silver oak, under appropriate ecological conditions (Nath *et al.* 2011). Ecological services of native shade trees were also superior to exotic shade trees like silver oak. Yield of coffee, consistency in yield and cupping quality of coffee beans were much improved under native shade trees (Dhanya *et al*. 2014).

Taungya system in Indo-Burma region

The Taungya system (Figure 3) is basically an organized and systematically managed shifting cultivation. The word is reported to have originated in Myanmar (Burma) and 'tauang' means hill, 'ya' means cultivation i.e. hill cultivation. It basically involves cultivation of crops in forests or forest trees in crop-fields. The system was first introduced to Chittagong and Bengal areas in colonial era in India in1890. Later it had spread throughout Asia, Africa and Latin America. The first taungya plantations were raised in 1896 in the northeastern hill region. In southern India, the system used to be called as 'kumri'. It was usually practiced in areas with an assured annual rainfall of over 1200-1500 mm (Tewari 2008). In the initial years of the plantation establishment after clearing virgin forest lands, the labour force were encouraged to grow agricultural crops like upland rice or root crops like Cassava in the interspaces to keep out

weeds. But over the years due to shade effects of the forest tree crops, agriculture crop yields declined and agroforestry was no longer possible. Though this system was highly successful in raising some of the finest teak (*Tectona grandis*) plantations in the country, it soon became unpopular due to exploitative management of the labour used for raising the 'taungya' plantations and socio economic fallout in the aftermath.(Tewari 2008)

Essentially, the taungya system consists of growing annual agricultural crops along with the forestry species during the early years of establishment of the forestry plantation. The land belongs to the forestry departments or their large scale lessees, who allow the subsistence farmers to raise their crops. The farmers are required to tend the forestry seedlings and, in return, retain a part or all of the agricultural produce (Nair 1993).

The *Acacia nilotica* system of Chattisgarh, Central India

This is a system practiced mainly by smallholder farmers in Madhya Pradesh in which *Acacia nilotica* (L.), locally known as *babul*, is grown in rice fields (Figure 4). Farm animals have a role in the natural regeneration of babul trees in crop fields. Even though there is profuse regeneration, thinning is practiced and an optimum spacing of around 10 m is maintained by the end of fifth year. Pruning commences in the third year of establishment of the tree and is a regular feature every summer until the final tree harvest. The trees are pruned initially in such a way to promote the formation of a clean straight pole that can fetch premium price in the market. The crown is maintained high and light by pruning off the lower branches so that the shade cast on the understory crops is minimized (Viswanath *et al*. 2000).

A separate calendar of farm activities is practiced in this agroforestry system for both agriculture and forest species. Agricultural activities include land leveling, bund repair and strengthening, collection and burning of stubbles, summer ploughing, application of manure, ploughing and broadcast of rice, planting of crops on bunds, weeding, fertilizer application and plant protection, sowing of relay crop, rice harvest and

Figure 2. Soppinabettas in Malnad region-Paddy fields with foliage hillocks in back drop.
(Photo: Purushothaman S.)

Figure 3. Taungya system -Teak (*Tectona grandis*) + rice (*Oryza sativa*). (Photo: P. K. R. Nair)

Figure 4. *Acacia nilotica* trees in rice fields, with sesame in risers (*Sesamum indicum*), Central India (Photo: S.Viswanath)

Table 1. Structure, ecological system and socio-economic function of TAFS in India.

