A Review of Agro Forestry Technologies Adoption among Small-Holder Farmers in Zimbabwe

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Abstract
A number of surveys to investigate the actual and potential adoption of agro forestry technologies have focused primarily on the influence of different household and farm characteristics on the adoption by farmers but the process of adoption is quite complicated, dynamic and the various factors are likely to influence each other – hence they should not be treated in isolation, ignoring their mutual interdependencies. This inevitable implication on measuring the influence of household and farm characteristics in itself may not provide sufficient explanations and necessitated the need for alternative approaches that address the inadequacies of household and farm-based traditional approaches. Therefore need to review qualitative research methodologies that would compliment quantitative research approaches and provide insights into farmers’
adoption patterns which can improve the understanding of the process of adoption of agro forestry technologies from the perspective of farmers. The qualitative methodologies may enable the comprehension of the process of adoption on the basis of diversity as found amongst informants and generating the relevant variables in the course of interviewing and observation.

Keywords: Adoption, Agro forestry, Technology, Farmers, Farm characteristics

Introduction

Rogers, (1995), defined adoption as a process whereby one fully use an innovation as the only best options available. Therefore, adoption of agro forestry technologies can be defined as a process whereby farmers fully use the agro forestry technologies as the only best option available. Adoption is a process, which according to Van den Ban and Hawkins, (1998), follows a sequence of five stages, which are awareness, interest, evaluation, trial and adoption. However, it does not always follow this sequence in practice since interest may precede awareness as what happens when farmers are looking for a method to solve a problem. Adoption literature shows that a host of socio-economic, demographic, institutional and technical factors, farmers’ perception about technology attributes and their attitude towards risk (Adesina and Zinnah, 1993; Nichola, 1994) affects the adoption of agro forestry technologies. Therefore, the level of adoption of agro forestry technologies varies from society to society, individual to individual and from household to household (Pannell, 1999).

A recent global review of the adoption of agro forestry show that the level of diffusion of agro forestry technologies has generally lagged behind scientific and technological advances attained in such technologies thereby, reducing their potential impacts (Mercer, 2004). The experience concerning the adoption of agro forestry technologies in Zimbabwe has not been too different from the global trend (Kuntashula, et al, 2002). Although agro forestry is financially profitable
and there has been an increasing trend in the uptake of the technologies by farmers, the widespread adoption of agro forestry technologies by many more smallholder farmers is nonetheless constrained by several challenges such as local customs, institutions and policies at the national level (Masangano and Miles, 2004).

Several empirical studies have been carried out to gain insights into the adoption of agro forestry in southern Africa region. The specific studies investigated the types of farmers who adopt (do not adopt) agro forestry (Kuntashula et al., 2002; Phiri et al., 2004; Gladwin et al., 2002; Ajayi et al. 2006b). Other studies examined the factors that drive the adoption of agro forestry, why do some farmers continue to adopt more than others (Ajayi et al., 2003; Franzel 2004; Ajayi and Kwesiga, 2003; Thangata and Alavalapati, 2003).

**Agro forestry adoption**

The biophysical performance and the relevance of the agro forestry technologies in southern Africa have been well demonstrated in the past one and half decades (Kwesiga and Coe, 1994; Mafongoya et al., 2003; Kwesiga et al., 2003). Research and development activities on agro forestry have expanded to include questions on farmer uptake, adoption and impact of the technologies. Farmer adoption and the impact of new farm technologies on adopters are some of the key measures of the overall success or otherwise of such innovations.

In general, the uptake of agro forestry technologies is more complicated than those of annual crops (Mercer, 2004; Scherr and Muller, 1991) because of the multi-components and the multi-years through which testing, modification and uptake of the technologies takes place. As a result, a precise definition of the ”adoption” of agro forestry often poses a challenge. Some authors (e.g. Franzelet
al., 2002) distinguished between “testers”, “experimenters” and “adopters”. Other authors (e.g. Ajayi et al., 2003) regard the uptake of agro forestry technologies as a continuum and posit that farmers can be assigned positions in the continuum based on the extent of uptake of the different components of the technology. A recent study in Zambia (Ajayi, et al, 2006b) reveals that the key criteria that farmers themselves use for assessing the level of “adoption” of agro forestry technologies are as follows: good management (timely weeding & pruning) of agro forestry fields, density and mix of trees species planted, number of years of continuous practice of agro forestry and, size of land area that a farmer cultivates to agro forestry. In a strict sense therefore, different degrees of “adoption” of agro forestry technologies can be identified.

