International Journal of Agriculture and Forestry 2013, 3(4): 178-184
DOI: 10.5923/j.ijaf.20130304.09

Analysis of Socio-Economic Conditions Influencing Adoption of Agroforestry Practices

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Abstract Recent years have witnessed a significant improvement in the adoption and promotion of agroforestry technologies among smallholder farmers world-wide and in particular, developing countries. This paper examines the main socio-economic factors related to farmers' decision to adopt and promote agroforestry practices. While environmental factors such as topography, soil types and climatic factors affect plant growth and development, findings suggest that the main socio-economic factors that determine the actual occurrence of agroforestry are household security, access to capital and incentives, labour, gender, land tenure, farm size and knowledge for management. Sustainable development through agroforestry can be achieved through genuine and continuous involvement of farmers in agroforestry activities. Recognizing and addressing fundamental factors that determine involvement of people in developmental activities predisposes an agroforestry project to genuine local participation.

Keywords Adoption, Agroforestry, Multipurpose Trees, Social Forestry, Socio-Economic Factors

1. Introduction

Present day advances in forest management have expanded its scope to accommodate methods and techniques involved in the management of trees for multiple uses rather than for timber alone in order to improve their economic, social and ecological role under dryland conditions. Agroforestry (AF) is one of the recent developments in forest sciences concerned with an integrated interdisciplinary approach to sustainable land use and on-farm tree management for multiple purposes.Various indigenous AF systems comprise a multitude of little-known woody species that have come to be described as 'multipurpose trees' or 'multipurpose trees and shrubs' (MPTs). For example, many fruit-producing trees are basic components of traditional home gardens in several developing countries[41]. This multifunctional role of AF has also been stressed by both the[33] and the[23].

Agroforestry, the growing of trees and crops on the same land with or without animals is an important land-use system which is widely practised in the developing world[41]. It has been described/defined in several ways. Most do not distinguish between the principle on which all agroforestry is based and the systems which are particular expressions of the principle in particular circumstances[56]. Perhaps the most comprehensive definition is that of the World Agroforestry Centre (known as the International Centre for Research in Agroforestry, ICRAF before 2002):

"Agroforestry is a collective name for land-use systems and practices where woody perennials (trees, shrubs, bamboos, vines etc.) are deliberately integrated to create an agro-ecosystem with crops and /or animals on the same land management unit. The integration can either be in spatial mixture or in time sequence. There must be both ecological and economic interactions between the woody and non-woody components to qualify it as agroforestry"[28].

This definition by[28] underlies a classification in agrosilvicultural (trees with crops) and silvopastoral (trees with pastures) practices, sequential and simultaneous systems and in zonal and mixed arrangements of trees and crops[39, 56]. Social forestry encompass agroforestry concepts and technologies[39] and the phrase 'social forestry' is widely used to refer to the practice of using trees and/or tree planting specifically to pursue social objectives, usually betterment of the poor, by providing forest products and/ or services to the local people; it is sometimes described as "tree growing by the people, for the people"[14, 11, 39, 56]. Although existing as an age-old tradition of land use practice[17], AF emerged in the 1970s as a modern, improved land-use system suitable for scientific study[32, 55].

The value of agroforestry is generally attributed to the ability to overcome some general problems for rural land use in many developing countries when making use of these production

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Published online at http://journal.sapub.org/ijaf

systems[57, 3,7]. The problems are related to deforestation, environmental degradation, scarcity of tree products, marginal crop yields and scarcity of chemical inputs[18, 5]. Now awareness has grown over the possibilities that AF can offer to increase productivity, increase rural household security and provide regional environmental benefits. In a study,[41] found that combining trees and crops in spatial or temporal arrangements helps to improve food and nutritional security and mitigate environmental degradation, offering a sustainable[40] alternative to monoculture production. He added that by providing supportive and complimentary roles with a flexible approach, AF can contribute significantly to the total social and environmental benefits across a range of landscapes and economies[4, 49].

