REVIEW ARTICLE

MULTIFARIOUS SCOPE OF AGRO-FORESTRY

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Abstract: Agroforestry is an ecologically sustainable land use system that maintains increase total yield by combining food crops (annuals) with tree crops (perennials) and/or livestock on the same unit of land. A large hectare is available in the form of boundaries, bunds, wastelands where this system can be adopted. Farmers retain tree of *acacia nilotica*, *acacia catechu*, *Dalbergia sissoo*, *Mangifera indica*, *Zizyphus mauritiana* and *Gmelina arborea* etc in farm land. Agroforestry-the deliberate combination of woody perennials on the same piece of land with agricultural crops and/or animals, plays a crucial role in climate change mitigation especially due to its tree component. Trees accumulate CO_2 (which is the most predominant GHG) in their biomass. Agroforestry not only helps in climate change mitigation but also climate change adaptation. It is an established fact that despite our present effort at climate changes mitigation (GHG reduction), there is a more pressing need to cope with the impact of climate change (adaptation). For instance, the trees in agroforests provide shade for both companion crops and the farmer against the rising temperatures, and also shelter the crops against the harmful effect of raging storms. The presence of trees on the farms ensures income diversification through the provision of additional resources like fruits, nuts, timber, vegetables, fodder, etc. People should be aware about the scope and benefits of Agroforestry and they should participate in implementation and development of Agroforestry in India. Therefore, agroforestry system is economically and ecologically sound practices with enhancement of overall farm productivity, soil enrichment through litter fall, maintaining environmental services such as climate change mitigation (carbon sequestration), phytoremediation, watershed protection and biodiversity conservation.

Keywords: Agroforestry, Biodiversity, Bund, Climate change, Phytoremediation

INTRODUCTION

Agro-forestry is not a new system or concept. The practice is very old. Agro-forestry (AF) can be defined as "a collective name for land-use systems in which woody perennials (trees, shrubs, etc.) are grown in association with herbaceous plants (crops, pastures) or livestock, in a spatial arrangement, a rotation, or both; there are usually both ecological and economic interactions between the trees and other components of the system" (Lundgren, 1982). In simple terms, it consists of raising tree species and agricultural crops on the same piece of land, resulting in unique ecological interactions and maximized economic returns (Young, 2002). These systems are deliberately designed and managed to maximize positive interactions between tree and non-tree components and encompass a wide range of practices like contour farming, intercropping, established shelterbelts, riparian zones/buffer strips, etc. The fundamental idea behind the practice of AF is that trees are an essential part of natural ecosystems, and their presence in agricultural systems provides a range of benefits to the soil, other plant species and overall biodiversity. With threats that smallholder farmers in the developing world face with predicted impacts of climate variability and change, the scope of AF systems to reduce vulnerability and adapt to the conditions of a warmer, drier, more unpredictable climate is now being recognized (McCabe, 2013). Ecological sustainability and success of any agroforestry system depends on the inter-play and complementarily between negative & positive interactions. It can yield positive results only if positive interactions outweigh the negative interactions (Singh *et al*., 2013). AF systems are also being increasingly recognized as a tool for mitigating climate change by reducing the overall volume of greenhouse gases in the atmosphere and profiting the economically weaker sections from emerging carbon markets. Significant research on the types of AF systems, their impacts on the environment, social and economic aspects has been carried out over the years at a range of spatial scales, right from local to regional and global scale. In this paper, the impacts of AF systems on various aspects such as ecology and environment, aesthetics and culture, social and economic status of farmers practicing AF and finally, climate change mitigation and adaptation is discussed, based on a review of papers over the temporal and spatial scale.

Constraint in Agro-Forestry systems

(a) Agro-Forestry technology development and transfer programmers are not adequately incorporating farmers' relevant criteria to evaluate the impact and implications of their work.

(b) Farmer participatory approaches are not being exploited in the various phases of development problem identification, programme design, technology transfer etc.

