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Agroforestry and its Role in Sustainable Agriculture

Rajwant K. Kalia and Rakesh Pathak*

ICAR-Central Arid Zone Research Institute, Jodhpur-342003 Rajasthan

**Corresponding Author: pathakjodhpur@gmail.com*

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ABSTRACT

The agroforestry system utilizes trees for diversification and protects the ecosystem under prevailing climatic conditions. The system having multi-purpose horticultural and silvi-pastoral tree species play an important role in attaining food security in a sustainable manner. Agroforestry system is comparatively complex with respect to mono cropping system as it involves interactions between the components grown under the system. It enhances the flexibility of agricultural production and reduces the threats of crop failure during harsh climatic conditions. The present article summarizes the role of agroforestry in sustainable agriculture.

Keywords: Climate change, economic conditions, food security, restoration

INTRODUCTION

Population growth, reduction in the availability of resources, climate change etc. are the major challenges to agriculture. These challenges need to be addressed systematically to double the production of food. The conventional agriculture has several issues including climate change, biodiversity losses, land degradation and various social and environmental concerns (Pretty and Bharucha 2014). The intensive agriculture forced to clearing of extensive forests. The increasing efforts to enhance the agricultural production have also imposed serious issues including water and land degradation. Incidence of soil erosion, soil salinity/alkalinity, micronutrient deficiency, contamination of ground water etc. has become frequent due to the extensive utilization of fertilizers, pesticides and rigorous farming leading to lower productivity. Adoption of an appropriate agricultural system is the most sustainable way to cope up with these issues.

Farmers have been cultivating crops and trees together for centuries to realize sustainable yields. The system was defined as agroforestry during the initial period of 20th Century and was looked as an effective method to control soil erosion. Hence, agroforestry system is an improved way of land management in which trees and crops are grown together purposely to obtain higher yields and carbon sequestration. Integration of trees with the crop production has several advantages and is economically, socially and environmentally beneficial. Agroforestry offers enhanced availability of food, fodder, fuel and building materials and creates better source to

increase income. Growing of native and exotic fruit trees along with agricultural crops provides nutritional foods, diversified production to ensure supply of foods throughout the year. Produces obtained from trees sustain the losses and becomes the source of survivability of small hold farmers during harsh periods of crop failure.

Agroforestry generates a microclimate that protects crops from extreme sunlight, rains, erosion and enhances soil fertility. Adoption of agroforestry system not only offers food security to the small holding farmers but also helps in carbon sequestration and ecosystem services. It has been reported that agroforestry has potential to increase the yields depending upon the crops grown under the prevailing environmental conditions and knowledge of the growers (Waldron et al. 2015). The increase in the yield is basically a reflection of agroforestry system such as microclimatic conditions brought in by the trees, soil fertility status, minimum stress on the crop, moisture availability etc. The sustainable yield under agroforestry system is maintained due to the conserved soil fertility and crop resilience towards droughts, higher temperatures, improved water infiltration and reduced evapotranspiration (Charles et al. 2013). Besides these, agroforestry also offers livelihood resilience during the poor crop productivity as trees substitute income through fruits, fuel and fodder. The amalgamation of higher yields, lower input and tree-based produces can considerably enhance the net income of farmers (Miller et al. 2017). The major benefits of an agroforestry system are depicted in the figure below:

