Diffusion and Adoption of Vertisols Technology Package in Highland Ethiopia*

Gezahegn Ayele
Ethiopian Agricultural Research Organisation

Mohammad A Jabbar
International Livestock Research Institute

Elias Zerfu
Ethiopian Agricultural Research Organisation

Abstract

The experience with Vertisols technology generation, diffusion and adoption process in case study areas indicate that either a full package of a technology may be adopted or some components of a package may be adopted depending on farmer knowledge, needs and resource conditions. Gradually adoption may evolve from components to the package as a whole. Experience also indicate that technology adoption is not a one-off static decision rather it involves a dynamic process in which information gathering, learning and experience play pivotal roles particularly in the early stage of adoption. Farmers move from learning to adoption to continuous or discontinuous use over time. The characteristics of both the user and the technology are important in explaining adoption behaviour and the pathway for adoption. The sets of factors that may significantly influence decisions to acquire knowledge about BBM, to adopt and then to use it continuously or discontinuously may be different. The lag between learning and adoption, and the possibility of discontinuation and readoption imply that a longer period will require for majority of the farmers to use the technology than if adoption was a one off decision leading to continuous use.

---

* In: Paulos Dubale, Asgelil Dibabe, Asfaw Zeleke, Gezahegn Ayele and Abebe Kirub (Eds) (2001) *Advances in Vertsols Management in Ethiopian Highlands*. Ethiopian Agricultural Research Organisation, Addis Ababa, Ethiopia. Pp.263-272

1. Introduction

The purpose of this paper is to understand the process of generation, diffusion and adoption of technology, the possible pathways for adoption of a new technology, and in the specific case of BBM, the factors that may influence adoption behaviour of potential adopters. Such understanding will help extension and development agencies in targeting potential areas where BBM may be promoted, and in those areas farmers who may be targeted for diffusion of BBM.

2. Theoretical Concepts about Diffusion and Adoption[1]

2.1 Generation and transfer of technology

In conventional systems research framework, farmers, technology transfer agencies and researchers need to be partners in the generation and transfer of any technology if appropriate technology is to be generated and wide adoption is to be expected. Researchers, farmers and technology transfer agencies interact to diagnose constraints and possible options to overcome those constraints. Researchers then design and test on-station identified options in consultation with technology transfer agencies and selected farmers. Once options have been successfully tested on-station, and promising options have been identified, they are tested on-farm with participation of selected farmers for validation, verification and demonstration. Local technology transfer agencies participate in these tests as well . These tests indicate the suitability of the technology in actual farm conditions and also indicate if any modification in original designs need to be made. Researchers then make those adjustments. At this stage some farmer-to-farmer diffusion may also occur, and good evidence of such diffusion is a good indication that the technology may have good potential for adoption. On the other hand, poor or no farmer-to-farmer diffusion may indicate that the technology has inherent deficiencies and poor prospect of wide adoption. Once verification, validation and demonstration produce good results, technology transfer agencies may take the technology for wider diffusion. The framework described here is a general guide, it may not be necessary to follow this framework exactly in the same way to successfully generate and diffuse all technologies.

Most agricultural technologies evolve as they diffuse. A technology may be changed or modified by a user in the process of its adoption and diffusion. Therefore, potential adopters may play an important role in the process of technology generation by being involved in the generation process rather than being merely passive recipients of a technology once it has been generated (Rogers, 1983). Incorporation of farmers as participants and their perceptions and preferences as important elements in the technology generation process are considered essential for generation of appropriate technology (Ashby et al., 1989; Asfaw Negassa et al., 1991)

2.2 Diffusion and adoption

[1] This section is primarily derived from Jabbar et al. (1998).

In the literature on technology adoption, a distinction is made between diffusion and adoption. Diffusion is considered to begin at a point in time when an innovation has passed through design and on-farm validation tests and is ready for wider use. The main focus of diffusion is to explain how the innovation or technology is made available by extension and development agencies to the potential users. The earliest users of the technology may be called innovators and the diffusion process involves the spread of the innovation to the rest of the population. On the other hand, adoption studies consider the behaviour of individuals in relation to the use of the technology, particularly the reasons for adoption at a point in time, or the reasons for time of adoption for individual users, are of primary interest. Empirical studies on agricultural technology adoption generally divide a population into adopters and non-adopters (potential adopters), and analyse the reasons for adoption or non-adoption at a point in time principally in terms of socioeconomic characteristics of the adopters and non-adopters as well as their subjective assessment of the attributes of the technology. Relative to adoption, diffusion may be viewed as a dynamic process over time in which feedback from adopters is used to modify the technology and continually respond to the needs of new adopters (Stoneman, 1983; ,Feder and Umali, 1993; Thirtle and Ruttan, 1987).