AF interventions, range from introducing completely new techniques, to rehabilitating or modifying existing systems; this though was not the case. The agroforestry principles rest upon a much wider array of ecological interactions than monocropping[48]. The degree and type of interactions depend on the architecture and dynamics of the system in terms of component[43]. In a sequential situation the maximum growth of the woody and herbaceous component occurs at a different time. In this case the woody perennials usually increase the yields of subsequent crops and pastures by improving the soil conditions. In simultaneous associations sharing of space and resources such as light, nutrients and water occurs. If one of this resources is in short supply, competition between the species takes place. This implies that the successful application of an agroforestry system is specific for both a site and an agro-ecologicalzone.

The empirical results of several years of research indicate that increased nitrogen (N) input through biological nitrogen fixation by nitrogen-fixing trees (NFTs)[2], improved availability of nutrients as a result of production and decomposition of tree biomass, and higher uptake and utilization of nutrients from deeper layers of soils by deep-rooted trees[48]. Additionally, the existence of deep-rooted trees in the system plays major ecological roles in improving soil physical conditions and greater soil microbiological activities under agroforestry. NFTs are important resource for soil improvement in the tropical regions, where there are many of such trees and where farmlands deteriorate in terms of lack of nutrients due to lack of adequate awareness and education among the farmers to adequately apply fertilizer after harvesting or allow the land to fallow. Integrated farming system involving the use of fertilizer trees is one of the favourable ways to address this problems as it increases on-farm food production[ibid.,41]. It is also pointed out that the integration of woody species in agroforestry systems can increase the amount of carbon sequestered compared to amonoculture field of crop plants or pasture[52, 26]. Many scientists are becoming increasingly aware of the role agroforestry plays in conserving biological diversity[47] in both tropical and temperate regions of the world[e.g. 51, 29, 20]. Shade coffee exemplifies an agroforestry system that demonstrates great promise to improve biodiversity compared to traditional agricultural practices[46, 34, 7]. Also, multistrata cacao (Theobroma cacao) agroforestry systems that consist of timber, fruit, and native forest species play important roles in biodiversity conservation[30] by providing habitat for avian, mammalian, and other species, improving landscape connectivity, and reducing edge effects between forest and agricultural land.

Even though AF practices show great promise, the record of adoption has been uneven. As[38, 45] aptly point out, despite some impressive scientific and technological advances, AF rural development efforts were frequently unsuccessful. Although AF projects failed for a number of different reasons, one common factor was the inadequate attention given to socio-economics in the development of systems and projects[32, 7, 31]. [10]mention that, many projects failed because producing benefits for farmers was rarely an important objective of AF.[8] related the poor performance of social forestry projects to lack of people's participation, the very foundation for self-help projects. To remedy this, many AF institutions are now calling for increased socio-economic research[32]. By examining less than successful projects, planners have increasingly recognized the importance of social and economic factors in the adoption of these systems[24].

According to[36], AF requires in-depth social and economic analyses in assessment of economic feasibility of agroforestry systems and factors contributing the adoption of agroforestry. They also stressed the importance of monitoring the relevance and effectiveness of investigations that can guide future research efforts.

The following section discusses a wide range of factors that influence the adoption decision of a farmer and explains the heterogeneity between individuals.

2. Conditions for the Successful Promotion of Agroforestry

Recent years have witnessed an increasing interest in the adoption and promotion of agroforestry technologies among smallholder farmers world-wide and in particular, developing countries. People live within a physical environment. Physical factors such as soil type, vegetation, climate and topography all influence agroforestry. However, socio-economic issues concern the human environment within which people live and act. The selection criteria for farmers' adoption of agroforestry practices depend on a number of physical (environmental) as well as socio-economic pre-conditions that are related to successful cultivation of perennial crops and in particular trees[12,44].

In the first place, the climatic conditions that go with elevation are important for trees to grow [44]. Secondly, the soil types, especially the deep ones, offer great potential for tree growing. While the above environmental preconditions determine the promotion of agroforestry it becomes important to understand the main socio-economic factors that determine the actual occurrence of agroforestry and these are: household security, access to capital and incentives, labour, gender, land tenure, farm size and

knowledge for management.

