Int. J. Adv. Res. Biol. Sci. (2016). 3(7): 99-104

International Journal of Advanced Research in Biological Sciences
ISSN: 2348-8069
www.ijarbs.com
Volume 3, Issue 7 - 2016

Review Article

SOI: http://s-o-i.org/1.15/ijarbs-2016-3-7-14

# Sustainable Silvi based cropping systems for improving socioeconomic status of horticulture farmers– A Review

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**Abstract**

As population has increased, increasing the need for agricultural production, the use of multiple cropping systems is more prevalent. Agroforestry has high potential to simultaneously satisfy objectives like protecting and stabilizing the ecosystem, producing a high level of output of economic goods, providing stable employment, improve income and basic material to rural population. Agroforestry is capable to conserve natural resources through various systems under different agroclimatic regions including the hot arid zone of India. The hot arid zone is spread 3.17million hectare. The productivity of this area is very low due to low rainfall, high evaporation and high wind speeds, which causes a great loss of soil and vegetation resources. Several alternate land use systems *viz.*, *Prosopis cineraria*, *Acacia tortilis*, *Acacia Senegal*, *Ailanthus excels*, *Zizyphus* spp. Based silvipastoral/ agrisilvicultural systems developed in hot arid zone are much remunerative than the sole cropping. Millions of farmers are dependent on agroforestry farming systems as a way of increasing and sustaining agricultural productivity, as a source of essential food, fuel wood, fodder and building materials and as a supplementary source of income that buffers instability in agricultural income. As forest resources have become increasing scarce, poor small farmers have become more dependent on agroforestry systems to sustain their livelihoods. The socioeconomic implications and the great potential for multiple cropping systems in agriculture and horticulture are reviewed.

**Keywords:** Agroforestry, silviculture, ecosystem, agriculture, horticulture, yield.

## Introduction

Agroforestry is a land use system that increases livelihood security and reduces vulnerability to climate and environmental changes. It requires optimization and sustained management of available resources in a given area rather than their over exploitation (Dhyani *et al.*, 2009). Agroforestry systems combine tree growing with the production of other crops or animals. By promoting tree planting agroforestry can be an economically and environmentally sustainable option for small scale farmers. For hungry and food insecure communities, agroforestry creates more resilient agricultural systems where the risk of crop failure in minimized and spread between diverse crops. “Agroforestry is a collective name for land use systems and technologies where woody perennials (trees, shrubs, palms, bamboos etc) are deliberately used on the same land management units as agricultural crops and / or animals, in some form spatial arrangement or temporal sequence. In agroforestry systems, there are both ecological and economical interactions between the different components".

- Agroforestry normally involves two or more species of plants (or plants and animals), atleast one of which is a woody perennial
- An agroforestry system always has two or more outputs
- The cycle of an agroforestry system is always more than one year and
- Even the simplest agroforestry system is more complex than a monocropping system.

By developing positive ecological and economical interactions between components, agroforestry systems aim to provide a range of environmental, economic and social benefits to farming communities (Sanchez, 1995). By increasing the productivity and diversity of their crops and by optimizing the use of natural resources on their farms, farmers can benefit from a reduced use of agrochemicals. Agroforestry systems typically use accessible and low cost technologies and generate employment and rural incomes.

## Agroforestry potential in India

India is estimated to have been 14,224 million to 24,602 million trees outside the forest, spread over an area of 17 million ha, supplying 49 per cent of the fuel wood and 48 per cent of timber consumed annually by country (Pandey, 2007). It serves as very good source for the food production along with fuel wood and production of other products. Agroforestry contributes in fuel wood, timber, fodder, food, fruits, livestock and bioenergy (Dhyani *et al.,* 2007). The area under agroforestry can be potentially extended to 25.36 million ha from the current 7.45 million ha in next two decades, which will help in augmentation and stabilization of production and productivity by minimizing ecological degradation (NRCAF, 2007).

## Agroforestry and food security

Farmland in the developing world generally suffers from the continuous depletion of nutrients as farmers harvest without fertilizing adequately or fallowing the land. Small scale farmers have removed large quantities of nutrients from their soils without using sufficient amounts of manure or fertilizer to replenish fertility. This has resulted in high annual nutrient depletion rates of 22kg nitrogen, 2.5kg phosphorus and 15kg potassium per hectare of cultivated land over the past 30 years in 37 African countries. Commercial fertilizers cost two to six times as much in Africa as in Europe or Asia. Even at these prices, supplied are problematic due to poorly functioning markets and road infrastructure. Consequently, most African farmers have abandoned their use. This is having dire (critical/ terrible/severe) effects on small holder food production. In the extensive maize (*Zea mays*) producing belt of eastern and southern Africa, there are 12 million farm house holds that support some 60 million people, with farm sizes ranging from 0.3 to 3 hectares. Few farms currently produce enough maize to feed the family, let alone provide a surplus for the market. For example, recent work shows that upto 90% of maize growing families in eastern Zambia experience hunger for three to four months during normal years and there is severe famine in drought years.