In the context of an adoption cycle, it is possible to develop a more holistic conception of participatory technology development (PTD) with reference to dynamic farmer needs, objectives, personal characteristics, capital assets and communication, in addition to the technological characteristics of the innovations themselves. Although there have been few major advances in the study of agro forestry adoption since Mercer and Miller (1997) identified it as a key priority for future research, there are two notable exceptions. Swinkels and Franzel (1997) developed a three-stage model, in which adoption potential depends on the feasibility, profitability and acceptability of an agro forestry technology. On the other hand, Pannell (1999) defined four conditions necessary for farmers' adoption of innovative farming systems:

- Awareness of the innovation.
- Perception that it is feasible to trial the innovation.
- Perception that the innovation is worth trying.
- Perception that the innovation promotes the farmer's objectives.

Although Swinkels and Franzel (1997) clearly defined feasibility (the appropriate information and resources to manage a technology) and profitability, the major concern is that their acceptability component depended on a diverse range of
factors, including perception of risk, suitability to accepted gender roles, cultural acceptance, and compatibility with other enterprises. Based on diffusion theory (Rogers, 1995), the model (Figure 1) attempts to create a more functional classification for acceptability factors, and offers a more holistic understanding of feasibility and profitability in the context of farmer needs, objectives, capital assets and communication. It also attempts to explain how perceptions of agro forestry innovations form in relation to farmer objectives and the feasibility and utility of trials (Pannell, 1999).

**Anthropological perspective for understanding farmers’ adoption of agro forestry**

A number of surveys to investigate the actual and potential adoption of agro forestry technologies have focused primarily on the influence of different household and farm characteristics on the adoption by farmers. However, the inevitable implication that measuring the influence of household and farm characteristics in itself may provide insufficient explanations and thus there is need for different approaches (Masangano and Miles 2004). The process of adoption is complicated, dynamic and the various factors are likely to influence each other – hence they should not be treated in isolation, ignoring their mutual interdependencies and reducing the adoption decision to a zero-sum game, as is frequently done. If individual household and farm characteristics are singled out, where one study considers a certain characteristic to have a positive influence on adoption, another study may view the same characteristic as having a negative influence. The differences can sometimes very well be clarified from the institutional and social contexts of the specific respective study areas. Such qualitative research methodologies compliment quantitative research approaches, provide insights into farmers’ adoption patterns and improve the understanding of the process of adoption of agro forestry technologies from the perspective of
farmers. The qualitative methodologies may enable the comprehension of the process of adoption on the basis of diversity as found amongst informants and generating the relevant variables in the course of interviewing and observation (Ajayi, et al., 2006b). This qualitative approach was used to study the history of interventions and the present-day consequences for agro forestry adoption in southern Malawi (Masangano and Miles 2004). Given the complex process of decision making by farmers, an after project assessment is necessary to gain a better understanding of the process of adoption, because it will be contextualized, both within the socio-economic context of the farm and family enterprise and in time.

**An innovation-decision approach model**

Although agro forestry is an old-aged practice, it has developed in response to similar pressures in numerous, often isolated societies, and continues to be re-invented by the communities that use it (Gilmour, 1987; Fujisaka and Wollenburg, 1991; Filius, 1997; Nasr et al., 2001). Aspects of agro forestry technologies that an individual has not formerly encountered may also be considered “innovations”. Rogers (1995) describes adoption as a five step “innovation-decision process” in which farmers:

- Gain knowledge of an innovation (such as agro forestry);
- Seek information about the likely consequences of adoption and form an attitude towards it;
- Decide to adopt or reject the innovation;
- Implement the innovation; and
- Confirm their innovation decision by seeking reinforcement, and discontinue it if exposed to conflicting experiences and messages.
Figure 1. The agro forestry innovation-decision model, showing the corresponding stages of Rogers’ (1995) innovation-decision process
Rogers (1995) identifies five key characteristics of innovations that determine their adoption potential: relative advantage, trialability, compatibility, observability and complexity. The most significant of these are usually high relative advantage, high compatibility and low complexity (Tornatzky and Klein, 1982). In addition to these characteristics, the agro forestry innovation-decision model presented in Figure 1 includes adaptability, integrates the innovation-decision process with farmer needs, objectives, and capital assets (natural, human, social, physical and financial), and examines the role of communication in the innovation-decision process. There have been many applications of diffusion theory in the field of agricultural technology (Rogers, 1995). Although partial applications of the theory have occurred in agro forestry (for example Evans (1988) in Paraguay, and Alavalapartiet al. (1995) in India), there have been few attempts to apply or develop diffusion theory in this field since it was first suggested by Raintree in 1983.

**A new model for agro forestry adoption**

The model presented in Figure 1 is iterative, recommencing as needs and objectives change, and as capital assets change. Farmer constraints to realize the needs, strategies and objectives are the primary stimulus for the development or adoption of an agro forestry innovation, and these are influenced by their capital asset endowments. The characterization of farmer needs and objectives, and the opportunities and constraints presented by their capital assets have been discussed extensively in the sustainable livelihoods literature (Carney, 1998; Ashley, 2000). Although agro forestry systems have the capacity to meet a diverse range of objectives, effectively communicating how agro forestry can help meet them may be key to success (Strong and Jacobson, 2006).

In the developing world, people often innovate to sustain their livelihoods ("livelihood constraints and strategies" in Figure 1), in response to population
pressure on a limited natural resource base ("natural assets" in Figure 1) (Reij and Waters-Bayer, 2001b). Whether an innovator chooses to disseminate their innovation, or other farmers observe the innovation for themselves, the mode of communication through which farmers become aware of an agro forestry technology will influence their perception of it. Different communication channels are more effective at different stages in the innovation-decision process. For example, mass media channels are relatively more important at the knowledge forming stage, whereas interpersonal channels such as other farmers and extension workers are relatively more important at the attitude forming stage (Copp, 1958). Evaluation of an innovation is to a large extent based on the experience of similar individuals (who share socio-economic status, education, beliefs etc). Communication tends to be more frequent and more effective between such individuals than between more dissimilar individuals (Lazerfield and Merton, 1964). However, this phenomenon can hinder the spread of ideas through diverse communities (Granovetter, 1973). If an agro forestry technology in Figure 1 is communicated effectively, its perceived complexity may be reduced, and observability and adaptability increased, enhancing its adoptability.

Depending on the outcome of this evaluation, the agro forestry innovation will be adopted and implemented, or rejected. If it is adopted and implemented, reinforcement will be sought. If the innovation meets the needs and objectives of the farmer satisfactorily, and they are not exposed to conflicting messages about the innovation, their decision is likely to be confirmed. If the converse is experienced, the innovation may be discontinued. In order to meet the needs and objectives that persist, farmers will acquire knowledge about alternative strategies, and repeat the process. Alternatively, the innovation may be adapted, and depending on the characteristics of the modified innovation, it may be adopted and implemented, or rejected. Once farmers have become aware of a "new" agro forestry technology, they begin to seek information about the likely consequences of adoption and form an attitude towards the agro forestry
innovation in relation to non-agro forestry alternatives and current practice. During this process, agro forestry innovations are evaluated using up to six criteria relating to innovation characteristics: relative advantage, trialability, compatibility, adaptability, observability and complexity. These are now considered in turn, to examine the factors affecting the likely adoption of new agro forestry technologies.

**Relative advantage**

In addition to financial profitability (Swinkels and Franzel, 1997), relative advantage accounts for “subsistence profitability”. This assesses the opportunity costs of the innovation, and its contribution to subsistence needs. The opportunity cost includes the value of resources lost or forgone in order to develop agro forestry, and the time invested that could have been spent elsewhere. Relative advantage assesses the profitability of an innovation in relation to current practice and other alternatives, such as natural forest resources. It also accounts for temporal aspects of profitability, as farmers assess the timing and magnitude of costs and benefits at each stage of an innovation’s life cycle. For example, the timing and size of initial investment, maintenance costs, sustainability, food and income security and the immediacy of rewards associated with the system influence the relative advantage of an agro forestry technology. Pannell (1999) identifies the ability to assess the profitability of agro forestry innovations in relation to current practice and other alternatives as a major challenge.

