African Journal of Agricultural Research Vol. 2(8), pp. 334-341, August, 2007
Available online at http://www.academicjournals.org/AJAR
ISSN 1991- 637X © 2007 Academic Journals

Review

Participatory technology development for agroforestry extension: an innovation-decision approach

M. S. Reed

Sustainability Research Institute, School of Earth and Environment, University of Leeds, Leeds LS2 9JT, UK. Email: mreed@env.leeds.ac.uk. Fax: +44 113 2336716.

Accepted 5 May, 2007

In order to facilitate Participatory Technology Development (PTD) in African agriculture, extensionists and scientists must collaborate with local innovators to optimise (where necessary) and disseminate their innovations. This literature review proposes a conceptual model for PTD in which technology is developed in the context of an adoption cycle. Building on an innovation-decision approach, the characteristics of innovations that achieve widespread uptake are identified. The link between these characteristics and livelihood constraints and strategies, capital assets and the role of communication is emphasised. Although the agroforestry innovation-decision process occurs in the absence of external intervention, by understanding the characteristics of adoptable innovations in the context of adoption behaviour, it may be possible to identify new roles for extensionists and scientists. They may be able to facilitate PTD through the identification of innovators and their innovations, optimise and adapt innovations with reference to the proposed model, and disseminate innovations to other smallholders who may benefit from them.

Key words: agroforestry; adoption; technology; public participation; Africa; innovation

INTRODUCTION

Optimising participation

There is a growing awareness that agricultural research and development must build upon farmer expertise; identifying, facilitating and building upon local innovation. As the Transfer of Technology (ToT) paradigm is increasingly replaced in African agriculture by the drive to facilitate Participatory Technology Development (PTD) (Haverkort et al., 1991; Martin and Sherington, 1997), it is becoming evident that scientists and extensionists need to develop a more facilitatory role. Farmer experimenttation must be supported, innovators and their innovations identified, and where necessary it may be possible to work with innovators to optimise their innovations, and disseminate them to other smallholders who may benefit from them (Reij and Waters-Bayer, 2001a).

In order to effectively facilitate PTD it is essential to understand what makes a good innovation. This can only be answered by the potential users who will adopt or reject innovations according to a complex range of interlinked criteria. So why certain innovations are widely adopted and rapidly spread, while others see limited uptake and diffusion? This paper provides a critical review of PTD, in the context of a new model for agroforestry adoption. Building on diffusion theory (Rogers, 1995), eight key design characteristics are identified and reviewed in the context of dynamic farmer needs, objectives, capital assets and communication. Finally, new roles are proposed for extensionists and scientists working on agroforestry technologies and related development programmes.

A better understanding of factors influencing the development of optimal technologies can facilitate wider participation and co-operation between farmers, extensionists and scientists, to optimise agroforestry technologies for widespread uptake and diffusion to enhance rural livelihoods.

Agroforestry adoption: current understanding

In the context of an adoption cycle, it is possible to develop a more holistic conception of 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 agroforestry 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 aceptability of an agroforestry technology. 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 trialing.
- Perception that the innovation promotes the farmer's objectives.

Feasibility (the appropriate information and resources to manage a technology) and profitability were clearly defined by Swinkels and Franzel (1997). However, 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 presented here 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 agroforestry innovations form in relation to farmer objectives and the feasibility and utility of trials (Pannell, 1999).

An innovation-decision approach

Although agroforestry is an age-old 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 agroforestry technologies that an individual has not formerly encountered may also be considered "innovations". Rogers (1995) describes adoption as a five step "innovation-decision process" (dashed arrow in Figure 1) in which farmers:

- Gain knowledge of an innovation (such as agroforestry);
- 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 re-enforcement, and discontinue it if exposed to conflicting experiences and messages.

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 agroforestry innovation-decision model presented in Figure 1 includes adaptability, integrates the innovation-decision process with farmer needs, objecttives, 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 agroforestry (for example Evans (1988) in Paraguay, and Alavalaparti et 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 agroforestry adoption

The model presented in Figure 1 is iterative, recommencing as needs and objectives change, and as capital assets change. Farmer needs and objectives are the primary stimulus for the development or adoption of an agroforestry innovation, and these are influenced by their capital asset endowments. The characterisation 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 agroforestry systems have the capacity to meet a diverse range of objectives, effectively communicating how agroforestry 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 agroforestry 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 phenomonon can hinder the spread of ideas through diverse communities (Granovetter, 1973). If an agroforestry technology is communi-

