SOCIOECONOMIC ASPECTS OF DIFFUSION AND ADOPTION OF ALLEY FARMING*

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1. Introduction

The realization of the potential benefits of alley farming will depend on the speed of imitation or diffusion of the technology among potential users. Various socioeconomic forces which may influence the process and the speed of diffusion will now be outlined. In this paper

2. Diffusion or Adoption

Theoretically, a distinction is made between diffusion and adoption. Diffusion begins at a point in time when the technology is ready for use; the process of invention of the technology is not considered. Explanation of how the technology is made available to the potential users is the main focus of diffusion. On the other hand, adoption considers the behaviour of individuals in relation to the use of the technology; more particularly the reasons for adoption at a point in time are of primary interest. In one sense, diffusion deals with the supply side while adoption with the demand side of the application of a technology. Relative to adoption, diffusion may be viewed as a dynamic, aggregative process over continuous time. However, there may be some degree of overlap between diffusion and adoption because technology generation is a continuous process. Most biological innovations evolve as they diffuse. A high degree of 'reinvention' may occur through the diffusion process in that "an innovation is changed or modified by a user in the process of its adoption and implementation" (Rogers 1983). The adopters may play an important role in the process of technology generation rather than being merely passive recipients of the innovation, and thus they may become their own change agents and active participants in the horizontal dissemination of innovations.
Issues related to diffusion and adoption of alley farming will be discussed separately.

3. Diffusion of Alley Farming

3.1. Appropriateness of Alley Farming

Historically, the nature of technical change in a society has been induced by the endowment of resources. In land abundant, labour scarce situations labour saving mechanical technologies has been adopted while in land scarce, labour abundant situations, land saving bio-chemical technologies have been adopted. As relative endowment of resources changed over longer periods, one form of technical change has

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been followed by another. For example, in North America, mechanical technical change preceded bio-chemical technical change while in Japan and subsequently in other Asian countries experiencing green revolution, bio-chemical technical change preceded mechanical technical change (Binswanger and Ruttan 1978; Hayami and Ruttan 1985). In Semi-arid and humid Africa, land/labour ratios are high, so innovations which increase labour productivity are considered to be more attractive to farmers than bio-chemical technologies which increase the productivity of land (Spencer and Byerlee 1976; Binswanger and McIntire 1987).

How does alley farming fit into this frame-work and how appropriate is it for Africa? Although land/labour ratio is high in tropical Africa, quality of soil is poor and soil degradation and erosion are serious problems. In order to sustain the rapidly rising population, current productivity of land has to be increased and future productive capacity of land has to be retained. Alley farming has been developed in response to these needs. As such it falls in the category of land saving bio-chemical technology, and a simple interpretation of the theory of induced innovation may imply that alley farming may not be attractive to the farmers until land frontier reaches its limit. However, alley farming may appear quite attractive, technically and economically, if its long-term functions are considered. Alley farming may also become attractive because of its labour saving potential. Some evidence already available shows that although additional labour is required for planting and managing trees and for regular pruning, on balance less labour is required for alley farming than traditional bush-fallow system because of the reduced need for labour for regular forest clearing and for weeding (Reynolds 1989). Alley farming may also eliminate/reduce the need for heaping and ridging, thereby save labour in these labour intensive operations. Farmer reports indicate that heaping/ridging help to get better yield through two main functions. First, by concentrating fertile top soil in a smaller area, plant growth is enhanced. Second, weed growth is reduced, so less frequent weeding is required. For most crops, alley farming can perform these two functions, thus reduce labour requirement. Where yam is a major crop, heaping perform an additional function of helping good tuber formation. If continuous mulching can make top soil adequately loose for good tuber formation, the size of heap for yam may also be reduced. These possibilities are yet to be explored.

3.2. Recommendation Domain

At the present state of knowledge, alley farming is recommended for areas with rainfall over 1200 mm with a bimodal distribution and a soil PH of over 5.2. This recommendation domain reflects the conditions in the areas where it has received most research attention (Reynolds 1989). This recommendation domain is rather small in relation to the total area of humid tropical Africa where soil degradation and erosion are serious problems requiring urgent solution. There is a high degree of diversity within this vast area in relation to resource endowment, physical, environment and institutional conditions. If alley farming is to be considered a potential solution for the problems of this vast region, it has to be developed into a highly robust technology which saves both land and labour and is adaptable to the diverse conditions.