Another aspect of diffusion and adoption is that often a package of technology is tested, developed and recommended. However, if the package is composed of components which can be separately used or if individual components are also divisible, individual farmers may choose to adopt either the recommended package or some components as it is or even a part of it depending on the circumstances (Gezahegn Ayele, 1999). If extension and diffusion agencies offer the recommended package and put restriction on access to credit or support services if the whole package is not used, then the rate of adoption may be slow in the beginning.

Generally five stages in a typical technology adoption-decision pathway may be identified and adopters may be categorized, according to time of adoption, as innovators, early adopters, early majority, late majority and laggards (Rogers, 1983). Innovators are described as respectable local opinion leaders who are prepared to test new ideas or technologies, and take risks involved; the early majorities are deliberate and willing followers of innovators, while late adopters often need peer pressure or influence to adopt. The laggards are skeptical about the new, so cling to the past and adopt at the tail end.

Adoption models of this nature implicitly assume that the entire population eventually adopts the technology and that, once adopted, the technology is never rejected (Thirtle and Ruttan, 1987). In some models a population is divided into adopters, rejecters, disapprovers, and the remainder who are as yet uncommitted (Sharif and Kabir, 1976). However, the implicit assumption here is that once rejected or disapproved, the technology is never adopted again.

However, there are some deficiencies of these approaches to analyse and predict the potential for adoption of a new technology, particularly at the early stage of diffusion. At a given point in time, the decision to adopt, reject or defer decision about a technology is influenced by the belief derived from the knowledge and perception about the technology at that point in time (Figure 1). Such knowledge and perception includes information on the characteristics of the technology, what it does, how it works, what benefits it generates, what disadvantages are there, if any, where and how to get access to it, what resources are required for its acquisition etc. 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. Therefore, forever rejected or never rejected after adoption are not realistic options in the real world. Learning and adoption is a continuous process (Jabbar et al., 1996). The characteristics of both the user and the technology are considered important in explaining adoption behaviour and the pathway for adoption. The resultant pathway for adoption has implications for the time frame and the volume of potential impact of a new technology.

When farmers are not involved in the technology generation process, awareness and knowledge about a new technology precedes any adoption decision. The importance of information gathering and updating information through learning-by-doing in the adoption process cannot be over emphasised. There may be a lag between the time when farmers first hear about an innovation and the time they adopt it. Any adoption decision is preceded by a period of awareness and learning. Initially only limited amount of information may be available or only a limited amount of available information may be digested or understood by potential adopters. The optimal level of information is reached when information acquired over a period of time reaches a threshold level at which the farmer feel confidant about taking a decision on adoption (e.g., Saha et al., 1994; Fisher et al., 1996).

At this point, a decision to adopt or reject or defer decision may be taken. The subsequent decisions may follow two pathways (Figure 1). In the first pathway, a decision to adopt is followed by a decision about the intensity or extent of adoption, for example, area of land to be devoted to the new technology (in practice, these two decisions may be initially taken simultaneously). New knowledge and experience is gathered from learning-by-doing as well as observing other adopters, and a decision is made to increase intensity (for example, increase the land area under the new technology) and/or modify the technology,[2] or to discontinue the use of the technology. After acquiring more knowledge, a decision to re-adopt or defer adoption is taken and the process continues until a more stable decision is taken.

In the second pathway, the initial perception or belief is modified on the basis of new knowledge and/or observed performance of adopters, and a new decision about adoption is taken. A decision to adopt takes the farmer along pathway 1 (Figure 1). A decision to reject or defer decision will keep the farmer within the second pathway whereby a new decision is taken after acquiring more knowledge.

Thus, the "innovation assessment lag", defined as the time required between initial awareness and actual use of a technology, may vary depending on the farmer's access to knowledge, ability to decode that knowledge and formulate decision. The lag is very short for innovators and very long for laggards (Fisher et al., 1996). For some technology, rate of adoption may be fast while for others rate of adoption may be slow so a long time is required for majority of farmers to adopt.

