

NEED OF AGROFORESTRY AND IMPACT ON ECOSYSTEM

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Abstract: Agroforestry is a modern and scientific farming practice. It is a sustainable land use system under which food crops (annuals) with tree crops (perennials) and/or livestock are maintain simultaneously on the same piece of land to increase the total yield and this management practices are economically and ecologically sound. It is just a compromise between these two resources of forest trees and agricultural crops to maintain the need of forest cover upto 33% as per given national forest policy. Agroforestry has the potential to alter the microclimate under the tree canopy. It plays a major role in enhancement of overall farm productivity, soil fertility through addition of litter and organic matter, climate change mitigation through carbon sequestration, phytoremediation, watershed protection and biodiversity conservation. Upto some extent biodrainage plantation might have improve the soil aeration, sulphide toxicity and nutrient use efficiency. Moreover, it reduces the water logging condition and maintains the soil aeration property. Under the agroforestry system multipurpose and N₂-fixing trees are played a valuable and significant role for upliftment of productivity and combating the soil health problem. Generally, farmers are used N₂-fixing trees like some leguminosae family comprises *Acacia spp.*, *Dalbergia sissoo* etc. on their farmland for enhancement productivity with better soil health and generating incomes through employment. Therefore, scope and potential of agroforestry are envitable.

Keywords: Agroforestry, biodrainage, biodiversity, carbon-sequestration, farming system.

INTRODUCTION

Agroforestry may be defined as an efficient and integrated land use management system by raising of certain agricultural crops, forest tree species and or animals simultaneously or sequentially on the same unit of land with appropriate management practices which result in overall increase in the production under a particular set of climatic and edaphic conditions and socio-economic status of local people (King, 1969). It involves interaction of woody perennial ecologically and economically with the crop and or livestock. According to Dhyani *et al.* (2013) in India the current area under agroforestry is estimated at 25.32 Mha, or 8.2% of total geographical area of the country. This includes 20.0 Mha in cultivated lands (7.0 Mha in irrigated and 13.0 Mha in rainfed areas) and 5.32 Mha in other areas such as shifting cultivation (2.28 Mha), home gardens and rehabilitation of problem soils (2.93 Mha). Traditionally, farmers allow growing *Acacia nilotica* naturally at irregular spacing on the bunds of paddy fields or in combination with *Butea monosperma* and *Terminalia arjuna* etc. *Acacia nilotica*, being a multipurpose and nitrogen fixer species, is highly preferred by farmers and as a result, it is widely distributed in the field. Similarly, Jhariya *et al.* (2013) has concluded a large scale plantation of neem trees helps to combat desertification, deforestation, soil erosion and to reduce excessive global temperature. Tree species viz. *Dalbergia sissoo*, *Azadirachta indica*, *Acacia nilotica*, *Grewia optiva*, *Morus alba*, *Ficus spp.* etc are grown on the borders of fields for meeting demand of timber,

fodder, fuel etc is common practices throughout the country (Singh, 1993).

Management practices are played a major role in maintaining the identity and sustainability of agroforestry system. As per Manna *et al.* (2008) management practices for agroforestry are more complex because multiple species has varied phonological, physiological and agronomic requirements. Agroforestry provides great opportunities to link water conservation with soil conservation; hence, the major focus has to be on this aspect (Dhyani *et al.*, 2003). It is also noted that stainable agroforestry can upsurge resilience against environmental change, to enhance carbon sequestration and also to generate income, which will result in improved livelihood of small and subsistence farmers (Buchman, 2008). Moreover, the role and scope of agroforestry are also studied in way of biodiversity conservation, yield of goods and services to society, augmentation of the carbon storages in agroecosystems, enhancing the fertility of the soil and providing social and economic well-being to people (Pandey, 2007). Therefore, agroforestry if properly developed, have the potential to improve socio-economically more sustainable and make the landscape more better (Kittur and Bargali, 2013).

Scope and Potential

The scope and potential of agroforestry is envitable. Tree species are adopted in a large hectare of boundaries, bunds, wastelands area and permits in the field where most annual crops are growing well. As per Fanish and Priya (2013) agroforestry has many potential, such as enhance the overall (biomass) productivity, soil fertility improvement,

soil conservation, nutrient cycling, micro-climate improvement, carbon sequestration, bio drainage, bio-energy and biofuel etc. Moreover, the important elements of agroforestry systems that can play a significant role in the adaptation to climate change include changes in the microclimate, protection through provision of permanent cover, opportunities for diversification of the agricultural systems, improving efficiency of use of soil, water and climatic resources, contribution to soil fertility improvement, reducing carbon emissions and increasing sequestration, and promoting gender equity (Rao *et al.*, 2007).