Many policy and infrastructural constraints have addressed to alleviate basic rural food insecurity in this region. But one promising pathway is to enable small holders to use fertilizer tree systems that increase on farm food production. After years of experimentation with wide range of soil fertility replenishment practices, three types of simple, practical fertilizer tree systems have been developed that are now achieving widespread adoption. These are,

1. Improved fallow using trees and shrubs such as sesbania (*Sesbania sesban*) or tephrosia (*Tephrosia rogelli*)
2. Mixed inter cropping with gliricidia (*Gliricidia sepium*)
3. Biomass transfer with wild sunflower (*Tithonia diversifolia*) or gliricidia

They provide 50 to 200kg N $ha^{-1}$ to the associated cereal crops. Yield increases are typically two to three times that with current farmer's practices. These fertilizer tree systems have now reached over 1,00,000 household in the maize belt of eastern and southern Africa and demand for tree seed and knowledge transfer is increasing exponentially. These practices tend to be adapted to a greater extent by the poorest families in the villages, which is unusual for agricultural innovations (Place *et al.,* 2002).

## Agroforestry systems of Karnataka

Karnataka, is situated in south west India with an area of 191791 sqkm (19.179 million ha). Most part of the state lies on a plateau bordered in the west by coastal strip along the Arabian sea (about 30km wide, averaged annual RF 3000 to 3700mm) and the western ghats which are a chain of low hills with altitude of 1500m and average annual rainfall of 2500mm. nearly two third of the state in the north eastern part form the dry zone and is classified as drought prone.

Karnataka has four agroecological regions, which fall under the following ecosystems

1. Arid-ecosystem: Parts of the state mainly comprising portion of Raichur, Bellary and Chitradurga districts fall in this category and can be described as Deccan Plateau hot arid ecoregion with mixed red and black soils. Bund planting is the most common agroforestry system with *Azadirachta indica* a dominant tree species.
2. Semi arid ecosystem: Is a region which is described as Deccan plateau hot semi arid ecoregion, which has shallow medium black soils. It has most parts of districts of Bidar, Gulbarga, Bijapur, Belgaum, Dharwad & parts of Uttara Kannada districts. Strip and bund planting are most common systems in addition to alley cropping system and very few agrihorticulture.
3. Another ecoregion which is again a semi arid ecosystem in Eastern Ghats and Deccan Plateau hot semi arid ecoregion with red loamy soils. Entire districts of Bangalore Urban, Bangalore Rural, Mandya, Hassan and major parts of Mysore, Tumkur, Chitradurga, Shimoga, Chikmagalore and smallportion of Kodagu, Bellary form this ecoregion. This zone is dominated by most of the agroforestry system. The common agroforestry systems are agrisilvipasture, agrisilvihorticulture and home gardens.
4. Coastal Ecosystem: This category is described as Western Ghats coastal plains hot humid pre-humid ecoregion with red soil and alluvial derived soils. Home gardens, agrisilvipasture systems are the common systems in this zone.

## Research activities under taken in Agroforestry Systems

Studies conducted in UAS, Dharwad has shown that growing agricultural crops along with teak and papaya yielded higher net returns as compared to growing only agricultural crops. Similarly net present value (NPV) and internal rate of returns (IRR) were higher with this treatment are presented in Table 1. However, in addition to teak and papaya if grass or subabul for pasture are included the net return per ha per year would be more. Hence, adopting agroforestry system is economically viable also.

**Table 1.** Income from an agroforestry system experiment.

| Sl. no | Treatment | Avg net return per ha per yr after seven yrs | NPV at 20 per cent discount rate (Rs/ha) | IRR per cent |
|---|---|---|---|---|
| 1 | Only agril crops | Rs. 4409 | - | - |
| 2 | Crops + teak + papaya | Rs. 7894 | 18967 | 117.59 |
| 3 | Crops + teak + papaya + grass | Rs.6754 | 15862 | 98.79 |
| 4 | Crops + teak + papaya + grass | Rs. 7035 | 16362 | 98.91 |

(source: Pathak and Ram Newaj, 2003)

## Coffee based agroforestry systems of Kodagu

Kodagu is one of the district in Karnataka which falls under Eastern Ghats and Deccan plateau hot semi arid ecoregion. The district is highly forested and nearly 30 per cent of its geographical area is under coffee based agroforestry. In these coffee plantations majority of the tree used for the shade are natural and are native and very recently, planters have planted few exotic tree species *viz., Grevelia robusta, Acrocarpus fraxinifolius.* The studies have shown that they are supporting high levels of biodiversity, as diverse and well stocked tree cover is retained. In addition to this, on an average rupee seven lakh timbers is present in these coffee plantations per hectare. These coffee based systems therefore can be considered as Managed agroforests (Satish and Kushalappa, 2007).