The relative advantage of agro forestry systems will vary with farmer needs and objectives, current practice, capital assets at their disposal and viable alternatives. However some illustrative generalizations can be made. Due to the slow growth of most tree species, the time-scale over which rewards are delivered through agro forestry systems is considerable, reducing their relative advantage
(Snappet et al., 1998). In common with forestry enterprises, this means that profitability needs to be determined with reference to discount rates, which are typically high. However, without specialist training or assistance, such calculations are beyond the reach of most African smallholders. The cost of exiting an agro forestry system can be high. For example, it can sometimes be higher than the cost of clearing primary forest (Votsi et al., 1997). The primary maintenance cost in agro forestry systems is labour, which can be higher than other land use systems, for example pasture maintenance. Agro forestry systems may have to compete with non-cultivated supplies from natural forests where extraction costs can be lower than cultivation costs (Reeves and Lilieholm 1993). In addition, the opportunity cost of land for other uses is particularly significant for smallholders (Dove, 1991), who are often perceived to benefit most from agro forestry technologies, and should be taken into account in location decisions (Hoekstra, 1983).

The benefits of preventative technologies are often long-term and in the absence of long-term trials, it is often difficult for farmers to predict the cost of non-adoption. These factors reduce observability and trialability, and make it difficult to assess relative advantage. Consequently, the adoption of preventative technologies is characteristically slow (Rogers, 1995). This may explain the low adoption rates of many agro forestry interventions with conservation objectives, such as erosion or deforestation control, unless their fulfillment will bring immediate rewards. Having said this, some agro forestry interventions have attempted to solve unperceived or low priority problems by packaging them as by-products of solutions to high priority problems (Raintree, 1983; Evans, 1988). Creating incentives (financial or material rewards and penalties) can increase the relative advantage of innovations. Although more people may adopt an innovation if incentives exist, the quality of adoption may be poor, leading to partial implementation and discontinuation (Rogers, 1995). For example, the financial incentives given to farmers who participated in the Malawian Tree
Planting Bonus Scheme (DeWees, 1995) resulted in poor silvicultural practices and high tree mortality due to farmers planting trees at extremely high densities in order to claim the maximum payment.

**Trialability**

Experimentation with innovations on a trial basis prior to adoption increases the likelihood of adoption (Rogers, 1995). Trialability is a more important factor for early adopters than for late adopters, who tend to substitute the experience of others for their own trial (Ryan, 1948). Farmers are characteristically risk adverse (Binswanger, 1980; Reeves and Lilieholm, 1993), and trials offer a valuable means of reducing perceived risk (Evans, 1988; Scherr, 1992). Trialability can be poor in agro forestry systems due to the length of commitment required to plant trees on a trial basis. Demonstration plots can improve trialability if farmers are prepared to substitute the experience of demonstrators for their own trial. This often occurs informally when farmers substitute their own trial of an agro forestry innovation for the experience of their peers. Where this occurs, the trialability of an innovation is highly dependent on effective communication between farmers.

**Compatibility**

Analogous to Swinkels and Franzel (1997) concept of feasibility, compatibility assesses the extent to which a technology is compatible with environmental and socio-cultural factors, and farmer needs and objectives. For a technology to be adoptable, it must be compatible with the physical environment of the target area. For agro forestry technologies, species must be selected with reference to climatic and edaphic factors. They must also be compatible with existing land use systems, and previously introduced innovations (for example, intercropping may not be compatible with mechanized ploughing and harvesting systems). Agro forestry
technologies that build on and incrementally improve existing land-use systems are likely to be more compatible than technologies that replace these systems. In order to build upon existing systems, it is necessary to understand their processes and components, and the current role of trees. An assessment of existing tree species, and their use, management and interaction with other components of the agricultural system should therefore form the basis for development of agroforestry interventions. Sociological studies have shown that innovations, which are consistent with socio-cultural values, are adopted more rapidly than innovations, which conflict with these values (Hassinger, 1959). For example, the right to plant trees is restricted in some societies because tree planting can confer property rights on the planter (Fortmann, 1987).