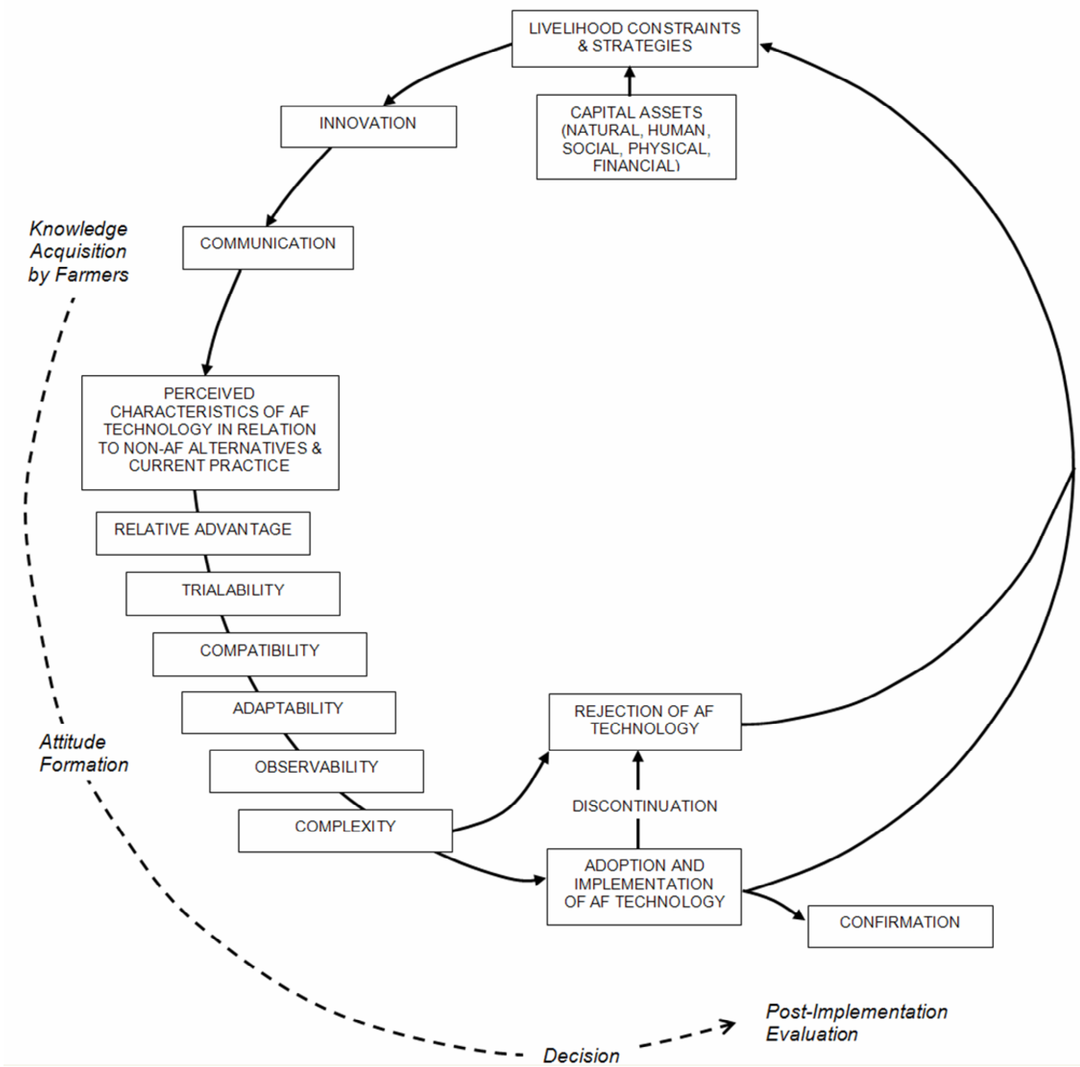

Figure 1. The agroforestry innovation-decision model, showing the corresponding stages of Rogers' (1995) innovation-decision process (dashed arrow) (AF = agroforestry)

cated effectively, its perceived complexity may be reduced, and observability and adaptability increased, enhancing its adoptability.

Depending on the outcome of this evaluation, the agroforestry innovation will be adopted and implemented, or rejected. If it is adopted and implemented, re-enforcement 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" agroforestry technology, they begin to seek information about the likely consequences of adoption and form an attitude towards the agroforestry innovation in relation to non-agroforestry alternatives and current practice. During this process, agroforestry innovations are evaluated using up to six criteria relating to innovation characteristics: relative advantage, trialability, compatibility, adaptability, observability andcomplexity. These are now considered in turn, to examine the factors affecting the likely adoption of new agroforestry 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 agroforestry, 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 relative advantage of an agroforestry technology is influenced by the timing and size of initial investment, maintenance costs, sustainability, food and income security and the immediacy of rewards associated with the system.