## Agrihorticulture

This system provides sound farm economy improved nutrition and health standards of the family and stability of income. In arid regions most commonly grown fruit crops are ber (*Ziziphus mauritiana*), pomegranate and aola (*Emblica officinalis*) and intercrops like mongbean, moth bean and cluster bean are grown every year. In semi arid situations mango, sapota (*Achras sapota*), Guava (*Psidium guajava*), tamarind, cashew, ber and jack fruit are generally grown with crops. Other fruit tree species like Phalsa, wood apple, passion fruit, guava etc., are potential alternative for the systems.

## Silvipasture

Annual draft, milk, milk products, meet, wool, hides, skins, bones etc. Provide a wide canvas of livelihood inputs ion silvipasture system woody perennial provides a fodder protein bank. Trees and bushes provide green fodder during non-rainy season when green grasses are not available. These systems are more suited to degraded lands and for area facing acute shortage of fodder. It has been reported that about 25 per cent of the total animal diet of livestock is composed of browse trees and shrubs.

## Sea-Buck Thorn based Agroforestry systems in Cold Desert Areas

Sea buck thorn (*Hippophae rhamnoides*) is well known for its environmental benefits, desertification control and land reclamation in fragile cold arid ecosystems. It fixes nitrogen by symbiotic association with microorganisms. E.g. *Frankia* to the tune of about 180kg/ha/yr. its plantation serves as windbreaks and also checks pedestrian traffic. In Ladakh region, it harvested from wild at large scale and fruit pulp was sold worth of INR14 million in 2007 for making fruit juices as a trade name "Leh berry" which had medicinal value (Kashyap *et al.*, 2014).

## Agroforestry in Hyper Arid ecosystem

The hyper arid zone is dominated by *Lasiurus sindicus* grassland along with scattered shrubs or trees. The economy of the region is livestock based. Even with a low rainfall, the *L. sindicus* resprouts and provide 20-30 quintals dry fodder. If this grassland is reseeded properly, then 40-45 $qha^{-1}$ dry fodder can be harvested by cultivating guar in between grass rows. By adopting this grass legume system, in long run productivity of livestock would be increased.

## Dune agroforestry model

About 58 per cent of western Rajasthan is covered by different types of dunes. Growing of trees on dunes does not have economic returns to farmers as its main role is for dune stabilization and gestation period for economic return is very long. Therefore, CAZRI has developed models which can increase the economic returns as well as check dune movement.

**Table 2.** Economic return from agrisilviculture model (Bajra + *A. tortilis* (16 trees $ha^{-1}$) dune complex.

| Treatments | Gross returns (Rs. $ha^{-1}$) upto 15 years | | | | Returns |
|---|---|---|---|---|---|
| | Bajra seeds & straw | Tree wood | Gum from tree | Total (Rs.) | Rs. $ha^{-1}year^{-1}$) |
| Agrisilvicultural system | 19200 | 11200 | 10520 | 40920 | 2728.00 |
| Trees only | - | 22400 | - | 22400 | 1493.00 |
| Trees used for gum exudation at the age of 12-15years | - | 22400 | 23040 | 45440 | 3029.00 |
| Bajra alone | 24000 | | - | 24000 | 1600.00 |

(Source: Pathak and Ram Newaj, 2003)

In general for dune stabilization, trees are planted at the spacing of 5m x 5m for crest to foot heal. But if trees are planted in belt of 5 rows of trees, leaving a space of 50m between the two belts and if grass or crops are sown between two belts then in such situation crops can be harvested as well as soil erosion can be stopped. From this model, the economic returns were enhanced by harvesting gum production from *Acacia tortilis*. By injecting ethephon, on an average 400 g/tree can be harvested after $12^{th}$ year of plantation. The comparative economic analysis revealed that growing of bajra only on the dunes can