Adaptability

The extent to which an innovation can be adapted to meet dynamic user demands and specifications can influence its adoption potential. In addition to characteristics of the agro forestry technology itself, adaptability depends on the adaptive capacity of farmers (influenced by factors such as marketing knowledge, access to credit and risk aversion). Votsi et al. (1997) describe these two components of adaptation as agronomic and socioeconomic “agility”. Understanding an innovation is a prerequisite to effective adaptation, as adaptation without the appropriate knowledge can result in technologies that are ineffective, inefficient and sometimes counter-productive. The inter-relatedness of components in agro forestry systems can limit the extent to which they can be adapted, as the adaptation of one component may influence other related components. Nevertheless, the multiproduct, multi-component nature of agro forestry technologies tends to make them more adaptable than single component agronomic innovations (Votsi et al., 1997). It is possible to alter the crop, product and input mix or any combination of these in response to changing needs, objectives or capital assets. This obviates the need to adopt different innovations.
under changing circumstances. Consequently, adaptable innovations have lower discontinuation rates (Rogers, 1995).

**Observability**

If the effect of an innovation is highly visible, it will be adopted more readily (Rogers, 1995). The slow growth rates of trees make their effects and rewards difficult to observe (Snappet et al., 1998). Indeed, some conservation benefits are indirect and intangible. One of the mechanisms through which trials can increase adoption rates is by tangibly demonstrating the benefits of an innovation. As such, demonstration plots can improve the observability of agro forestry systems and have been shown to have a direct impact on agro forestry adoption rates (Evans, 1988).

**Complexity**

Innovations, which are unfamiliar and/or difficult to understand and implement, are less likely to be adopted than technically simple innovations (Rogers, 1995; Strong and Jacobson, 2006). The complexity of an agro forestry innovation depends on the characteristics of the innovation and the farmer. For example, young and more educated farmers are more likely to adopt new technologies and are likely to adopt them before other sectors of society. Having said this, younger farmers may favour agro forestry innovations simply because they have longer planning horizons than older farmers do, and cost-benefit calculations for agro forestry systems tend to favour long planning horizons. It should also be noted that although younger farmers may be earlier adopters, innovators tend to be older and more experienced (Reij and Waters-Bayer, 2001b). Social forestry interventions with group adoption objectives have been shown to increase the social tree tenure and the distribution of responsibilities and benefits. Most agro
forestry projects are now conducted at a household level, although the nature of many common grazing lands often makes group-centered approaches unavoidable. Effective communication and trials or demonstration plots can reduce the level of complexity perceived.

**Roles for extensionists and scientists in Agro forestry adoption**

The agro forestry innovation-decision process (Figure 1) takes place in the absence of any external inputs; indeed, there is evidence that it has done so throughout history (e.g. Gilmour, 1987; Fujisaka and Wollenburg, 1991; Nasr et al., 2001). However, by understanding what makes a "good" innovation that is likely to be widely adopted and rapidly spread, it may be possible to identify new roles for extensionists and scientists in which they can facilitate optimal participatory technology development (Figure 2). In the absence of external help to identify, optimize and communicate innovations to other smallholders, the responsibility to disseminate an innovation lies with the innovator. Project experience has shown that these farmers often promote their innovations energetically to their peers, investing considerable time and resources. However, this is not always the case, and is often beyond the priorities or capabilities of innovators (Upadhyay et al., 2003).

Dissemination of innovations, particularly beyond the immediate community in which they arose, is therefore a key role for development agencies. Extensionists may also be able to enhance the efficacy with which innovations are communicated, thereby reducing the perceived complexity, and enhancing their observability and adaptability. Before innovations can be disseminated, they must be identified (Upadhyay et al., 2003). As such, they must be clearly defined, and definitions may vary from area to area (for example, whether "family innovations" developed by parents or grandparents should be considered innovations). Extensionists may be the most effective agents to identify
innovators and their innovations. However, they must be able to leave the transfer of technology (ToT) framework in which they were oftentrained, in order to learn effectively from farmers (Neupaneet al, 2002).