Tree crop interaction

Under the agroforestry system the interaction between tree and crop are studied in positive, negative and neutral way. This interaction depends upon the type of model including varying species, their nature and composition. Further, interaction is defined as the effect of one component of a system on the performance of another component and/or the overall system (Nair, 1993). Various interactions take place between the tree and herbaceous plants (crops and pasture), which are referred to as the tree-crop interface. Studying tree-crop interaction in agroforestry would help to devise appropriate ways to increase overall productivity of land. Increased productivity, improved soil fertility, nutrient cycling, soil conservation are the major positive effects of interactions and competition is the main negative effect of interaction, which substantially reduces the crop yield. It may be for space, light, nutrients and moisture. Ecological sustainability and success of any agroforestry system depends on the inter-play and complementarity between negative & positive interactions. It can yield positive results only if positive interactions outweigh the negative interactions (Singh *et al.*, 2013).

Agroforestry and soil health

The property of soil under agroforestry practices is depend on tree species and their intercropping pattern, management practices, arrangement direction and the quantity and quality of litter and their decay rate. Trees are simultaneously planted in rows sparsely in crop field and/or along the alies (bunds). These trees provide food, timber, fuel, fodder, construction materials, raw materials for forest-based small-scale enterprises and other cottage industries and in some cases, enrich soil with essential nutrients (Ghosh *et al.*, 2011). According to Torquebiau and Kwesiga (1996) in agroforestry fallows with *Sesbania sesban*, decreased soil bulk density and improved water infiltration explain better early growth of the subsequent crop. Tree roots can reach 7 m deep in 2 years and represent 1.7 to 2.9 Mg ha⁻¹ after 2 years, i.e. about 0.6 to 1 Mg C ha⁻¹. Plantation of tree and crops are a boost to increase or sequester the carbon content of the soil which helps

to beat the problem of climate change and global warming. As per Kumar *et al.* (2006) increase in soil carbon through plantations may also act as an important carbon sink. Biodrainage tree including eucalyptus played a major role to combating the water logging condition. Chowdhury *et al.* (2011) has reported that biodrainage plantation might have improved the soil aeration, nutrient use efficiency and reduce sulphide toxicity. Agroforestry models are also helps in reclamation of salt affected soil. As per Ram *et al.*, (2011) lowering of water table and associated soil improvement by *Eucalyptus* plantations increased the wheat grain yield by 3.4 times and resulted in reclamation of waterlogged areas. Generally, agroforestry practices increases the soil organic matter through leaf litter addition. It maintains the population dynamics of beneficial microorganism and improves biological nitrogen fixation in soil. All microbiological activity in soil contributes to cycling of nutrient and other ecosystem functions and all soil functions contributes to ecosystem services. Recycling in natural system is one of the many ecosystem services that sustain and contribute to the well being of human society (Jhariya and Raj, 2014).

Agroforestry for CO₂ mitigation

Climate change is a burning issue of the world. Rise in CO₂ level accelerate the global warming which necessitated the sink and sequestration of carbon. These problems are mitigated through plantation of valuable tree and crop either singly or simultaneously on same piece of land through agroforestry system. As per Nair *et al.* (2009) under the agroforestry system carbon sequestration has potential to mitigate the green house gases because of greater efficiency of resource (nutrients light and water) capture and utilization. Moreover, reforestation and agro-forestry systems offer perhaps the greatest potential to remove large quantities of carbon from the atmosphere. However, as per Sudha *et al.* (2007) agroforestry is an attractive option for climate change mitigation as it sequesters carbon in vegetation and soil, produces wood, serving as substitute for similar products that are unsustainably harvested from natural forests, and also contributes to farmers' income. Similarly, according to Kursten (2000) agroforestry can, arguably, increase the amount of C stored in lands devoted to agriculture, while still allowing for the growing of food crops. According per given report of FAO (2007) and Rawat (2010) the total C content of forests has been estimated at 638 Gt for 2005, which is more that the amount of carbon in the entire atmosphere. In India total carbon storage (tC/ha) of different agroforestry systems including Silvi-pastoral system (age 5 years), Silvipastoral system (age 6 years), Block plantation (age 6 years), Agri- silvicultural system (age 8 years) and Agri-silvicultural system (age 11 years) are varies from 9.5-19.7, 1.5-18.5, 24.1-31.1, 4.7-

13.0 and 26.0 respectively in different region of semi-arid (Rai *et al.*, 2001), north western India (Kaur *et al.*, 2002), central-India (Swamy *et al.*, 2003), arid (Singh, 2005) and semi-arid region (NRCAF, 2005). As per Yadava (2010) C sequestration ranged from 4.66 to 18.53 t C ha⁻¹ in different agroforestry systems in Tarai region of Central Himalaya. Maximum value was recorded in systems S1 (*Populus deltoides* 'G-48' + wheat) as 18.53 t C ha⁻¹, which was followed, by systems S4 (*P. deltoides* + Lemon grass). Minimum C sequestration was recorded in System S3 (*P. deltoides* + wheat boundary plantation). Further, Verma *et al.* (2008) studied soil organic carbon and sequestration potential of agroforestry Systems in Himachal Pradesh and found average carbon stocks (t ha⁻¹) in the decreasing order as Silviculture (31.71), Natural grassland (19.2), Agrihorti silviculture (18.81), Horti-pastoral (17.16), Agri-silviculture (13.37) and Agri-horticulture (12.28). Thus the importance of agroforestry are not only studied in the way of sustainable productivity but also in issue related the carbon mitigation in global view.