---

[2] Technical progress consists of infrequent major innovations coupled with a steady accretions of innumerable minor improvements and modifications done by users, particularly innovators and early adopters.

The possibilities of permanent discontinuation or temporary discontinuation and re-adoption imply that a distinction need to be made between "the number of new adopters" and "the number of net new adopters" in a given period or year. The net new adopter in a given year is the number of new adopters in that year, minus the number of adopters from previous year who dropped out in the current year, plus the number of previous dropouts who re-adopted in the current year. If at the early stage of adoption, significant number of farmers temporarily drop out and then readopt at a later date, a much longer period will elapse before a majority of the potential adopters will adopt and use the technology in a sustained manner than if farmers continue to use the technology after initial adoption. Frequent dropout and readoption have important practical implications for farmers and extension agencies as such behaviour may indicate that farmers have varying experience about the technical performance of a technology or it may indicate that factors that may facilitate adoption, e.g. credit, supply of inputs, knowledge and information, are absent. It is therefore necessary to understand the possible pathways for adoption of a new technology and the associated factors, and take corrective measures, e.g. take more positive steps for diffusion of information for increasing awareness, remove supply constraints, to facilitate rapid adoption.

3. Development and Testing of Vertisols Technology Package

The JVP developed a package composed of the following elements to better utilise Vertisols:

- A broad bed maker (BBM) by modifying local mareshas to drain excess water from vertisols plots to allow early planting compared to current practice
- Wheat variety suitable for early planting on Vertisols
- Seed rate and fertiliser rate for optimal yield
- Planting dates for optimal plant growth and yield
- Weed and pest management recommendations.

After on-station trials, the BBM package was tested on-farm at five sites in the highlands during 1986-89 in collaboration with a small number of farmers selected in collaboration with the local Peasant Associations (PA), which had a dominating role in rural Ethiopia at that time. The field sites are Hidi, Ginchi, Inewari, Dogollo and Dejen. These trials indicated some problems with the technical performance of the BBM and other components of the package, so modifications to some components of the package were made.

In 1990, the new Ethiopian Government deregulated the PAs and Cooperatives and gave individual farmers more secured usufruct to land which gave them a better position to take decisions about choice of technology. So during 1990-95, on-farm research was continued in three of the five sites (Inewari, Ginchi and Hidi) with a particular focus on the adoption behaviour of the participants in on-farm research. The JVP through the local extension office of the Ministry of Agriculture (MOA) provided training to prospective participants on the BBM package including handling, dismantling and reassembling of the BBM. Additionally in 1993, experienced and well performing farmers in Inewari were recruited to contact new farmers and train them with the objective of encouraging farmer-to-farmer diffusion. Participants were supplied improved seeds and fertilizers on credit to be repaid after harvest of the crop, and the services of BBM were provided free of charge. One set of BBM served 6-8 farmers. A committee managed the credit fund with representatives from JVP, the MOA and the PAs. In 1995, the management of the revolving fund was handed over to the PAs with local MOA staff having a supervisory role.

Since 1992, the government has gradually introduced market liberalization policies and a drive for achieving food self-sufficiency. Consequently a congenial environment has emerged for diffusion and adoption of improved technologies. Responding to this opportunity, the MOA and several NGOs including Sasakawa Global 2000 have started diffusion of the BBM package alongside other improved technologies. A private manufacturer of BBM, who was formerly an ILRI technician involved in the design and testing of BBM, is also active in the diffusion effort through selling BBM sets as well as imparting training to local blacksmiths in the fabrication of the equipment. The equipment has reportedly been diffused in Eritrea as well. However, It is uncertain how many BBM sets have been so far distributed where and how many are in actual use.

4. Case Studies on Adoption Pattern and Factors Affecting Adoption

4.1 Adoption pattern in on-farm research sites[3]

During phase 2 (1990-95) of on-farm research in three sites (Inewari, Hidi and Ginchi), information on the BBM package was made accessible to all the farmers in the research villages yet it was observed that some farmers participated in the research process for different duration either continuously or discontinuously, some did not yet participate, some even did not know how the technology functioned. In the three research sites, there were 1553 households in 10 Peasant Associations (5 in Inewari, 2 in Hidi and 3 in Ginchi). Out of these, 598 (28%) households participated in on-farm research and tests during 1989-95, so they could be considered as adopters. During late 1995 and early 1996, a survey was conducted among 585 farmers: 474 adopters and 111 non-adopters.