Components in Agro-Forestry system

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

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enterprises and other cottage industries and in some cases, enrich soil with essential nutrients (Ghosh *et al*., 2011). Management practices for agro-forestry are more complex because multiple species having varied phonological, physiological and agronomic requirements are involved (Manna *et al*., 2008). Woody perennial tress, herbaceous crops and livestocks are the major components of Agro-Forestry system which can control and governed by village peoples and farmes that residing in/around the village. Therefore, farmers play an inevitable role in Agro-Forestry management and development in any area. Land is another essential component which affects existence of Agro-Forestry models as per changing agroclimatic zones. In lieu of the above components, farmers role in Agro-Forestry are described below,

Farmer: For the purpose of this survey, a farmer is defined as "a person who operates some land and was engaged in Agro-Forestry. The poor, particularly the rural poor, depend on nature for many elements of their livelihoods, including food, fuel, shelter and medicines (Jhariya and Raj, 2014). Agricultural activities is meant the cultivation of field crops and horticultural crops, growing of trees or plantations (such as rubber, cashew, coconut, pepper, coffee, tea, etc.), animal husbandry, poultry, fishery, bee-keeping, vermiculture, sericulture, etc. Thus, a person qualifies as a farmer if

(i) he possessed some land (i.e. land, either owned or leased in or otherwise possessed),
(ii) It may be noted that persons engaged in Agro-Forestry / allied activities but not operating a piece of land are not considered as farmers. Similarly, agricultural labourers,
(iii) Coastal fishermen, rural artisans and persons engaged in Agro-Forestry services are not considered as farmers. It is also quite possible such farmers are also excluded from the coverage of the present Situation Assessment Survey.

Farmer household: A household having at least one farmer as its member is regarded as a farmer household in the context of the present survey. The expenditure incurred by a household on domestic consumption during the reference period is the household's consumer expenditure. Household consumer expenditure is the total of the monetary values of consumption of various groups of items, namely

(i) food, pan (betel leaves), tobacco, intoxicants and fuel & light,
(ii) clothing and footwear
(iii) miscellaneous goods and services and durable

Enhancing Soil Fertility and Water Use Efficiency

This is a debatable concept today as soil is "friends or foe". Indeed, soil works as substratum which can hold all the living and non-living substance. Soil provides some essential nutrients to the tree and crops by decomposition and decaying of plant residues which can represented by leaf and liiter shedding in frequent time interval in any agro ecosystem models. Trees in Agro ecosystems can enhance soil productivity through biological nitrogen fixation, efficient nutrient cycling, and deep capture of nutrients and water from soils. Even the trees that do not fix nitrogen can enhance physical, chemical and biological properties of soils by adding significant amount of above and belowground organic matter as well as releasing and recycling nutrients in tree bearing farmlands. In 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 (Raj *et al*., 2014a). As per Raj *et al*. (2014b) the soil biological attributes are also responsible for determination & maintenance of physical properties of soil. Ecological intensification of cropping systems in fluctuating environments often depends on reducing the reliance on subsistence cereal production, integration with livestock enterprises, greater crop diversification, and Agro-forestry systems that provide higher economic value and also foster soil conservation. The next green revolution and concurrent environmental protection will have to double the food production.

Agro-forestry may hold promise for regions where success of green revolution is yet to be realized due to lack of soil fertility. A useful path, complementary to chemical fertilizers, to enhance soil fertility is through Agro-forestry. Alternate land use systems such as Agro-forestry, agro-horticultural, agro-pastoral, and Agrosilvipasture are more effective for soil organic matter restoration. Soil fertility can also be regained in shifting cultivation areas with suitable species.