The following sections address the potential socioeconomic factors, with the most direct connection to farmers and communities. The sections examine some of the main factors related to adoption of AF techniques, namely household security, access to capital and incentives, labour, gender, land tenure and knowledge for management. Factors examined are mainly ones directly related to farmer adoption; some attention is given in the conclusion to the policy aspects that influence adoption.

2.1. Household Security

Household security, as a factor in the adoption of AF systems, relates to the need that any introduced system must at least not detract from farmer/household security, and at best increase it[22]. The reliance of people on trees and forests is limitless. Nearly 1.6 billion people in the world rely on forest resources for their livelihood[59] and 1.2 billion people in developing countries use trees on farms to generate food and cash[13].While farmers are often aware of environmental degradation caused by their current practices and understand the long term benefits of AF, they are reluctant to adopt them unless the security of their household is not put at risk and preferably enhanced such as through meeting basic needs e.g. food or poles or through production of goods which can be sold. For example, AF systems may be introduced to create windbreaks, prevent soil erosion, improve the soil quality, species variety, or control of weeds. Although such projects may bring indirect benefits to the farmers, they are not likely to be successful if the species used do not bring direct, observable benefits. In Niger, the establishment of windbreaks was helping to prevent soil erosion however maintenance of the windbreaks depended on management and inputs from the Non-Governmental Organization (NGO) which started it[25]. While it seems that the windbreaks were having a positive effect on yields, it was not enough for an incentive for farmers to manage them on their own. Another example is alley farming where farmers must wait 3-4 years before their yields increase, when the soil fertility is improved. For some farmers, this could be an unacceptably long period to wait for a return on their investment, so projects should include some sort of transition period until benefits begin to pay back.

Security can be enhanced by an AF system through provision of basic needs such as food, construction wood, and fuelwood, through cash income or through decreasing labour or input costs[10]. On the other hand, adoption of an AF system brings risks that are less familiar to a farmer. The choice of system should then be guided by the farmers and their households and compromises may have to be made particularly when the intervention has a wider goal than benefits to the farmer.

A home garden system may be more interesting[27] where subsistence food needs are not being met by the current production system. In Zimbabwe, the Rural Afforestation Project, which had the objective of increasing fuelwood supplies through woodlot establishment, was discovered to have the wrong orientation[25]. After a survey of farmers, it was found that planting fruit trees was most popular followed by trees for shade or ornament and lastly for poles and firewood. When the objective is food security, then it is particularly important to pay attention to when a species is fruiting and leafing[15].

2.2. Accessibility to Markets

Agroforestry systems can provide cash income through production of marketable goods. Home gardens or live fence posts may be particularly suitable for fruit production, while taungya or trees intercropped with annuals may be better for fuel wood production. When the objective is a marketable product, a critical aspect is the accessibility and stability of a market. The prices on the market have to be favourable and attractive to the farmer. This does not only mean that prices have to be high enough to secure a profit margin, but also that prices have to be stable.

2.3. Accessibility to Information (Demand, Supply and Prices)

Because the marketing aspects are also important to the farmer, he also needs to have access to information about the market (e.g. prices, demand and supply, expectations). A farmer will not decide to change his production system unless he sees the security of marketing possibilities. Farmers are not likely to be interested in producing commodities if transport costs are high. They will also be reluctant to make or continue investments in AF if prices fluctuate widely[6].

Knowledge of market is critical, as it can help identify whether agroforestry interventions have the possibility of saturating them and therefore bringing prices down[9]. It can also help identify demands that could be met by AF. Over emphasis on cash cropping, though, can potentially have a negative impact on household food security. This can be through the reduced quality and diversity of purchased foods, increasing food prices as land is transferred from food production and more vulnerability through changes in prices[15].