The speed with which the recommendation domain of the technology can be expanded will partly depend on the research priorities of the parent organizations, viz, IITA, ILCA and ICRAF, who contributed most towards the development of the technology. But most importantly, it will depend on the capacities and priorities of the National Agricultural Research Systems (NARS) of those countries and regions who want to acquire access to this technology. They have to go beyond reliance on simple transfer of the technology from the principal research stations, and invest in the capacity to adapt the technology for their own resources, environment and institutions. Building adaptive capacity is important because, like any other agricultural technology, some elements of AF will have high degree of location specificity. This limits returns to scale in agricultural research and raises adaptive research to the status of a prerequisite for diffusion (Thirtle and Ruttan 1987).

3.3. Role of On-farm research

While some amount of on-station research will be necessary to test the adaptability of the trees or find suitable new tree species, the diffusion process will be expedited if on-farm research is initiated without unnecessary delay for finding the best practice technology. This is because the best practice technology on-station rarely performs at that level in actual farm conditions. On the other hand, much of the adaptive research will result in "...a steady accretion of innumerable minor improvements and modifications with only very infrequent major innovations" (Rosenberg 1982, p. 7). Since research should be aimed at solving farmers' problems, involving farmers in the research process quite early on, rather than waiting for them to be passive recipients at some future date, may yield three advantages in relation to diffusion.

First, the length of time required for standardization and adaptation of the technology to various specific farmer situations may be shortened through contributions from the participating farmers. Farmers' own adjustment mechanisms and experiences will be important input towards the adaptive process.

Second, on-farm research may demonstrate the viability of the technology and thus create "neighborhood effects" whereby "innovation waves" may spread from the centre to the periphery (Mahajan and Peterson 1979). Since on-farm research is likely to be conducted in many locations across the region, the innovation waves will spread from many centres and thus speed up both generation and diffusion of the technology. A large extent of horizontal (farmer to farmer) diffusion is likely to take place due to lateral learning within each research location.

Third, one of the functions of OFR is to promote collaboration with extension and development agencies in order to improve the efficiency of the technology generation and diffusion process (Merril-Sands 1989). Involvement of extension and development agencies as partners/participants in the technology generation process will bring them directly in contact with the farmers as well as making them acquainted with the salient features of the technology as it is generated. This is a step ahead of the situation where such agencies have to wait until some best practice technology package is made available to them for their own dissemination. Suitability of the existing institutional frame-work for proper delivery of the technology to the users may also be tested during OFR stage. For example, in most countries, crop, livestock and forestry extension services may be independent with little collaborative activity and also the crop extension service may be much better organized than the other two. Since the scope of alley farming cut across all three fields, appropriate mechanisms may be developed at the technology generation stage to integrate the roles of these various agencies in the diffusion process. Mechanism for using non-government and traditional institutions such as cooperatives, village associations, local leadership structures, in the diffusion process may also be found out at on-farm research stage. The role of such institutions may be highly complementary to governmental institutions in the diffusion process.

3.4. Importance of Intellectual and Public Support

The task ahead is rather big and to accomplish it, "... the cause of alley farming requires a champion" (Iyamabo 1989, p. 10). In fact, champions, promoters and sponsors will be needed at various levels. First, alley farming needs to be incorporated in the priority research agenda of various universities and research institutions and it also needs to be incorporated into the appropriate courses in universities, colleges and schools of agriculture who turn out future extensionists and development works. Iyamabo (1989) mentioned in 1986 that "many agriculturalists unfortunately have not accepted the concept of agro-forestry as beneficial to arable crops". Little progress will be made if such a low level of intellectual support remains a constraint. The question of farmer adoption will remain a distant goal if the scientists and educationists of the region remain unconvinced about the appropriateness and usefulness of alley farming as a technology.

Secondly, public support for research and education, for building appropriate institutional and legal frame-work, and for providing incentive structures will be needed. In addition to supporting formal research and education, special programmes of informal education for raising peoples' awareness about the long-term consequences of soil degradation and the role of AF in arresting this problem should be promoted. Where initial private benefit from AF is low but social benefit high, public support in various forms such as subsidy, tax concession, cost share and soft credit may have to be provided. The farmer may have to be paid to love the land in order to maintain its future productivity because even when the farmer is the owner of the land, he may not see too far into the future (Weinschank 1986). Since returns to investment in AF will accrue over a long period, long term secured access to land is a pre-requisite for farmers to feel encouraged to make substantial investment. Where land tenure system may not be ideal for wide adoption of the technology, modification of the tenure system may be required. Where institutional structure for delivering the technology does not exist, it has to be created and where existing institutions are inappropriate, modifications have to be made. Of course, the relationship between technology and institutions is interactive. While introduction of the technology may require some institutional change, institutions may change once the technology is introduced.