**Table 3.** Economic analysis of selected agroforestry systems prevalent in India.

| Sl no. | Zone/ region | Tree | Crop combination | years | Expenditure Rs/ha$^{-1}$ | Net benefit /ha$^{-1}$ net present value @15% DF | Internal Rate of Return (IRR) | B:C ratio |
|---|---|---|---|---|---|---|---|---|
| 1 | Eastern Himalayan | *Anthocophalus cadmba* | Paddy | 8 (irrigated) | 43776 | 24348 | 31 | 1.60 |
| 2 | Western Himalayan | *Prunus persica* | Maize soybean | 15 (Rainfed) | 57144 | 12039 | 30 | 1.21 |
| 3 | Lower Gangetic Plain | *Eucalyptus hybrid* | Paddy wheat | 10 (irrigated) | 86237 | 114532 | 32 | 2.33 |
| 4 | Middle Gangetic plain | *Bamboo* | grass | 10 (non-arable land) | 24796 | 18907 | 55 | 1.76 |
| 5 | Upper Gangetic plain | *Populus deltoides* | Paddy, wheat | 7 (irrigated) | 82292 | 190241 | 68 | 3.31 |
| 6 | Trans Gangetic plains | *Acacia nilotica* | Pearlmillet clusterbean | 20 (Rainfed) | 17262 | 27789 | 38 | 2.61 |
| 7 | Eastern Plateau & Hill | *Hardwickia binata* | Grass | 15 (non-arable land) | 60062 | 68035 | 47 | 2.13 |
| 8 | Central Palteau & Hill | *Emblica officinalis* | Groundnut gram | 8 (Rainfed) | 86494 | 7410 | 27 | 1.01 |
| 9 | Western Plateau & Hill | *Albizia amara* | Cenchrus ciliaris | 16 (Non-arable) | 62341 | 34952 | 43 | 1.56 |
| 10 | Southern Plateau & Hill | *Ceiba pentandra* | Groundnut | 15 (irrigated) | 109840 | 46746 | 28 | 1.43 |
| 11 | West Coast & Ghat | *Tectona grandis* | Sweet potato | 20 (Rainfed) | 209715 | 210246 | 30 | 2.00 |
| 12 | Western dry zone | *Prosopis cineraria* | Pearlmillet | 20 (Rainfed) | 14732 | 227968 | 36 | 16.5 |
| 13 | Gujarat Plains & Hill | *Dalbergia sisoo* | Castor | 20 (Rainfed) | 7080 | 8037 | 30 | 2.14 |

(Source: Pathak and Ram Newaj, 2003)

give the gross returns of Rs. 1600 $ha^{-1}year^{-1}$ and growing *A. tortilis* on the dunes for fixation purpose can give the gross returns of Rs. 1493 $ha^{-1}year^{-1}$ keeping 15 year rotation. But by using the imported agroforestry model i.e. growing of bajra with *A. tortilis* (160 trees $ha^{-1}$), the gross returns can be Rs.2002 $ha^{-1}year^{-1}$. In addition to improved model, gum exudation technique super imposed, then the gross return from agroforestry model can be Rs.2728 $ha^{-1}year^{-1}$. Thus, it is observed that agroforestry model with value addition can give Rs.1100 more than the pure cultivation of bajra, which is almost 68 per cent higher. It is reported and presented in Table 2 that in *A. tortilis* based agrisilvicultural system with value addition, the returns can be much higher [8].

## Increasing Farmer Income through diversification and commercialization

The role of agroforestry products such as timber, food, fruit, fibre, fodder and medicines and environmental services can progressively meet the subsistence needs of low income households and also provide a platform for greater and sustained livelihood of the society. Recent researches have also provided best and diverse alternative models of timber, fruit trees, crops and grasses combinations for different agroclimatic regions of the country. It also became possible to conduct diagnosis and design exercise for existing agroforestry practices in India. The economic analysis of dominant agroforestry systems based upon completion of one rotation is presented in **Table 3**. In regions of high fertility and good rainfall like Kerala, small farmers usually maximize returns from land through multistoried cropping where perennial trees such as coconut, arecanut, rubber and pepper are intercropped with seasonal and annual crops like tapioca, bananas, pulses and vegetables. Trees are preferred, which have multiple uses, especially yielding fruit, fodder and mulch. Most of the farmers in India combine agricultural crops with trees and livestock in their farming practices. India is also endowed with wide variety of agroecological regions such as arid and semiarid, low land humid tropics, upland sub-humid and humid tropics, temperate uplands and arid alpine uplands. There are different systems of agroforestry under different agroclimatic region. For example, silvipastoral systems (fodder-fuel) for cattle production and agrisilviculture system for soil conservation are practiced in tropical savannah (Pathak and Newaj, 2003).

The advantages derived from multiple cropping are many. With a greater diversity of crops, a farmer is less affected by market fluctuations and is able to shift from one crop to another depending on price and demand. At the same time, the harvest is spread out over a longer period of time. Less dependence on outside energy sources has obvious advantages, especially in areas where capital is limited.

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**How to cite this article:**

Ashok, Shantappa Tirakannanavar, Vithal Navi, Ratnakar M Shet, Shivanand Hongal, Raju Chavan, G.K.Halesh. (2016). Sustainable Silvi based cropping systems for improving socioeconomic status of horticulture farmers – A Review. Int. J. Adv. Res. Biol. Sci. 3(7): 99-104.