Adaptation role of Agro-forestry

Agro-forestry systems can be useful in maintaining production during both wetter and drier years. During the drought deep root systems of trees are able to explore a larger soil volume for water and nutrients, which will help during droughts. Furthermore, increased soil porosity, reduced runoff and increased soil cover lead to increased water infiltration and retention in the soil profile which can reduce moisture stress during low rainfall years. Tree-based systems have higher evapotranspiration rates and can thus maintain aerated soil conditions by pumping excess water out of the soil profile more rapidly than other production systems. Finally, tree-based production systems often produce crops of higher value than row crops. In drought-prone environments, such as Rajasthan, as a risk aversion and coping strategy, farmers maintain Agro-forestry systems to avoid long-term vulnerability by keeping trees as an insurance against drought, insect pest outbreaks and other threats, instead of a yield-

maximizing strategy aiming at short-term monetary benefits. Numerous examples of traditional run-off Agro-forestry discussed in this article and elsewhere are other examples of adaptation to climate variability.The role of Agro-forestry in reducing the vulnerability of agro ecosystems—and the people that depend on them—to climate change and climate variability needs to be understood more clearly

Analysis of Existing Land –Use System

Common factors usually noted with regard to the analysis of an existing land use system are:

(a) Resource allocation at the community and household levels with respect to land, labour and inputs in alternative on farm and off farm activities and resource with respect to land, tree, animals and water are not well understood.
(b) Management levels associated with the various production system of crop , livestock or tree are not well understood
(c) Performance (yield) in terms of meeting socioeconomic priorities and criteria of the household are not usually measured. Therefore governmental projects should be analyzed to identify the extent to which they are addressing these socioeconomic factors in the analysis of land –use systems.

Biodiversity Conservation

Biodiversity is threatened worldwide, and despite some local successes, the rate of biodiversity loss does not appear to be slowing. This can decrease ecosystem functioning and services. Different species promote ecosystem functioning during different years, at different places, for different functions and under different environmental change scenarios. The species needed to provide one function during multiple years are often not the same as those needed to provide multiple functions within one year. Therefore, precautionary investments are required for managing biodiversity over the landscape. Actions focused on enhancing and restoring biodiversity are likely to support increased provision of ecosystem services.

Assessment of Agro-forestry Technologies

Common problems identified relating to assessment of Agro-forestry technologies are planning of Agro-forestry projects Is not appropriately addressing the socioeconomic potentials, Impacts and implications of improving or integrating new Agro-forestry projects are not adequately and systematically assessing the economic viability and social acceptability of on farm research of extension work. There is no training program to evaluate Agro-forestry technologies. Hence the following socioeconomic criteria should be addressed in technology assessment:

(a) Net returns to labourers and cash resources
(b) Compatibility with other on –farm and off farm activities of the house-hold.
(c) Technology effects on the reduction / increase of risk and uncertainty normally faced by farmers.
(d) Technology effects on the responsibilities of household members with respect to resourse allocation , implementing charges and receiving the benefits
(e) Technology effects on the goals /objectives of the household and their relations in the community.

Infrastructure and Support for Agro-forestry

It is generally noted that infrastructure and support services for Agro-Forestry are inadequate because Agro-Forestry. Information support (technical communication, farmer, training, on- farm demonstration research support etc.) does not exist in most areas of the country. Credit is restricted by conventional policies and markets for Agro-Forestry products are not well developed and promoted and multipurpose tree seeds, seedlings, and access to nurseries and other sources of inputs may not be adequately developed. To be freed problems. The following criteria should be considered.

(a) Government policy on rural service centres should take into account the needs for Agro-Forestry.
(b) Training of extention workers should aim at an all-round extention worker who can handle the multidisciplinary and multicommodity issues of Agro-Forestry and land-use systems.
(c) Agro-Forestry development should be supported with appropriate technology services at rural markets and growth centres.
(d) Project design should be such that adequate technical and managerial skills are passed on so that by the end of the project local households or farmers themselves can take over the project effectively.

Economic and Agriculture Development Policies

Operation and implementation of policies related to Agro-Forestry development present an extremely difficult task of co-ordination across government must ministries and departments.