The sample farms were classified in two different ways (Figure 2). In Panel A, farms were first divide into adopter s and non-adopters and it was found that about half of the non-adopters did not yet acquire sufficient knowledge about BBM while the other half had acquired knowledge but did not yet decide to adopt[4]. Among adopters, about two thirds used the technology discontinuously and one third continuously. In Panel B, farms were first divide into those who knew about BBM and those who did not, then those who knew were divided into adopter and non-adopters. It was found that 9% of the sample did not yet know about BBM, 91% of the sample knew about BBM of which 89% adopted, and the use pattern was the same as that in Panel A. It was argued earlier that acquisition of knowledge and information precedes any decision to adopt (Figure 1). Therefore Panel A cannot be considered to correctly depict the sequence of learning and adoption. Panel B shows a more appropriate sequence: farmers move from learning to adoption to continuous or discontinuous use. It is important to recognise the practical implication of classification in Panel B because it shows that learning and adoption is a continuous process to which extension and

[3] This section is derived from Jabbar et al. (1998)

[4] A producer was considered to have knowledge about BBM if he/she heard about the BBM and its functions and/or saw it functioning. Here acquisition of information was the key, acquisition of operational skill for the BBM was not yet an issue.

development agencies have to respond. Their role does not end once a farmer has adopted a new technology. If a farmers discontinues either because of problems with the technology or because of other reasons, e.g. lack of access to credit, these issues need to be addressed if sustained use of the technology is to be expected.

Based on experiences in Inewari, Hidi and Ginchi, it appears that there may be significant differences between locations in terms of farmers' willingness and speed of learning and acquiring knowledge about BBM, and in terms of adoption and continuity in use. Some of the factors that may contribute to such differences are summarised in Table 1 and described below. The factors and the direction and importance of their influence are only indicative, they may not be exactly true for all circumstances. However, this experience may be helpful in identifying and targeting potential adopters by extension and other diffusion agencies.

Area under vertisols and area with major waterlogging problem may be more important than area under cropland *per se* in a farmer's decision to acquire knowledge about BBM, adopt and use it continuously. This is so because the BBM is supposed to solve the problem of vertisols management, particularly major waterlogging problem. For example, average cropland per farm was 1.45 ha in Inewari, 1.75 ha in Hidi and 2.95 ha in Ginchi. Vertisols constituted 49% of cropland in Inewari, 51% in Hidi and 91% in Ginchi. However, only 19% of cropland in Inewari and 17% in Hidi faced major waterlogging problem compared to 42% in Ginchi. These differences contributed to their knowledge acquisition, adoption and use pattern. An average farmer in Inewari was more likely to acquire knowledge about BBM than in Hidi and Ginchi, but among those who had knowledge, an average farmer in Ginchi was more likely to adopt and use continuously.

Household heads with better education (primary level or over) would be normally expected to be more eager to know about BBM and adopt it (though in the three areas studied, opposite was the case). Households with larger number of work animals are more likely to acquire BBM knowledge, adopt BBM and use it continuously. The positive effect of number of work animals may be explained by the fact that a pair of animals is required to pull the BBM, so farmers with two or more animals should be more interested to know about the BBM and use it than those having one or no work animal.

Larger family size may decrease the incentive to learn about BBM and adopt it perhaps because larger family labour supply decreases the need for alternative technology. In Inewari, handmade broadbed require a lot of family labour, so larger families with a lot of labour may show less interest in BBM unless they are willing to reduce the drudgery of women and children by adopting BBM.

Table 1: Factors likely to influence acquisition of knowledge about BBM, its adoption and continuous use

Factors	Acquisition of knowledge	Adoption	Continuity in use
Area of cropland	+	+	Neutral
Area under vertisols	++	++	+++
Area with major waterlogging	++	++	+++
Family size	-	-	Neutral
Number of work animals	+	+	Neutral
Distance from major market	-	-	-
Expected extra yield/return	+	+	-
Education	+/-	+/-	+
BBM training	NA	+++	++
Access to credit	NA	+++	++
Perception that BBM has technical problems	NA	-	-

NA Not applicable + Low importance ++ Medium importance +++ High importance

Greater distance from market (poor access to market) also decrease the incentive of learning about BBM and adopting it perhaps because the transaction costs of acquiring knowledge increase with distance and reduces potential benefits. Distance may also hinder farmers from benefiting from occasional rise in product prices. Also information to distant areas may trickle down slowly from the extension agencies.