Climatic Zone	AFS system	Description of system components	TAFS Characteristics
			Structure
Sub Tropical High-lands	Bamboo in rice paddies in Ziro valley, Arunachal Pradesh, India	Two crops of rice per year along with rearing fish in paddy fields	Woody perennials include bamboo and pine + landraces of Paddy which also includes indigenous rice varieties like Ampu ahare and many others + fish species like common carp, grass carp and others
Tropical humid and subhumid zones	Foliage forests "Soppinabettas"of Malnad, Karnataka	Soppinabetta or foliage forests are minor forests allowed for Arecanut farmer/ grower's to use organic waste from the Western Ghats as manure	Betel nut and Paddy is grown by farmers. Compost is mainly in the form of organic matter obtained from surrounding community managed forest areas
	Coffee under native shade trees in Coorg, Karnataka	Traditionally managed shaded coffee plantations of Coorg in Karnataka contain a high proportion of native species.	Four native timber species viz., *Acrocarpus fraxinifolius*, *Dalbergia latifolia*, *Lagerstroemia microcarpa* and *Syzygium cumini* or common exotic shade tree Silver oak (*G. robusta*) + robusta coffee (*Coffea robusta*).
	Taungya system in Indo-Burma region	An organized and systematically managed shifting cultivation.	Cultivation of crops in forests or forest trees in crop-fields.
	Acacia nilotica system of Chattisgarh, Central India	AFS system practiced mainly by smallholder farmers in Madhya Pradesh in which *Acacia nilotica* is grown in rice fields	*Acacia nilotica* with paddy
	Dendrocalamus stocksii (Manga Bamboo) in Konkan region	Bamboo species used as live hedge in the region	Bamboo (*D. stocksii*) live fence in home gardens
Arid and semiarid zones	Scattered trees in pasture lands - *Acacia leucophloea* silvipasture of Tamil Nadu	Integration of multipurpose tree species and shrubs with agricultural crops and/or livestock	*Acacia leucophloea* is grown in combination with agricultural crops like millets and horse gram
	Ficus-based system of Mandya, Karnataka	Common AFS System in Arid regions of Karnataka wherein Ficus trees are seen alongside agricultural crops	*Ficus* spp. With crops like millets, pulses, maize and oil seeds
	The *Prosopis cineraria* 'Khejri' system of Rajasthan, Western India	Lynchpin of traditional agroforestry system located at the interface of rainfed agriculture and silvo-pastoralism	*Prosopsis cineraria* (5-80 trees/ha) with cereals and pulses
Tropical Wet Humid	Home gardens of Kerala	It constitutes the predominant farming systems of the state.	Woody perennial crops: Areca catechu etc. Fruit trees: *Mangifera indica* and *Tamarindus indica,* Timber species: *Tectona grandis*, *Ailanthus triphysa*. Pepper vines are grown on tree species
	Homegardens of North-East India	Extremely common in NE India especially in the Barak valley region in Assam	Composed of 3–4 canopy layers: the emergent layer, the canopy, the understory, the shrub and the herb layer.

Table 1.contd.

TAFS Characteristics		Agroforestry system classified under	References
Ecological System	Socio Economic		
Rice + fish cultivation reported an increase of 27.9%, 44.3%, 6.5% and 28.2% in soil total N, P, K and SOM compared to traditional rice farming, Capable of lowering the emission of CH_4 by nearly30% .	Integrated TAFS considered as sustainable, self-sufficient and efficient	Aquaagroforestry Systems	Tangjang and Nair 2015, Lu and Li 2006, Zheng and Deng 1998
A completely organic venture with locally prepared compost from leaf litter and green foliage from surrounding forests	Community based farming where the entire community benefits from this organically managed AFS system	Agrisilvicultural System	Purushothaman and Dharmarajan 2005
Native trees contribute to the quality and consistency of coffee production.	Enhances the quality of the product while ensuring good yield. Also reduces external input cost thereby increasing profit margin.	Agrisilvicultural System	Dhanya *et al*. 2014
Initial years of growing agricultural crops are beneficial when shade is less. However eventually does not work for agricultural crops	Farmers tend the forestry seedlings and retain a part or all of the agricultural produce giving economic benefit	Taungya	Tewari 2008, Nair 1993
Sharing of growth resources between the FAS components.	Higher cash returns on a short-term (10-year) harvest cycle of trees, Labour input on farms gets distributed uniformly	Agri-silvicultural System	Viswanath *et al*. 2000
Natural fence for protection as against conventional fence. Leaf litter from bamboo plantations used as compost for other vegetable and flower crops.	Revenue generation from harvested bamboo culms with an approximate annual income of INR ₹ 1,00,000	Home gardens	Rane *et al*. 2014, Viswanath *et al*. 2014, Rane *et al*. 2016
20-23% increase in height of fodder crops like sorghum when udner shade.	Fuel wood, charcoal, fruit and fodder harvested regularly Drought-tolerant "Kangayam" breed of cattle is a much coveted bull in local festival	Agri-silvipastoral System	Jambulingam and Fernades 1986
Birds, small mammals and insects help pest control and facilitate tree propagation. Acts as a keystone species	Highly sustainable system wherein Food rains, fuel wood, timber etc. is obtained in addition to dairy products and farmyard manure.	Agri-silvicultural System	Dhanya 2011, Dhanya *et al*. 2013
Tree litter fall improves soil fertility. Tree induced improvement in soil physical condition Drought resistant tree	Fodder of high nutritive value), fuel wood of high calorific value, thorny twigs as fencing materials, and medicinal products are derived from the system	Agri-silvicultural System	Shankaranarayan *et al.* 1987
Food, energy and building materials come from tree species of home gardens	High productivity rates and diversity of production	Home gardens	Depommier 2003
Composed of multipurpose tree species and the herbaceous layer of vegetables, ornamentals and medicinal species which enhances bidoiversity in the region	Varied crops ensures consistent income to farmers.	Home gardens	Das and Das 2005