The fact remains that based on the socioeconomics system of a place appropriate technology needs to be provided so that it becomes acceptable to the people in the north east region where the jhum system is to be followed the new system should not only make good the return from jhum cultivation but should give substantially higher returns with elimination of jhum practices which are undesirable. Likewise, in the arid region of Rajasthan, the economy of the farmer is based on rain-fed agriculture and animal husbandry, for which dry-land agriculture has been adopted with scattered trees of Prosopis species, a multipurpose tree which provides fuel, fodder, food, and timber and also enriches the soil through nitrogen fixation. The system provided to such area should be such the farmer could harvest better through rain-fed agriculture and also grow trees in the most efficient manner. Jatropha based intercropping systems has potential to improve the socioeconomic conditions in rural areas and to

transform the National energy scenario and the ecological landscape (Raj *et al.*, 2016). Similarly, gum production is a pillar of family economy and considered as an income-generating source that requires only a low input of work after the rainy season (Raj *et al.*, 2015; Raj, 2015a). As per Painkra *et al.* (2015) India is a rich diversity centre of medicinal and aromatic plants and plays an important role in supporting health care system in India. The central India comprises, Madhya Pradesh, Chhattisgarh, Andhra Pradesh, Orissa, Jharkhand and Bihar and to some extent Gujarat and Rajasthan are major source of commercially important gums in good quantity and forms one of the major ecosystems of the Indian subcontinent and constitutes a large tract of tropical dry deciduous and tropical moist deciduous forest type (Raj and Toppo, 2014; Toppo *et al.*, 2014). The tree characteristic that are particularly important to many local communities include smokiness of fuelwood fodder, fodder and flavours imparted by fuelwood and charcoal and thorniness.

Accordingly, relevant technologies for different situations should be made available to make this land-use system a reality.

Agro-forestry Promotion

The World Congress on Agro-Forestry with the theme 'Trees for Life' was organized in February 2014 at New Delhi to have a forward outlook to any constraints that might restrict the adoption of Agro-Forestry practices. Moreover, NAP, 2014 is a path-breaker in making Agro-Forestry an instrument for transforming the lives of the rural farming population, protecting ecosystem and ensuring food security through sustainable means. The major highlights of the Policy are establishment of institutional set-up at the national level to promote Agro-Forestry under the mandate of the Ministry of Agriculture GoI simplify regulations related to harvesting, felling and transportation of trees grown on farmlands; ensuring security of land tenure and creating a sound base of land records and data for developing an market information system (MIS) for Agro-Forestry. Investing in research, extension and capacity building and related services; access to quality planting material; institutional credit and insurance cover to Agro-Forestry practitioners. Increased participation of industries dealing with Agro-Forestry produce, and strengthening marketing information system for tree products. One of the objectives of NAP, 2014 is to bring together various programmes, schemes, missions among the elements of Agro-Forestry under one platform functioning in various departments of agriculture, forestry and rural sectors of the government. It is proposed to be achieved through setting up of a National Agro-Forestry Mission/ Board under the Department of Agriculture and Co-operation (DAC), Ministry of Agriculture, GoI and upgrading of NRCAF, Jhansi (now CAFRI, Jhansi) as a nodal centre with agro-ecology-based regional centres in different parts of the country. This step will promote value chain, climate-resilient technology development and pave the way for region-based marketing linkages in Agro-Forestry.

CONCLUSION

Agro-forestry is an interactive and sustainable farming practice which not only maintains structure and diversity but also helps in boosting income of farmers by providing mulfarious products as timber and NTFPs. The scope and potential of Agro-Forestry should not be underestimated in term of providing food and nutritional security, phytoremediation, mitigating climate change, effective bio-geochemical cycle, water and nutrient management, watershed management and providing socio-economic security to farmers. Therefore, a scientific oriented research should done under the partnership of several government, non-govermental institutions, university, NGOs etc for proper and effective management of both traditional and new age Agro-Forestry systems.

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