Agroforestry systems can also provide benefits through reducing the cost of purchased inputs, labour or period to use the land again. For example, nitrogen contribution through use of leguminous woody species in alley cropping systems with rice is less costly, despite higher labour requirements, than using chemical fertilizers[37]. In regions where the non-farm economy is growing and population density increasing, then AF systems with low requirements become interesting particularly as they provide a buffer during transition from a farm economy to a cash one[5]. In the case of shifting cultivation, adoption of enrich fallow permits the use of land after shorter period than the period of soil recovering without fallow and other hand, the system requires a low labour investment.

With respect to prices the local situation is less comfortable as these are entirely determined by the market. The higher the prices that often accompany scarcity and

correspondingly higher profits can be an important incentive for farmers to turn to agroforestry. Including trees in agricultural systems therefore, makes tree, crop and livestock systems less sensitive to changes in yield and prices and improves overall profitability. Adoption of an AF system can both reduce risks, particularly through income diversification[10] and create capital stocks available to meet intermittent costs or unforeseen contingencies[5]. At the same time, it can create risks, for example if seedlings die from poor climate conditions or because of inappropriate species. Another risk stems from the possibility that the trees may be too competitive in relation to the amount of annual crops, creating unacceptable losses of those crops.

2.4. Security of Land and Tree Tenure

Tenure in AF concerns both land tenure and tree tenure. Because of the long term nature of AF systems, security of land tenure [1] is important for adoption of AF system. Consequently the following conditions are needed for adoption[6]: access to land on which the farmer has the right to plant trees; rights over trees must be sufficient to justify the effort of planting them and the right to harvest and utilize trees must be exclusive enough to give a return on investment. If the farmer does not have the security that the land will be his for a longer time, then he will not be interested in activities to improve the soil. As an example, in AF, a farmer will not plant trees if he is not sure he will also be able to harvest; since the point of return of investment is more than a year away. Fruit trees are usually not harvestable before the age of four or five years and maybe productive fordecades. Timber trees are only full grown after ten to eighty years. Consequently the cultivation of perennials offer a long-term investment which will only take place if the farmer can be certain of his rights on the yields. In practice this will only happen on land in property. Tenants do not care much about soil management, how bad the deterioration of soil fertility or the run-off erosion of the land they operate maybe. So agroforestry practices are not found on leased land.

Although tree and land tenure are distinct, each affects the other[58,18,19]. On the one hand, planting trees can be used to establish de facto private ownership of land. On the other hand, the right to land also affects right to trees. Where private rights to land are strong, the strength of a household's or individual's right to trees may depend on the strength of their right to the land. In this case, land owners are relatively advantaged, while those with temporary or weak claims to land may be relatively disadvantaged. But, where land tenure is communal and tree rights are strong, it appears that tree planters are advantaged in their right to trees. This is particularly so in the case of shifting cultivation. In Ghana, tenants were required to maintain economic trees growing on the land but they were prohibited from planting any themselves[17]. The landowners had the right to the fruits; the tenants could harvest for personal use, but never for sale. Without the landlord's permission they could not fell certain trees. Therefore in such a system, a tenant may hesitate to plant trees.

2.5. Labour

Agroforestry is also sometimes viewed narrowly and vaguely as synonymous with a specific practice that may have some drawbacks[41]. Availability of labour and its cost or reduced possibilities for commercial production, without acknowledging the existence of a broad spectrum of different agroforestry options under various conditions will affect a farmer's decision to adopt a particular AF system. Some systems such as alley cropping are labour intensive and therefore more difficult to introduce.In any situation, asystems perspective that accounts for the sum of all (tangible and intangible) benefits in the long term is required in order to appreciate the full value of potential benefits, as opposed to being solely concerned with the performance of a single crop[ibid].