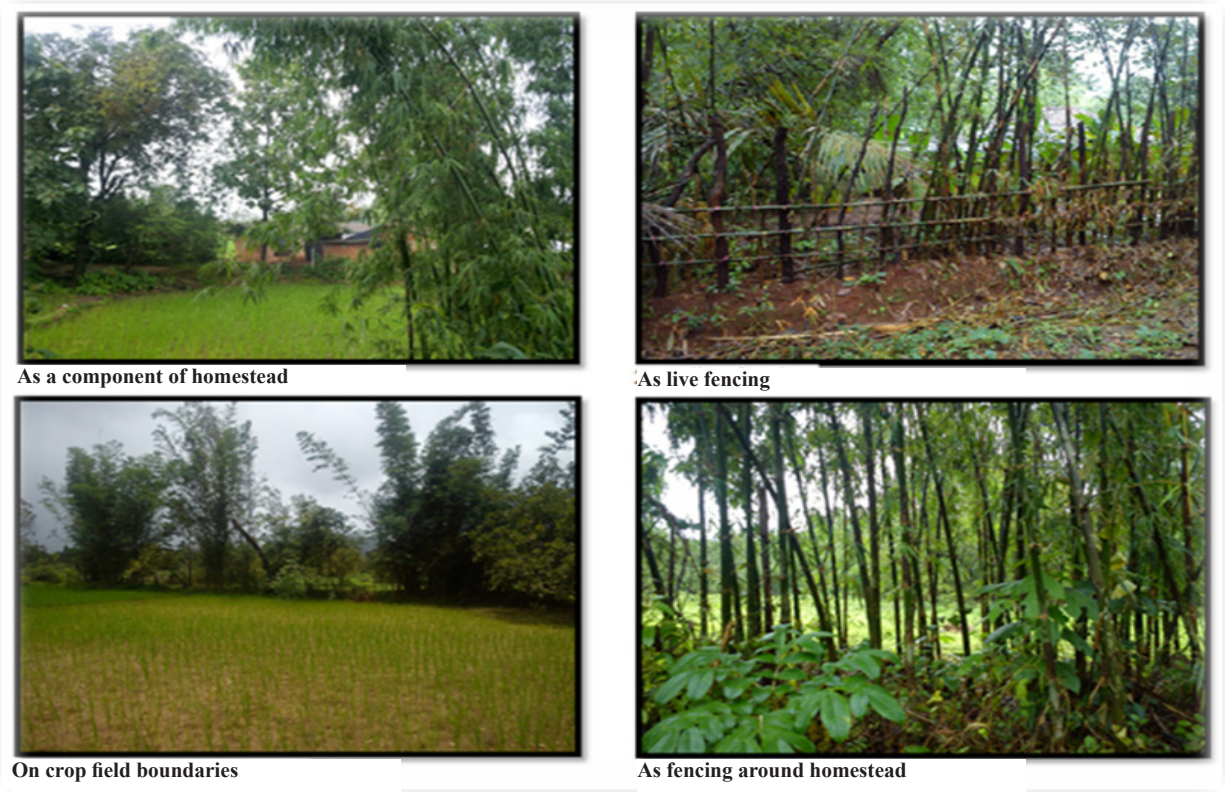

Figure 5. *Dendrocalamus stocksii* closely integrated with farmlands in Konkan belt of Maharashtra. (Photo: S. Viswanath)

bundling, threshing, winnowing and bagging, This is also followed by harvest of crop on bunds, its threshing and winnowing, followed by harvest of relay crop and its post harvest operations. Major events in *Acacia nilotica* management timeline include seed germination, initial seedling establishment, canopy management and pruning, fuel wood collection and stocking, bio fencing, pruning of roots and branches, seed and gum collection, thinning, harvest and extraction. By practicing this agroforestry (rice + babul) system, farmers get higher cash returns on a short-term (10-year) harvest cycle of trees, and the labor input (both family- and hired) on farms was distributed more uniformly throughout the year than in rice monoculture (Viswanath *et al*. 2000).