Agroforestry and microclimate amelioration

Trees on farm bring about favourable changes in the microclimatic conditions by influencing radiation flux, air temperature, wind speed, saturation deficit of understory crops all of which will have a significant impact on modifying the rate and duration of photosynthesis and subsequent plant growth, transpiration, and soil water use (Monteith *et al.*, 1991). Shade tree performs a good role to moderating the temperature, humidity, evapotranspiration of that locality on which either tree are scattered or on bund of agricultural crops under the agroforestry system. As per Beer *et al.* (1998) shade management in coffee and cacao plantations have buffer high and low temperature extremes by as much as 5°C. According to Steffan-Dewenter *et al.* (2007) the removal of shade trees increased soil surface temperature by about 4°C and reduced relative air humidity at 2 m above ground by about 12%. Soil temperature under the baobab and *Acacia tortilis* trees in the semi-arid regions of Kenya at 5-10 cm depth were found to be 6°C lower than those recorded in open areas (Belsky *et al.*, 1993). In the Sahel, where soil temperatures often go beyond 50°C to 60°C, a major constraint to establish a good crop, *Faidherbia* trees lowered soil temperature at 2-cm depth by 5°C to 10°C depending on the movement of shade (Vandenbeldt and Williams, 1992). As per Mukherjee *et al.* (2008) tea under plantation of alley of seven shade tree species including *Acacia auriculiformis*, *Casuarina equisetifolia*, *Dalbergia sissoo*, *Gliricidia sepium*, *Albizia lebbek*, *Gmelina arborea* and *Eucalyptus hybrid* and reported that both atmospheric temperature and Soil temperature were lowered by 2-3 °C compared to a non-shaded open condition,

whereas relative humidity values increased by 3-9% within the shade. The shade provided by *Acacia auriculiformis* and *D. sissoo* seemed to be beneficial for tea yield. Shelterbelt and windbreak are also perform protecting function in term of beneficial aspects of microclimate change are extensively used. Based on the response of crops to shade, Brenner (1996) has classified leafy horticultural crops (e.g., alfalfa, clover) as the most responsive crops and cereals as moderately responsive (e.g., barley and millet) or less responsive (e.g., maize, and wheat). The net shade effect was reported to be more positive when the annual crop is a C3 plant which is normally light saturated in the open (Ong, 1996).

Socioeconomic development

Agro-forestry as a land use system that integrates trees, crops and animals in a way that is scientifically sound, ecologically desirable, practically feasible and socially acceptable to the farmers (Nair, 1979). It can improve the livelihoods of smallholder farmers as by providing fruit and nuts, fuel wood, timber, medicine, fodder for livestock, green fertilizers, additional / diversified income (WAC, 2010). Agroforestry models for different site conditions have to be developed and demonstrated under different agro-ecological regions in the country. In Chhattisgarh state, Agri-horticulture model comprises combination of horticulture tree (Aonla) and field crops (groundnut and gram) and their different parameter of economic analysis (input/output) including total expense (tree+crops) per ha (86,494 Rs.), total benefits per ha (93,903 Rs.), net Benefit per ha. (7,410 Rs.), B: C ratio (1.09). Similarly, Agri-silviculture system comprises combination of tree species (*Gmelina arborea*) and field crop (paddy and linseed) and their economic parameters are total expense (tree+crops) per ha (69139 Rs.), total benefits per ha (119,997 Rs.), net benefit per ha. (50,858 Rs.), B: C ratio (1.74). These economic analysis are sufficient to measure socio-economic potential of different agroforestry models and gives idea about whether this model be accepted or not (GoI, 2001).

CONCLUSION

Agroforestry is not a something new. It is a relatively new name for a set of old farming practices. Agricultural crops (herbaceous plants), woody perennials (tree crops/ forest plants) and animals are the component of Agroforestry. Under the agroforestry model, a suitable combination of nitrogen fixing and multipurpose trees with field crops are played a major role in enhancement of better yield productivity, soil nutrient status and microbial population dynamics which plays a major role in nutrient cycling to maintain ecosystem. In developing countries forests and agroforestry provide substantial benefits to rural dwellers, national

economies, and the environment. Therefore, Agroforestry system gives diversification, creates green cover for carbon sequestration and increases the nutrient uptake and their utilization management practices that lead to improved organic matter status of the soil will lead inevitably to improved nutrient cycling and better soil productivity.

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