Pannell (1999) identifies the ability to assess the profitability of agroforestry innovations in relation to current practice and other alternatives as a major challenge. The relative advantage of agroforestry systems will vary with farmer needs and objectives, current practice, capital assets at their disposal and viable alternatives. However some illustrative generalisations can be made. Due to the slow growth of most tree species, the time-scale over which rewards are delivered through agroforestry systems is considerable, reducing their relative advantage (Snapp 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 agroforestry 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 agroforestry systems is labour, which can be higher than other land use systems, for example pasture maintenance. Agroforestry systems may have to compete with non-cultivated supplies from natural forests where extraction costs can be lower than cultivation costs (Guimaraes and Di Addario, 1998). 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 agroforestry 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. As a consesquence, the adoption of preventative technologies is characteristically slow (Rogers, 1995). This may explain the low adoption rates of many agroforestry interventions with conservation objectives, such as erosion or deforestation control, unless their fulfilment will bring immediate rewards. Having said this, some agroforestry intervenetions have attempted to meet 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 agroforestry 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 agroforestry 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 sociocultural 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 agroforestry 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 mechanised ploughing and harvesting systems). Agroforestry 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 characterristics of the agroforestry 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 socio-economic "agility". Understanding an innovation is a pre-requisite to effective adaptation, as adaptation without the appropriate knowledge can result in technologies that are ineffective, inefficient and sometimes counter-productive (Larsen and Agarwala-Rogers, 1977).

The inter-relatedness of components in agroforestry systems can limit the extent to which they can be adapted, as the adaptation of one component may influence other related components. Nevertheless, the multi-product, multi-component nature of agroforestry 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 (Snapp 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 agroforestry systems and have been shown to have a direct impact on agroforestry 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 agroforestry 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 (D'Souza et al., 1993). Having said this, younger farmers may favour agroforestry innovations simply because they have longer planning horizons than older farmers, and cost-benefit calculations for agroforestry 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 objecttives have been shown to increase the social tree tenure and the distribution of responsibilities and benefits (Cernea, 1992). Most agroforestry 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.

New roles for extensionists and scientists

The agroforestry 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; Filius, 1997; 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 PTD (Figure 2).

Table 1 shows some typical characteristics of innovative farmers. In the absence of external help to identify, optimise 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 energeticcally 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.

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 adaptablity.

Before innovations can be disseminated, they must be identified. 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 ToT framework in which they were often trained