The degree of public support for these programmes depends on public perception and priorities. In general, politicians' time preference is very high. So they normally look for quick yielding technologies and projects for allocating limited public funds. The short-run function of AF is to substitute chemical fertilizers. Therefore, the supply of land and public perception about its capacity to supply fertilizer at a reasonably low price may largely determine its attitude towards AF. If land is abundant and fertilizer can be supplied at a low price, there may be little attraction for AF. If land is scarce but fertilizer can be supplied at low prices, AF may still have little public support. However, research has shown that chemical fertilizer will not be enough to maintain long-term fertility of low activity clay soils, rather organic matter incorporation through mulching will help to better utilize any extra chemical fertilizer that may be applied. If this kind of knowledge is brought to the notice of public policy makers, the value of AF may be better appreciated even when chemical fertilizer may be available at low prices. Recognition of the long-term role of AF in maintaining future productivity may depend on public perception about other technological possibilities to solve the problem of soil degradation. For example, if it is perceived that biotechnology or similar other technology will ultimately diminish the need for soil as a base production resource, there may be little attraction for AF to solve the problem of soil degradation. If import rather than development of domestic agriculture is the accepted public policy; AF is unlikely to get any serious attention.

Public perception is derived from the stock of knowledge within and outside a country. Therefore a strong intellectual commitment to AF, as discussed earlier, may mould public perception in favour of AF.

3.5. International Cooperation

Given the size, complexity and geographical coverage of the problem, a high degree of international support and cooperation in research, extension and institution building will be required for successful diffusion of AF. Research and development projects aimed at combating desertification, promoting aforestation, controlling soil erosion and degradation, and enhancing crop-livestock interaction have some common and overlapping objectives which should be integrated for developing sustainable agricultural technology. Collaboration among IITA, ILCA and ICRAF in promoting AFNETA is a good example of such effort. But AFNETA is a small inter-country diffusion network whose present role is to provide experimental seeds and other materials and to help information exchange through various means (newsletter, publications, seminar, workshop, and training). This will create little impact if national governments and institutions in the region do not play a much bigger role through both independent and collaborative programme than they are doing now.

4. Adoption of Alley Farming

4.1. Target Adopters

Within a recommendation domain, and technology may be more appropriate for some than for others, and some may adopt earlier than others. At least two contrasting views have been expressed about the potential adopters of AF. Reynolds (1989) stated that AF is recommended for small farms (around 2 ha.) cultivated by hand or with limited mechanization. Low input agriculture should be the norm with maize or cassava as the main food crops. The system is also said to be suitable for male and female farmers, tenants and land owners, and with respect to livestock, for confined and free roaming animals. Kang (1989) stated that AF is a scale neutral technology which, although initially developed for small holder farms, can also be used for mechanized large scale farming. This is an indication of the evolving nature of the technology whose target adopters are not clearly known.

4.2. Characteristics of AF Affecting Adoption

Whether AF will be adopted by a particular farmer will depend on his/her knowledge and perception about the following.

a. the form of the technology and its working mechanism;
b. the short and long-run functions of the technology;
c. its adaptability to the resource endowment (land, labour, capital) and the system of farming practiced by the farmer;
d. pay-off period and the time lag in deriving benefits;
e. Profitability and the degree of risk involved.

Some features of AF with respect to the above are these:

1. It is a composite therefore fairly complex technology. Although farmers are familiar with the management of trees under the bush-fallow system and plantation tree crops, tree management under AF involves a number of innovations in relation to planting and establishing trees within arable farm, their management for mulch and fodder, and cutting and carrying feeds for animals, and altering land use and rotation patterns (Atta-Krah and Francis 1989). Learning these innovations may require time.
2. The short-run function of AF is to substitute chemical fertilizer and/or protein feeds for improving crop and/or animal productivity, but if the soil is too poor, chemical fertilizer may have to be applied initially to get the trees established. With proper demonstration this function may appear attractive to the farmer depending on land availability, and fertilizer and feed prices. A farmer currently using chemical fertilizer is likely to perceive the benefits sooner than the one who is not using chemical fertilizer. The long term benefit of soil conservation may not be easily apparent particularly in a land abundant situation because soil degradation occurs slowly, so its implication is also understood slowly.
3. Out of the three forms of AF, viz. tree-crop, tree-grass and tree only systems, crop farmers will be interested in only tree-crop system but crop-livestock farmers have a wider choice and a complex decision to make. They can adopt tree-crop system and use part of the foliage as animal feed or adopt tree-crop system for crop fields and tree-grass/tree only system for animals. A predominantly livestock farmer may like to adopt tree-grass/tree only system for animals and use manure to improve soil fertility of the arable fields rather than planting trees in crop fields. Then there are problems with choice of crops in tree-crop system. The best practice technology on-station has been developed with maize, a shallow rooted crop. In the humid tropics, maize is not the most important crop. Cassava, yam, cocoyam and a variety of other crops and vegetable are grown and mixed rather than sole cropping is the norm. The problems of establishing alley farms and its performance under such complex cropping systems are not yet adequately known so that proper farmer recommendations also cannot be made. The most important resource required for establishment and management of AF is labour. Total labour requirement under AF may be less then that under traditional system but how much less labour is required for different cropping mixes is yet to be ascertained. Moreover, the distribution of labour over a given year is quite different under the two systems so that the farm household will have to adjust its work, leisure and life patterns to the requirements of AF.

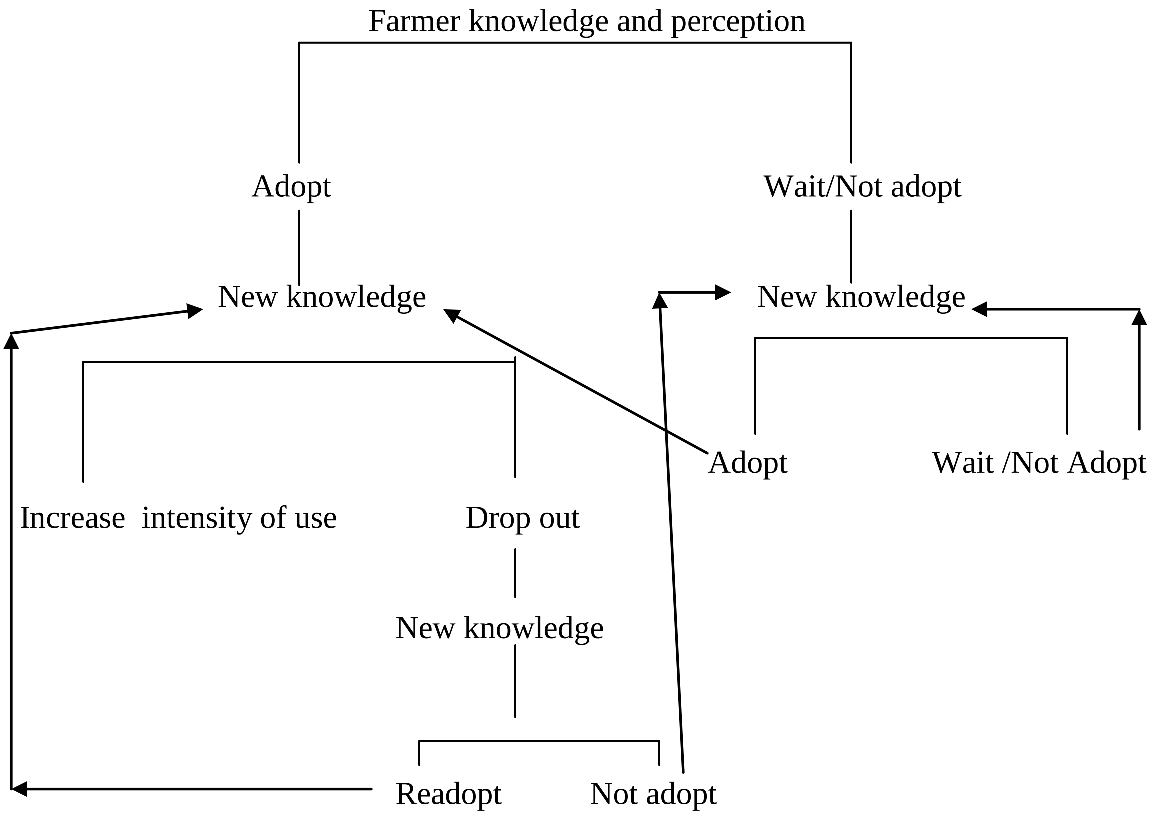
4. Tangible benefits from the trees may not become available before 2-3 years and trees have to be established and well maintained for perhaps 10-15 years in order to derive any long-term benefit. This will require long-term resource adjustment within the farm and also long-term land use planning. Small farmers need to conserve the fertility of their meager land most but the initial time lag in deriving benefit may be a constraint for them to adopt AF unless their staying power for that period can be enhanced through some incentive structures such as soft credit.
5. Under a range of assumptions, alley cropping in Nigeria has been found to be more profitable than traditional bush-fallow system and incorporation of animals into the tree-crop system has also been found to be competitive with alley cropping if feed supplementation increases animal productivity by 25-30 percent (Sumberg et al. 1987; Ngambeki and Wilson undated). But in semi arid tropics of India alley cropping has been found unprofitable because of good fertilizer distribution system and its low price (Walker 1987). However, the profitability and risk of AF under varying physical, environmental, institutional and economic stable return and lower risk is essential for speedy adoption. Knowledge about how much of the potential benefit can be internalized by the user and how much will accrue to others including the society is also not clear. Such knowledge is particularly of interest for tenants and woman farmers who may have to plant alley farms on land owned by others.