Dendrocalamus stocksii (Manga Bamboo) in Konkan region

Dendrocalamus stocksii is naturally distributed in Central Western Ghats, in Karnataka, Goa, Kerala and Maharashtra (Figure 5). It is a strong, solid and thornless bamboo that can attain a height of 10 m, diameter of 2.5 - 6.0 cm and internodal length of 15-29 cm. Presently, it remains confined to the coastal tracts where it is cultivated in homesteads, and in farm and community lands as live fences and/or block plantations. This thornless erect , solid species is now increasingly being used in furniture industry as a replacement for cane. In certain villages like Oras, Oveiye in Sindhudurg district of Konkan belt of Maharashtra traditionally the entire village communities have been engaged in cultivation of this bamboo species for centuries. This could be seen either as scattered clump in homesteads, as live hedges or ever as compact as block plantations. Vegetative propagation with Rhizome offsets of 2-3 m are typically used as new planting material which is extracted in the beginning of monsoon season in May-June and planted in slanting moreover in 0.75 m^3 pits. Mature culms of > one year old are harvested during the dry season (Jan-

Figure 6. Scattered *Acacia leucophloea* trees in farmland. (Photo: P. K. R. Nair)

Figure 7. Kangayam Bull. (Photo: Senaapathy Kangayam Cattle Research Foundation)

May). The typical commercial length of the culms is 15-20 ft and fetches a price of around INR 80-100, which is good revenue for the farmer. The *D. stocksii* bamboo known in Konkan belt as 'manga' and in Karnataka as 'marihal' bamboo produces 10-15 new culms annually from mature clumps (>4yrs) and fetches the cultivator an assured annual income of a minimum of INR 1,00,000 (Rane *et al.* 2014, Viswanath *et al.* 2014).

Agroforestry Systems in tropical arid and semiarid zones

Arid and semiarid zones are regions that have atleast one long dry period. Because of the dry period, droughts are a cause of common concern in these regions. Lack of fodder during the dry spells is another concern in these regions. With agroforestry practices, these concerns can be minimized.

Scattered trees in pasture lands - Acacia leucophloea silvipasture of Tamil Nadu

This system (Figure 6) covers 100,000 ha in the dry tracts of Coimbatore and Periyar Districts where annual rain fall is around 600 mm. Although the rainfall pattern is highly erratic, *Acacia leucophloea* regenerates profusely when the land is ploughed after the first rains. Farmers encourage the growth of the young seedlings and sow crops like *Pennisetum glaucum* and *Dolichlos uniflorus* (horse gram). If the rainfall distribution is normal, crops will be harvested as grain. Otherwise, they are likely to be used as fodder. At the end of the first year roughly around 1,000 or so tree seedlings remain and this number may further be depleted by natural morality to around 500-800 per ha. At the end of the third year when the trees are 1.0-1.5 m tall, tillage of soil up to the base of the trees for sowing crops is practiced (Jambulingam and Fernandes 1986).

After about ten years when the trees are around 10 m tall and 20 cm in diameter at breast height, thinning of trees to allow a tree density between 60 and 100 per ha is done. This may be done to allow adequate sunlight to reach the understory crops. Studies carried out by Jambulingam and Fernandes (1986) have reported a 20-23 per cent increase in dry-matter yield of fodder sorghum growing beneath the trees as compared to the crops grown without tree cover. The trees develop large spreading canopies when they are 15-20 years old and farmers thin them out to between 25 and 60 per ha. Such trees yield up to 100 kg of pods annually, which form an excellent high-protein fodder supplement in the dry season.