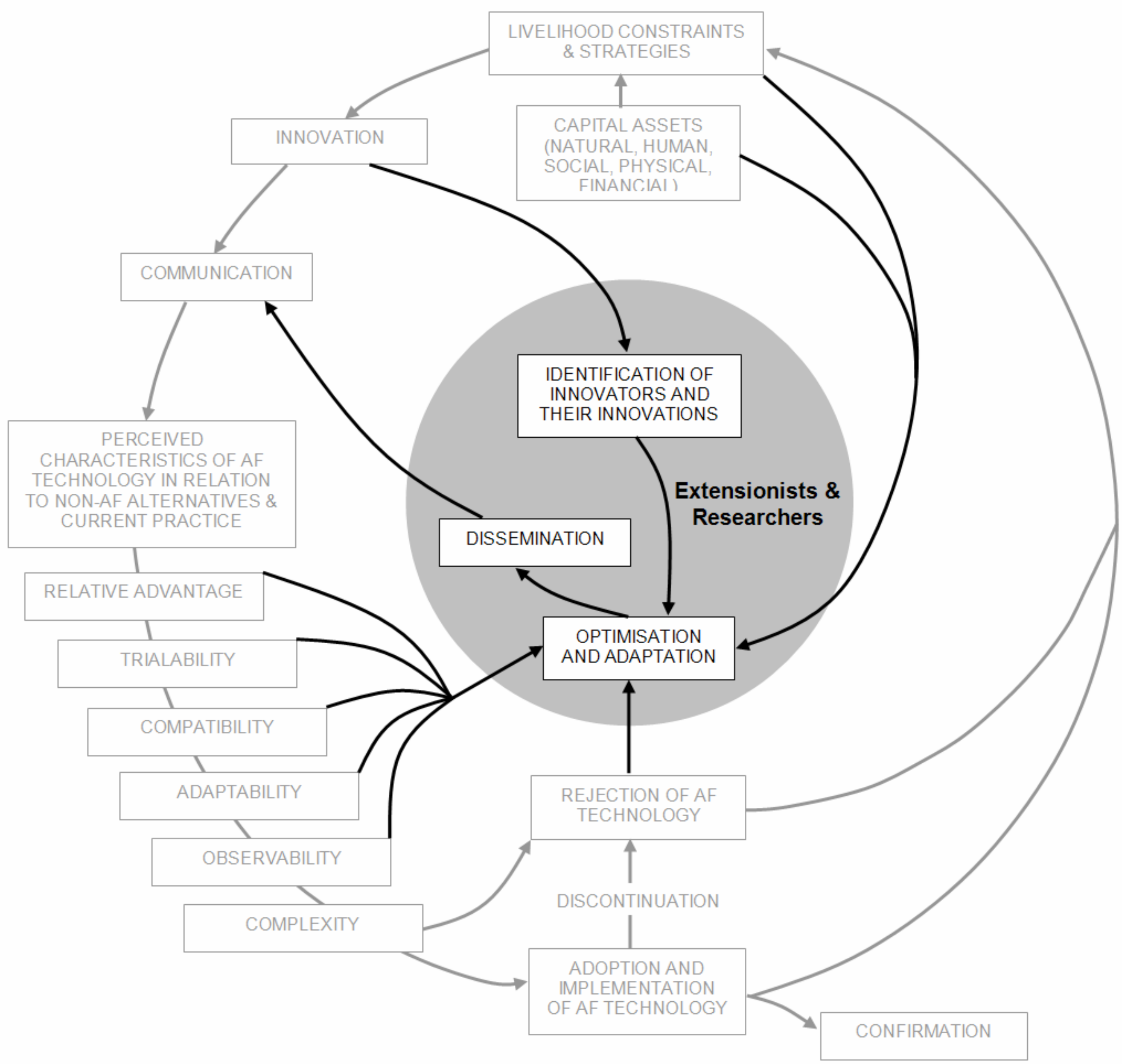

Figure 2. The agroforestry innovation-decision model (grey), showing the role of extensionists and scientists (black) (AF = agroforestry).

trained, in order to learn effectively from farmers.

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. An understanding of the technological characteristics that lead to adopatable innovations (Figure 1), and an awareness of the inter-linkages between innovations, capital assets, and livelihood constraints and strategies, can inform this process. In addition to optimising new 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.

Conclusion

It may be possible to facilitate more effective participation in agroforestry technology development between innovators, extensionists and scientists, by better understanding the characteristics of adoptable technologies. The model proposed in this paper provides a route to achieving this, through a holistic understanding of agroforestry adoption. Building on this approach, it may be possible to optimise participation in agroforestry technology development to achieve widespread uptake and diffusion and enhance rural livelihoods. It is clear that extensionists and scientists must adopt new roles to facilitate this, gaining access to and building on local innovation as the starting

Table 1. Some characteristics of innovative farmers

Innovative farmers are more likely to be:	Reference
Younger	Neupane et al. (2002); Chianu and Tsujii (2004)
Better (formally) educated than average	Upadhyay et al. (2003); Chianu and Tsujii (2004); Masangano and Miles (2004); Boz and Akbay (2005)
Owners of larger than average land holdings	Salam et al. (2000); Upadhyay et al. (2003); Boz and Akbay (2005)
Owners of higher than average numbers of livestock	Neupane et al. (2002)
More wealthy	Hossain and Crouch (1992); Mahapatra and Mitchell (2001); Upadhyay et al. (2003); Wu and Pretty (2004); Boz and Akbay (2005)
Using credit	Boz and Akbay (2005)
Food secure	Chianu and Tsujii (2004)
Familiar with relevant extension programmes	Yaron et al. (1992); Salam et al. (2000); Upadhyay et al. (2003)
In regular contact with extension staff	Boz and Akbay (2005)
Members of village organisations	Mahapatra and Mitchell (2001); Neupane et al. (2002) – males only
In households with more social connections than average	Wu and Pretty (2004)
Using more modern farming techniques	Mahapatra and Mitchell (2001)
Less likely to perceive risks associated with agricultural production	Mahapatra and Mitchell (2001)
In good mental health	Hounsome et al. (2006)
Considered to be hardworking by their peers	Reij and Waters-Bayer (2001b)
Working on land in key sites e.g. steep slopes, run-on sites or close to large gullies	Reij and Waters-Bayer (2001b)
Usually full-time farmers	Reij and Waters-Bayer (2001b)

point for development interventions.