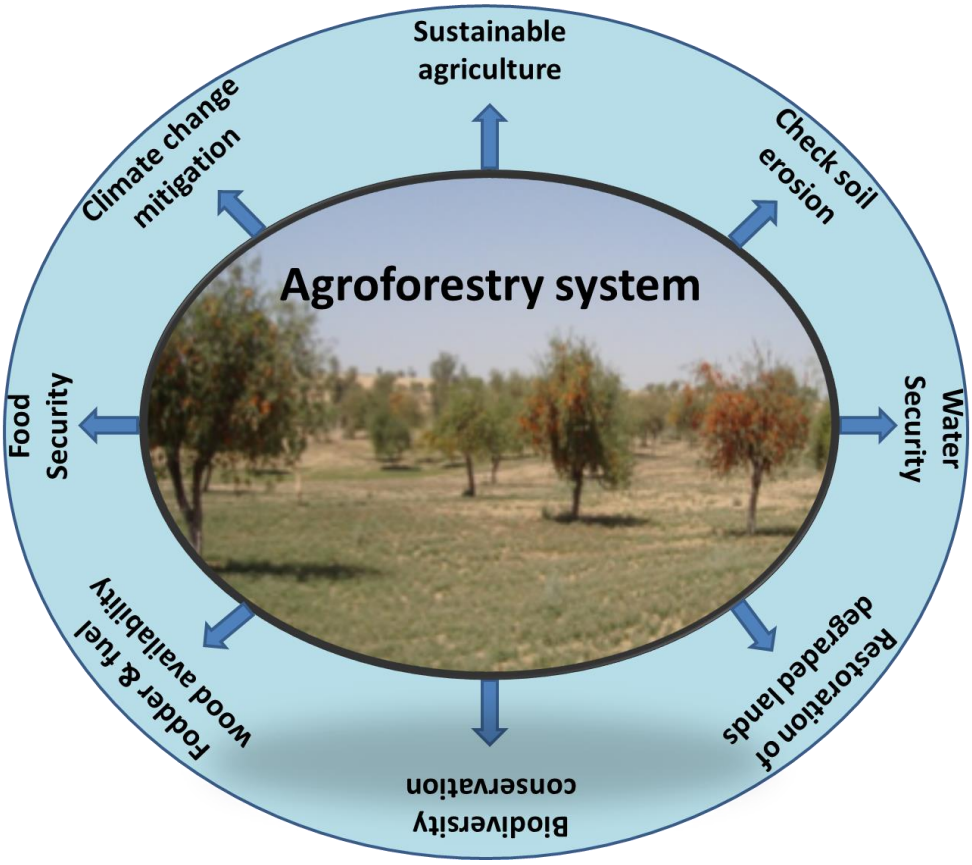

Fig: Benefits of agroforestry system

1. BENEFITS OF AGROFORESTRY SYSTEM

1.1 Sustainable Agriculture

Agroforestry system having multi-purpose horticultural and silvi-pastoral tree species play an important role in attaining food security in a sustainable manner. The woody component and fruits obtained from trees help small farmers to realize sustainable livelihood during the adverse climatic conditions. Medicinal plants and cash crops grown under agroforestry systems have immense values in enhancing the income of rural populace. Fast growing tree species may add an early income and contribute towards improving economic conditions of the farmers. Agroforestry system is comparatively complex with respect to mono-cropping system because it involves interactions between the components grown under the system (Sanchez 1995).

1.2 Checking of soil erosion

Soil erosion displaces the top soil, which is the most important layer having all the essential micro- and macronutrients for crop production. Hence, checking of soil erosion is essential to realize sustainable crop productivity. The potential of agroforestry in controlling the soil erosion has been underlined globally. The increased organic matter in the soil under agroforestry system improves soil structures and reduces the incidence of soil erosion. The dense canopies of trees diminish kinetic energy of rain and simultaneously reduce the soil erosion to a higher extent. Besides this, the shrubs and shrubby trees utilized under agroforestry system works as obstacle to runoff. Several investigations on soil loss and runoff using agroforestry models including Eucalyptus + bhabar grass, *Acacia catechu* + napier grass, Leucaena + napier grass, Teak + leucaena+ bhabar grass, Eucalyptus + leucaena + turmeric, poplar + leucaena + bhabar, Sesamum + rape seed has been carried out in the Himalayan region of India (Grewal 1993). Eucalyptus + bhabar grass was found more beneficial with respect to soil loss and runoff.