Once acquired the knowledge about BBM, skill training in BBM use may increase the possibility of adoption and continuous use greatly. Some adopters may not actually initially acquire the skill to operate the BBM, they may hire somebody else to operate it. A typical example would be a farmer without BBM operational skill and another farmer with skill joining together with their *mareshas* to make the BBM.

The possibility of adoption and continuous use should be lower for farmers who perceive that the BBM has some problems or disadvantages compared to those who do not perceive such problem. In the three survey areas, the most important problem reported by some farmers was about the heaviness of the BBM unit. The other problem mentioned by a few was the unsuitability of the BBM when the soil is too wet during heavy rains.

For many farmers cash to buy the BBM and related inputs (improved seeds, fertilizers, pesticides) may be a major constraint given their subsistence nature of production and low cash income. Therefore, access to credit for BBM package may significantly increase the possibility of adoption and continuous use among those who have acquired knowledge and skill about BBM.

The primary attraction of the package is the extra yield or return from BBM compared to the enterprise it will replace. Moderate expectation may positively influence acquisition of knowledge, adoption and continuous use, as there may be a chance of exceeding the expected target, which may raise incentive to continue. On the other hand, high expectations about extra yield/return may sometimes act negatively as actual result may fall far short of target. The extent of higher average yield expected from improved wheat compared to the traditional crop (local wheat or teff) the BBM package replaced was 418 kg for the three sites (441 kg for Inewari, 365 kg for Hidi and 441 kg for Ginchi). These were moderate expectations as actual average yields in the areas surpassed these expectations. However, yield are likely to vary between farms and location due to many factors, so while promoting the technology and educating farmers, potential benefit should be expressed in terms of a range of yield rather than a single yield figure. Otherwise, farmers may develop wrong perception and expectation about potential yield.

4.2 Adoption pattern and related factors outside the on-farm research sites[5]

The Ministry of Agriculture along with the Global 2000 demonstrated and diffused BBM package in different parts of the country since 1994. A survey was conducted in 1996 in two weredas - Becho and Gimbichu – among 142 randomly selected farmers. Among these 85 were adopters of the BBM (used at least once) and 57 non-adopters (never used BBM). The analysis of the data included understanding of adoption of the complementary elements of the package (wheat variety, seed rate, fertiliser rate and sowing date) as well as farm level analysis of general characteristics of adopters and non-adopters.

Average intensity of use: About 70% of adopters of used the recommended seed rate of 150 kg/ha, while 30% of non adopters follow the recommended date of sowing (dry planting) and seed rate. Both the adopters and non-adopter groups have used the improved variety. In Gimbichu area, the non-adopter group used almost the same level of improved variety. More than 60% of the farmers have applied the recommended rate of fertilizer, although nearly all the farmers in the study area are applying fertilizer. There is no significant difference in the use of fertilizer between adopters and non-adopter groups (Table 2). This trend shows that the use of fertilizer is a long time experience among the farmers in the survey region. The use of improved variety is relatively a short time experience as compared with fertiliser.

Advantages of BBM: About 96% of adopters confirmed that BBM helps to avoid drainage problem successfully and improves the yield substantially. It helped them to reduce the drudgery of labour. About 80% of adopters claim that BBM is highly applicable to their situation, 9% claim that there is no much visible difference between the BBM and manual BBF (Table 3). Only 10% claim that BBM had no real applicability on their land. More than 85% of the farmers who used the BBM have observed substantial improvement in yield and even some of them who are never used to growing wheat on their farms are able to do so for the first time by using BBM. Their subjective assessment is that they need precision of using

[5] This section has been derived from Gezahegn Ayele (1999).

BBM. More than 85% of the farmers claimed that they prefer to plant their crops on flat land with gentle slope because the waterlogging problem on such land topography is severe and easy to drain. Researchers also recommended that the slope of the land should be a certain minimum so that its workability would be easier.