Due to the uncertainty in rainfall pattern and distribution in recent times, an increasing number of farmers are now planting *Cenchrus ciliaris* instead of cereals and pulses. *C. ciliaris* is a hardy fodder grass, which dries up in the summer but regenerates naturally soon after the first rains. The emphasis nowadays is shifting from an agrisilvopastoral to a more predominant silvopastoral system while still giving the farmer the leeway to raise

crops should conditions permit. The drought-tolerant "Kangayam" breed of cattle (Figure 7) developed in this area is a much coveted bull in annual bull fighting festival or 'Jallikattu' in TamilNadu (Jambulingam and Fernades 1986).

Ficus-based system of Mandya, Karnataka

In Mandya district of southern dry agro climatic zone of Karnataka, trees of the genus Ficus have been integral components of traditional rain fed agro ecosystems with field crops like millets, pulses, and maize and oil seeds (Dhanya *et al.* 2014) (Figure 8). *Ficus benghalensis* L. is the major species of Ficus grown in these agroforestry systems, followed by *Ficus religiosa L., Ficus amplissima Sm., Ficus virens aiton, Ficus racemosa L.,* and *Ficus mysorensis* var. *pubescens*.Tree management including pruning, lopping for fuel wood and harvest are usually carried out during non-cropping periods (February-April), implying seasonal division of labor and complementarity in labor utilization. Although family labor is largely used for tree management, these systems are capable of generating alternate employment avenues. Ficus-based agroforestry systems provide grains, fuel wood, timber etc. to the household. Fodder and straw are fed to livestock, which provides dairy products and farmyard manure. Birds, small mammals and insects help pest control and facilitate tree propagation (Dhanya 2011).

The ability of the species to survive under harsh conditions, cultural acceptability, multiple use benefits, and ability to provide vital ecological services besides reduced dependence on external inputs are plausible explanation for farmers embracing this Ficus tree in dry land tracts of Mandya and Chamrajnagar districts in southern Karnataka. Analysis of litter revealed that nutrients from ficus litter can potentially meet upto 76.70 per cent N, 20.24 per cent P and 67.76 per cent requirements of dryland crops annually A socio-economic survey analysis of farmers revealed that total land holding, percentage of irrigated area, income from livestock and availability of family labour are crucial variables determining ficus tree adoption in the area (Dhanya *et al.* 2013).

The *Prosopis* cineraria 'Khejri' system of Rajasthan, Western India

Prosopis cineraria in Rajasthan and *Faidherbia albida* (syn. *Acacia albida*) in Sahelian Africa are the lynchpins of traditional agroforestry system located at the interface of rain fed agriculture and silvo-pastoralism (Figure 9). The species in Rajasthan, western India, known as Khejri is a versatile multipurpose tree which provides fodder (leaves and pods of high digestibility and nutritive value), fuel wood (high calorific value), thorny twigs as fencing materials, medicinal products from its bark and various other specific secondary products (food, crafts, etc.). The tree, which is drought resistant mainly due to its long extensive tap root system, can draw water from the deepest layers of the soil, is also

Figure 8. Ficus based agroforestry in semiarid region of Mandya, Karnataka (Photo: Dhanya B.)

Figure 9. Prosopis cineraria in arid zones of Rajasthan, India (Photo: P. K. R. Nair)

well known for its ability to maintain soil fertility. It is an appropriate, less competitive species in a subsistence system, evolved over the ages in areas where rainfall ranges from 100 to 350 mm per year (arid climates). In Rajasthan, 'Khejri' trees are maintained in croplands in a scattered way (sometimes on boundaries) in association with cereals and pulses at a density of 5 to 80 trees ha^{-1}. Khejri is a slow-growing species in its early stage, with low fodder production and limited soil beneficial effects in the initial years. Farmers continue to maintain it in their fields to sustain crop production and feed their livestock, while the droppings contribute to the much needed maintenance of soil fertility of the desert landscape (Depommier 2003).

Thus maintenance of favorable soil moisture and improvement in the soil physical and fertility conditions by *P. cineraria* makes this tree suitable for agrisilvicultural and silvipastrol systems. Lopping of tree just before the cropping season eliminates the adverse effects of shading on the understorey crop (Shankarnarayan *et al.* 1987). This system has striking similarity to the *Faidherbia albids* parkland system of West Africa. The only difference in this system is the reverse phenology exhibited by the tree during the rainy season (Roupsard *et al*. 1990).