ACKNOWLEDGEMENTS

This work was conducted under the tenure of the Department of Agriculture and Forestry at the University of Aberdeen, and was funded by the European Social Fund. Thanks to A.J. Dougill, H.W. Parry and two anonymous reviewers for helpful comments.

REFERENCES

Alavalapati JRR, Luckert MK, Gill DS (1995). Adoption of agroforestry practices: a case study from Andhra Pradesh, India. Agroforestry Syst. 32: 1-14.

Ashley C (2000). Applying Livelihood Approaches to Natural Resource Management Initiatives: Experiences in Namibia and Kenya, Working Paper 134. London: Overseas Development Institute.

Binswanger HP (1980). Attitudes toward risk: experimental measurement in rural India. American J. Agric. Econ. 62: 395–407.

Boz I, Akbay C (2005). Factors influencing the adoption of maize in Kahramanmaras province of Turkey. Agric. Econ. 33: 431-440.

Carney D (1998). Sustainable Rural Livelihoods: What contribution can we make? Papers presented at the Department for International Development's Natural Resources Advisers' Conference, July. DFID, London.

Cernea MM (1992). A Sociological Framework: Policy, Environment, and the Social Actors for Tree Planting. In Sharma NP (ed), Managing the World's Forests. Looking for Balance Between Conservation and Development. Kendall/Hunt, Iowa. pp. 301-336.

Chianu JN, Tsujii H (2004). Determinants of farmers' decision to adopt or not adopt inorganic fertilizer in the savannas of northern Nigeria. Nutrient Cycling in Agroecosyst. 70: 293-301

Copp JH (1958) The function of information sources in the farm practice adoption process. Rural Sociol. 23: 146-157.

Dewees PA (1995). Trees on Farms in Malawi: Private Investment, Public Policy, and Farmer Choice, World Develop. 23: 1085-1102.

D'Souza G, Cyphers D, Phipps T (1993). Factors affecting the adoption of sustainable agricultural practices, Agric. Resour. Econ. Rev. (October), pp. 159-165.

Dove MR (1991). Forester's beliefs about farmers: an agenda for social science research in social forestry, EAPI Working Paper No. 28, October. East-West Environmental and Policy Institute, Honolulu.

Evans PT (1988). Designing Agroforestry Innovations to Increase their Adoptability: a case study from Paraguay. J. Rural Stud. 4: 45-55.

Filius AM (1997). Factors changing farmer's willingness to grow trees in Gunung Kidul (Java, Indonesia). Netherlands J. Agric. Sci. 45: 329-345.

Fortmann L (1987). Tree Tenure: An Analytical Framework For Agroforestry Projects. In Land, Trees and Tenure, Raintree JB (ed), Proceedings of an International Workshop on Tenure Issues in Agroforestry. LTC and ICRAF.

Fujisaka S, Wollenberg E (1991). From forest to agroforest and logger to agroforester - A case-study. Agroforestry. Syst. 14: 113-129.