1.3 Restoration of degraded lands

The continuous deterioration of quality of lands is one of the major issues affecting the productivity of agricultural lands and the same has been emphasized by several workers globally. Enhancement in the vegetation coverage has been seen as the basic method to cope up with land degradation. Forest and trees have been looked upon as important components to check the land degradation and several studies have been carried out to tackle land degradation using agroforestry. The exploited agroforestry models exhibited higher productivity and significantly conserved the natural resources and improved the land quality. Various tree species including *Acacia farenesiana*, *Tamarix articulata*, *Prosopis juliflora*, *Pithecellobium dulce* and *Parkinsonia aculeata* were reported to be effective in the recovery of salt affected land (Singh et al. 1993). Eucalyptus trees were found effective in reclaiming the waterlogged areas while *P. chilensis* has the potential to reduce the pH, EC and sodium levels in the soil (Bhojvaid et al. 1996). Plantation of *Ipomoea carnea*, *Vitex negundo* and napier with *Erythrino suberosa*, *Dalbergia sissoo* and *Acacia catechu* have effectively stabilized the landslide-prone area at Nalotanala situated on the Dehradun-Mussoorie road in India (Sastry et al. 1981). Lower nutrient loss has been reported under agroforestry system as compared to several other cropping systems. The agroforestry model i.e. leucaena-napier grass had lower nutrient loss in comparison to cropping system (Grewal et al.

1994). Soil properties under different tree species in semi-arid region of Rajasthan revealed higher amount of soil microbial biomass, carbon, nitrogen and phosphorus under agroforestry system as compared to soil having no trees (Yadav et al. 2008).

1.4 Conservation of soil moisture and improvement of water

Agroforestry system provides better approach towards conservation of soil moisture and improvement of water through mulching. The system has potential to catch more water and simultaneously improve the availability of soil water. Impact of several agroforestry model comprising of *Prosopis cineraria*, *Tecomella undulata*, *Acacia albida* and *Azadirachta indica* were exploited to study the productivity of *Hordeum vulgare* under arid region (Kumar et al. 1998) and it was observed that the agroforestry models had significant impact on the yield potential of crop over the control. Deep-rooted trees grown under agroforestry system utilized the surplus nutrients applied to the crops. In this way, it decreases the groundwater pollution by filtering the water. The soil infiltration potential is enhanced under agroforestry system. In an experiment, three times higher infiltration rate was observed with the agroforestry model having eucalyptus and bhabar as compared to the agricultural field (Grewal et al. 1995). The multi-storeyed agroforestry system and silvi-horti-pastoral systems have higher potential to conserve soil moisture, improve soil structure and porousness.

1.5 Climate change mitigation

Agroforestry models have potential to capture atmospheric carbon and store them as carbon sink and also play important role in the process of carbon sequestration, thus plays an important role in the climate change mitigation. It may depend on the tree species, its age, density, geographic region and several management practices. Generally, tropical humid climatic regions have higher capability to sequester carbon as compared to arid, semi-arid and temperate areas. According to an estimate the 8.2 per cent area under agroforestry in India, adds about 19.3 per cent carbon in various land use systems (Fanish and Priya 2013) with an estimate of 2400 m tonnes of total carbon storage. The farms under agroforestry system have significantly contributed towards the mitigation of climate change and it has been reported that the system can add about 2000 lakh tonnes of carbon annually to the field (Zomer et al. 2016).

CONCLUSION

Varying food habits, increasing population, shortage of resources etc. are the major threats towards future agriculture wherein maximum potential of agricultural lands required to be exploited without any detrimental effects on the environment. The agroforestry models utilizing trees for diversification and protecting the farming systems are looked upon as one of the important methods of integrated cropping systems under prevailing climatic conditions. It enhances the flexibility of agricultural production and reduces the threats of crop failure during harsh climatic conditions. Agroforestry practices are attaining importance from the researchers towards development of approaches for food security and sustainable agriculture under climate change scenarios. Increased biological nitrogen fixation, nutrient cycling, soil physico-chemical properties, insect-pest control and availability of soil moisture are some of the key issues that may be exploited under agroforestry system for better crop production.

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