2.6. Farm Size

Farm size refers to the preference of the farmers to grow as much food for their household and the market for sale as possible. When farm size is large and labour availability is low, then farmers may be more ready to adopt AF practices such as woodlots, or enriched fallows. On the other hand, when farm sizes decrease, they may also become more interested in higher yielding but more labour intensive systems such as alley cropping or highly productive home gardens.Substantial efforts are required to domesticate new and underutilized tree species, to increase their cultivation on smallholder farms, and to develop market infrastructures. Awareness must be created by extension services about research on issues such as tree enterprise development and tree-product marketing enhancement.Markets are often constrained by high risks and high transaction costs in rural areas in tropical zones. This necessitates production diversification, noted a preference of small-scale cash limited farmers. In these conditions, integrated agroforestry practices are a convenient approach toward improved livelihoods[41.1, 50].

2.7. Gender

The different roles men and women play in a community can hinder the adoption of AF if they are not considered in advance. For example, in some cultures women may not be allowed to plant trees. Adoption of AF could also change the social fabric of a community by cutting down on the opportunities for group work and the chance for talking that goes with them.

2.8. Knowledge for Management

With a change in production system comes also a need for change in knowledge, management skills and extension services. For farmers, introduction of a new species means

[1] Tenure held without risk of loss and for a long time; alternatively, tenure resembling full private ownership. The second is the preferred use of the term (Juma&Ojwang 1996)

that they will have to learn how to take care of it. On the other hand, in areas where there has been a tradition of AF or use of forest products, promoters may be able to gain useful knowledge from the people practising those techniques. For example some cultures have a classification of interplant relationships which could be useful in developing AF techniques[21].

As local knowledge and management originates from farmers' direct observations of nature processes and its influence on the crops, the explanation of the techniques and the process itself is not always known. For this reason, some AF researchers, as in the case study of "modern" sustainable AF system developed in Brazil by[53], apply local knowledge but at the same show some scientific hypothesis to be proved in the process. In other cases effective integration of local knowledge and perspective into AF are increasingly necessary for AF programmes. However, the problem is the inadequate attention to the synthesis of local and scientific knowledge and this is because this process demands a strong analysis of both types of knowledge and effective means of distributing the knowledge concerned. All projects have to face the difficult task of communicating their message to local people. Extension method and way of giving knowledge play important role in adoption of agroforestry system. It appears that in some project extension staff has poorly briefed on the technical aspects of alley farming resulting in inadequate and misleading technical advice to farmers in important matters such as species selection and hedge row pruning regimes[6]. In addition to being conversant with technical issue, it would be appropriate for extension staff to have an understanding of the socio-economic aspects likely to influence alley farming adoptability and experience in participatory work methods.

2.9. Incentives

AF interventions, as new techniques, often used cash incentives and subsidies to promote adoption[4]. Several studies have found, however, that external incentives are most successful when they are small and or of an in – kind nature, such as through provision of seedlings or initial materials[10]. Low levels of incentives and self-financing may lead to a slower, pace of adoption but one that may ultimately be sustainable.

Many AF interventions were designed with social and environmental aspects in mind with the consequence that subsidies were supporting market productions, often areas where it would not be profitable on its own[41]. Food for work schemes also create problems because they cause dependency and lack of interest once the incentive is withdrawn[10]. A danger at the national level is the use of incentives requiring foreign exchange, particularly if it is borrowed[9]. This is because AF may not necessarily produce goods that generate foreign exchange.

2.10. Government Policy

Inappropriate national policy and strategy has been a further constraint on food, agricultural, forestry and rural development. Concerning policy environment, the task is to find interventions in the micro environment that can protect farmers' welfare while macro forces strengthen their links to the economy in the long run. Issues on e.g. land use planning and regulation, in soil and water conservation and in livestock development policy, until very recently, a lack of clear land use rights and inheritance have been considered major stumbling blocks in convincing farmers to exert more effort to raise agricultural production.

3. Conclusions

The promotion of agroforestry technologies is important because it offers the prospect of increasing production and hence raising farmers' income. Sustainable development through AF can be achieved through a concerted effort to actively and continuously encourage farmers' involvement in AF activities. Recognizing and tackling main factors that determine participation of farmers in AF practices predisposes an AF project to successful local involvement. These findings are relevant to the adoption of agroforestry technologies involving economic as well as sociological considerations.

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