Gilmour DA (1987). Not seeing the trees for the forest: a re-appraisal of

the deforestation crisis in two hill districts of Nepal. Nepal-Austrailian Forestry Project, Kathmandu.
Granovetter MS (1973). The strength of weak ties. Am. J. Sociol. 78: 1360-1380.
Guimaraes V, Di Addario (1998). Pesquisa de mercado de produtos vegetais nao madeireiros. Pesquisa de mercado – estudos de caso: Pimenta longa (Piper hispidinervium) e pupunha (Bactris pasipaes HBK). Documento Series, Empresa Brasiliera de Pesquisa Agropecuaria (EMBPRAPA). Acre, Brazil.
Hassinger E (1959) Stages in the adoption process. Rural Sociol. 24: 52-53.
Haverkort B, van der Kamp J, Waters-Bayer A (1991). Joining Farmer's Experiments: Experiences in Participatory Technology Development, Intermediate Technology Publications. p. 281.
Hoekstra D (1983). The Use of Economics in Agroforestry, Working Paper No. 2, ICRAF, Nairobi.
Hossain SMA, Crouch BR (1992). Patterns and determinants of adoption of farm practices - some evidence from Bangladesh. Agric. Syst. 38: 1-15.
Hounsome B, Edwards RT, Edwards-Jones G (2006). A note on the effect of farmer mental health on adoption: The case of agri-environment schemes. Agric. Syst. 91: 229-241.
Larsen JK, Agarwala-Rogers R (1977) Re-Invention of Innovative Ideas: Modified? Adopted? None of the Above? Evaluation 4: 136-140.
Lazerfield PF, Merton RK (1954). Friendship as social process: a substantive and methodological analysis. In: M Berger et al (eds), Freedom and Control in Modern Society. Octogon, New York pp. 18-66
Mahapatra AK, Mitchell CP (2001). Classifying tree planters and non planters in a subsistence farming system using a discriminant analytical approach. Agroforestry Syst. 52: 41-52.
Martin A, Sherington J (1997) Participatory research methods - Implementation, effectiveness and institutional context. Agric. Syst. 55: 195-216.
Masangano CM, Miles CA (2004). Factors influencing farmers' adoption of Kalima bean (*Phaseolus vulgaris* L.) variety in Malawi. J. Sustainable Agric. 24: 117-129.
Mercer DE, Miller RP (1997) Socioeconomic research in agroforestry: Progress, prospects, priorities. Agroforestry Syst. 38: 177-193.
Nasr N, Chahbani B, Reij C (2001). Innovators in land husbandry in arid areas of Tunisia. In: Farmer Innovation in Africa: a source of inspiration for agricultural development, Reij C and Waters-Bayer A (eds), Earthscan Publications pp. 122-131.
Neupane RP, Sharma KR, Thapa GB (2002). Adoption of agroforestry in the hills of Nepal: a logistic regression analysis. Agric. Syst. 72: 177-196.
Pannell DJ (1999) Social and economic challenges in the development of complex farming systems. Agroforestry Syst. 45: 393–409.
Raintree JB (1983) Strategies for enhancing the adoptability of agroforestry. Agroforestry Syst. 1: 173-187.
Reeves LH, Lilieholm RJ (1993) Reducing financial risk in agroforestry planning: a case study in Costa Rica. Agroforestry Syst. 21: 169-175
Reij C, Waters-Bayer A (2001a) Entering research and development in land husbandry through farmer innovation. In: Farmer Innovation in Africa: a source of inspiration for agricultural development, Reij C and Waters-Bayer A (eds), Earthscan Publications pp. 3-22.
Reij C, Waters-Bayer A (2001b) An initial analysis of farmer innovators and their innovations. In: Farmer Innovation in Africa: a source of inspiration for agricultural development, Reij C and Waters-Bayer A (eds), Earthscan Publications pp. 77-91
Rogers EM (1995) Diffusion of Innovations, 4th Edition, The Free Press, New York
Ryan B (1948) A study in technological diffusion. Rural Sociol. 13: 273-285
Salam MA, Noguchi T and Koike M (2000) Understanding why farmers plant trees in the homestead agroforestry in Bangladesh. Agroforestry Syst. 50: 77-93
Scherr SJ (1992). The role of extension in agroforestry development: evidence from Western Kenya. Agroforestry Syst. 15: 47-68
Snapp SS, Mafongoya PL and Waddington S (1998) Organic matter technologies for integrated nutrient management in smallholder cropping systems of southern Africa. Agriculture. Ecosystems and Environment 71: 185-200.
Strong N, Jacobson MG (2006) A case for consumer-driven extension programming: agroforestry adoption potential in Pennsylvania. Agroforestry Syst. 68: 43-52
Swinkels R, Franzel S (1997) Adoption potential of hedgerow inter-cropping in maize-based cropping systems in the highlands of western Kenya 2. Economic and farmers' evaluation. Exp. Agric. 33: 211-223.
Tornatzky LG, Klein KJ (1982) Innovation characteristics and innovation adoption-implementation - a meta-analysis of findings. IEEE Trans. Eng. Manage. 29: 28-45.
Upadhyay BM, Young DL, Wang HH (2003) How do farmers who adopt multiple conservation practices differ from their neighbors? Am. J. Altern. Agric. 18: 27-36.
Votsi SA, Witcover J, Oliveira S, Faminow M (1997) Policy issues in agroforestry: technology adoption and regional integration in the western Brazilian Amazon. Agroforestry Syst. 38: 195-222.
Wu B, Pretty J (2004) Social connectedness in marginal rural China: The case of farmer innovation circles in Zhidan, north Shaanxi. Agric. Hum. Values 21: 81-92.
Yaron D, Dinar A, Voet H (1992) Innovations on family farms - the Nazareth region in Israel. Am. J. Agric. Econ. 74: 361-370.