Agroforestry Systems in Tropical Humids

Home gardening has been a way of life for centuries and is still critical to the local subsistence economy and food security (Kumar and Nair 2004) Home gardens are good replicas of native vegetation in humid tropics and help in conserving local biodiversity as well as meet the subsistence needs of local communities in a sustained manner; Tropical home gardens exist along biodiversity hotspots in Western Ghats and Eastern Ghats in India. It can also been seen in Sri Lanka, South East Asian regions like Java, Indonesia and in Philippines, in foothills of Mt Kilimanjaro in Tanzania, Africa. The basic structure of homegardens remains more or less the same across the different geographical regions. The main features are the minimal size of individual home garden unit, multi storied canopy structure and predominance of fruit and nut trees in the upper and middle canopy levels, spice crops or root crops trailed along the woody components and understorey dominated by food or cash crops or medicinal plants (Depommier 2003).

Figure 10. Homegarden in Kerala. (Photo: B. M. Kumar)

Homegardens of Kerala

The home gardens of Kerala (Figure 10) constitute the predominant farming systems of the state. They are small (more or less around 0.5 ha) and traditionally coconut-based. *Cocos nucifera* is widely used multipurpose tree species preferred in Kerala homegardens for food, energy and building materials. Home gardens are typically multi-strata systems characterized by a high density of multiple species and diversity of the woody tree components. The other main characteristic of the home gardens is their high productivity rates and diversity of production to satisfy the primary needs of the farmer, like food fuel, timber and cash. Woody perennial crops include *Areca catechu, Hevea brasiliensis, Anacardium occidentale, Artocarpus heterophyllus Artocarpus hirsutus,* fruit trees like *Mangifera indica* and *Tamarindus indica*, many other timber species such as *Tectona grandis*, *Ailanthus triphysa*. Legume trees like *Erythrina indica* are used to trail *Piper nigrum* (pepper vines) and *Glycricidia* maculate along farm boundary for meeting green manure needs. (Depommier 2003)

Homegardens of North-East India

The Barak Valley region, covering an area of 6922 km^2 located in southern Assam is known for its home gardens. Homegardens exhibit complex structure, both

Figure 11. Bambusa tulda in a homestead in Cheesa, Arunachal Pradesh. (Photo: S. Viswanath)

vertically and horizontally (Figure 11). The vertical structure of homegardens is usually composed of 3–4 canopy layers: the emergent layer, the canopy, the understory, the shrub and the herb layer. The emergent layer has a height of 15 m or more and composed of multipurpose tree species such as *Artocarpus lakoocha, Bombax ceiba, Tamarindus indica, Tetrameles nudiflora* and *Toona ciliata*. The canopy layer is usually between 10 and 15 m with species such as *Areca catechu, Artocarpus heterophyllus, Mangifera indica, Syzygium cuminii, Terminalia chebula,* and Bamboo sp. The understory layer has a height of 5–10 m and dominated by *Citrus* spp., *Cocos nucifera, Litchi chinensis*. In the shrub layer of 1–5 m species like *Hibiscus rosa-sinensis* dominate and the herbaceous layer is mainly composed of vegetables, ornamentals and medicinal species. The shade provided in the homegardens supports a large number of shade-loving climbers like *Piper nigrum* and root crops like *Alocasia macrorrhiza.*(Das and Das 2005)

Summary

Traditional Agroforestry Systems (TAFS) have many ecological and economic benefits and it is these reasons that have made it thrive over time. Described as a set of age-old agroforestry systems which are generally devoid of intentional intensified cultivation of agricultural or forage crops. TAFS have been practiced across the world with varying structure, function, socio economic attributes and ecological services. TAFS are distributed worldwide though predominantly in the tropics across Asia, Africa, South America and Pacific islands. Invariably in almost all TAFS native trees appear to predominate and have a major structural, functional and service role to play whether it is in the tropics, subtopics or temperate regions across the globe. In the Indian context scattered trees on croplands similar to silvipasture system focusing on some particular species like *Acacia leucophloea, Acacia nilotica, Prosopis cineraria* and *Ficus* spp appear to have been reported prominently and characterized by its specificity. Some of the prominent TAFS and practices reported in scientific literature have been discussed in detail in the literature review.

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