In some cases, there may be an opportunity to improve the innovations that have been identified, before disseminating them more widely. Extensionists and scientists should collaborate closely with innovators in this process (Haverkortet al., 1991). An understanding of the technological characteristics that lead to adoptable innovations (Figure 1), and an awareness of the inter-linkages between innovations, capital assets, and livelihood constraints and strategies, can inform this process (Rogers, 1995). In addition to optimizing innovations, extensionists and complexity of innovations, for example, issues of land and scientists may be able to collaborate with innovators and communities to adapt rejected or discontinued technologies.
Figure 2. The agro forestry innovation-decision model showing the role of extensionists and scientists
Constraints to the adoption of agro forestry technologies

Some of the constraints that have been identified as to affect adoption of agro forestry among different societies are highlighted below:

**Local and national policies:** some local customary practices and institutions prevailing in the sub-region (especially incidence of bush fires and browsing by livestock during the dry season, and absence of perennial private right over land) limit the widespread uptake of some agro forestry technologies (Phiri et al, 2004). The animals destroy the trees after planting either by browsing the leaves and removing the biomass or by physically trampling over the plants. Community’s institutional regulations for fruit collection, land and tree tenure all affect individual farmer’s decision to invest in establishing an indigenous fruit tree orchard. Land ownership is also likely to influence adoption if the investments are tied to the land and the benefits of these investments are long term (Fernandez-Cornejo et al, 1994). Tenants are less likely to adopt technologies that require high investments on the land and whose benefits are long term because the benefits of adoption do not necessarily accrue to them. However, agro forestry institutions have been working in collaboration with traditional rulers, government officials, community-based organizations, NGOs, and national partners to resolve these institutional bottlenecks (Ajayi and Kwesiga, 2003).

**Training:** Agro forestry technologies are generally incipient technologies and relatively new phenomenon compared with conventional agricultural practices that farmers have known, been used to and have received training for a much longer period. Unlike annual crop production technologies and conventional soil fertility management options, fertilizer trees systems require skills in terms of management of the trees. Capacity for doing this need to be built at the national level (Ajayi et al, 2003), the costs of providing information greatly decrease over time, but they are critical when helping farmers get started with the practice.
Seed and germplasm: One of the greatest constraints of some agro forestry technologies is lack of access to quality seeds (Thangata and Alavalapati, 2003). Unlike the seeds of annual crops in which established institutions exist to promote them and private sector organizations have been engaged in their multiplication and distribution, there is little or no institutional structure to make the seeds of agro forestry available “off the shelf”. There are also no improvements on the tree varieties used in agro forestry.

Awareness: Over several years, there have been structural shifts towards “quick fixes” and technologies that render immediate benefits (Ajayi and Kwasiga, 2003). The opportunity of agro forestry technologies to provide some medium and long-term benefits to individuals and the public simultaneously is not yet well communicated to many stakeholders.

Human resource capacity: The human capacity, infrastructures and institutional supports for agro forestry are not as well developed as for annual crop technologies (Gladwin et al., 2002). Such missing support include well developed input and output market to enhance access of small-holder farmers to ensure that they get the price premium for their crop produce. Households will likely adopt labour intensive innovations with high access to farm and off-farm labour. Fernandez-Cornejo et al (1994) identified another type of farm labour that influences technology adoption, that is, the labour provided by the farm operator him/herself. This kind of labour is often called operator labour and is thought to have a positive impact on level of adoption of agro forestry technologies because the technologies have a high requirement of operator's time.

In general, the factors, which influenced farmers’ adoption decision concerning agro forestry technologies, fall within four broad categories. These are those, which exert (1) positive influence on farmers’ adoption decisions, (2) negative
impacts (3) ambiguous or no direct effect (4) systemic influence on all types of households in a given community and spatial locations (Place and DeWees, 1999, Place, 1995).

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