4.3. The Learning-Adoption Process

Given the above characteristics of alley farming and its present state of knowledge, the adoption process is likely to be slow. The process of learning and adoption may be charted as in the diagram below.

The learning-adoption flow chart above shows that at a given point in time, the decision to adopt, reject or wait will be influenced by the belief derived from the knowledge and perception at that point in time. Only limited amount of information may be available initially or only a limited amount of available information may be digested initially. So adoption decision may be taken on the basis of knowledge accumulated over a period of time. The prior belief of a point in time may be later modified on the basis of new knowledge and/or observed performance and a new decision about adoption may be taken. Thus, the "innovation assessment lag" defined as the time required between initial awareness and actual use of a technology (Linder; Fischer and pardey 1978) may vary depending on the farmers' access to knowledge, his ability to decode that knowledge and formulate decision.

Figure: Learning-adoption process



4.4. Importance of Education

Education, both formal and informal, has been found to influence technology adoption through four effects: (a) innovation effect whereby farmers know why, what, when and how of the technology, its costs and benefits and where to look for information and capital, (b) allocative effect whereby optimal choices are made, (c) worker quality effect whereby tasks are performed better, and (d) externality effect whereby others are helped to learn and adopt (chaudhri 1979). A generation of adoption studies has shown the role of education in adoption. Even where larger farm size and greater extension contact were found important variables in adoption, both of these variables were found to be highly correlated with the level of education.

Experience with green revolution in Asia shows that although the technology was originally characterized as scale neutral, larger farms became early and major adopters. Thus, the technology itself may be scale-neutral but returns to scale may prevail in adoption because of the ability of the large farms to spread learning and acquisition costs over a larger volume of output (Lindner 1980; Ruttan 1977). Usually, larger farmers have better access to information and capital because of their better education and contact with the supply sources related to the technology. So they end up being early adopters and derive the benefits of early adoption such as premium returns and capitalization of that returns in increased investment in land. Unless special programmes for information dissemination to the resource poor farmers are promoted, such farmers are likely to remain as laggards and miss the benefits of a new technology.

5. Summary

Diffusion and adoption are conceptually different but some degree of overlap exists between them particularly in the case of biological technologies which evolve as they diffuse. Alley farming is basically a bio-chemical technology which increases land productivity in the short-run and conserve soil fertility in the long-run. Therefore, it may not appear very attractive for land abundant situations unless long-run soil conservation is important. However, alley farming also has a labour saving potential and this may make it an appropriate and attractive technology for vast area of Africa where land/labour ration is high. Substantial research by both international and national research systems in the region will be needed to develop alley farming as a robust technology adaptable to diverse conditions. The generation-diffusion process should be, to a certain degree, simultaneous. On-farm research has and important role in the technology generation and diffusion process. A constituency of committed intellectuals in schools, colleges, universities and research institutions, and a strong public support for education, research, institution building and incentive structure creation will be required for speedy diffusion. International cooperation will help cross country diffusion.

Adoption by farmers will depend on their knowledge about the technology, its functional mechanism, short and long run benefits, its adaptability to the resource endowment and farming system, its pay-off period and profitability. Given the composite and complex nature of the technology, the learning-adoption process is likely to be slow. However, special educational and promotional activities may reduce the innovation lag as well as making it available to the resource poor farmers who, under normal circumstances, may not have adequate access to the technology.

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