Table 2: Average intensity use of technology components

	Adopters N=85	Non-Adopters N=57
Fertilizer use (kg/ha)		
for wheat- urea	105	85
DAP	110	105
Tef- urea	102	100
DAP	150	120
- improved seed -wheat (kg/ha)	136	114
- local –wheat (kg/ha)	123	130
- improved tef (kg/ha)	30	20***
- local tef (kg/ha)	57	40
Sowing date (% of farmers)		
- wheat - end June-mid July	85	60
- tef - early July	63	60
Share of wheat area on total farm land (%)		
Gimbichu (N=72)	48	40**
Becho (N=70)	14	7*

*, **, *** significant at 1%, 5% and 10% respectively

Source : Field survey

Disadvantages of BBM: Close to 75% of non-adopters claimed that the use of BBM increases the demand for labour (Table 4). Some of them said labour requirement decrease fore land preparation and increase for weeding and harvesting, which would be expected as a vigorous crop need more labour for harvesting and early planting allows weed growth that need to be removed. Over 40% of the farmers do not know the benefit and did not hear about the use of BBM. Close to 15% of the non-adopters, although they have been already trained and know the benefit, either have no suitable land or do not have cash to buy the BBM. Close to 10% claim that , BBM is expensive and they cannot afford to buy it. Some of them claim the lack of credit and limitation of cash as major constraints to purchasing the BBM. However, some of them also claim the shortage of seeds to be the major problem of using the BBM . Majority of the farmers prefers to use the BBM with improved seed to local seeds. However, about 70% claimed to have had experienced seed shortages while about 13% mentioned the shortage of land and the rest mentioned problem of risk, cost of improved seeds and unawareness of the benefits of improved seed. Risk associated with shortages of rainfall creates favourable condition for pest and insects and hence causes yield losses.

Table 3: Adopters' perception on benefits of adopting BBM innovation (% adopters)

Avoids drainage problem	95
Helps to increase productivity	86
Avoids drudgery (increase labor efficiency)	90*
Highly suitable depending on the weather	80
Highly applicable on flat land (gentle slope)	84
Applicable on every land with waterlogged	18
Of no significant difference	9

- Some respondents claimed that labour requirement decrease in land preparation but increase in harvesting and weeding. This would be natural as a more vigorius crop needs more labour for harvesting.

Factors affecting adoption: The benefits obtained from the technology differ across the sample farms. With sub-optimal use of the BBM technology, the yield advantage decreases, hence leading to lower benefit derived from the technology. Generally, there is evidence that the economic advantage is much higher for the adopters than the non-adopters group.

The household level analysis demonstrated a spectacular increase of yield as a result of dry planting using the BBM package as compared to traditional practices of the farmers. The results confirm that there is marked marginal increment from the use of the BBM technology at the household level. Although there seems to be variability in the average yield obtained from the use of the BBM technology, the overall yield has almost more than doubled over the traditional one on the same soil type. The variability of output on the same soil could be attributed to different levels of efficiency in implementing the BBM package, specially improved drainage, which in turn depends on the skill of individual farmer in using the BBM and shaping the land. In addition to this, the optimum time of using the implement determines the efficiency of the BBM in draining the excess water.

Table 4: Non-adopters' perceptions about BBM and reasons for non-adoption (% of nonadopters)

1. Reasons for not adopting BBM	
- Expensive	14
- Can't work with it/don't know how it works	10
- Don't need it	21
- Don't know the benefit	53
- Delay in getting credit	27
- No access to credit	90
2. **Reason for not using improved varieties**	
- Too expensive	7
- Shortage of improved seeds	68
- Do not know the benefit	8
- Risk and uncertainty	4
- Shortage of land	13
- price instability	70

Source : Field survey

Following a multitude of theoretical and empirical works of adoption and diffusion models, in general, it was hypothesised that economic, demographic, environmental factors and those of the technology characteristics influence farmers' response to an innovation. This analysis clearly indicated that, the adoption pattern and speed of adoption varied among individual farmers. As a result, farmers in the study villages responded differently to the technology package. Some adopted the technology in the first period and continued to use it, others adopted it at different times and discontinued practising it while others heard about it but were found reluctant to adopt and use it. Analysis of the sampled farmers at the household level confirmed that age factor has negative effect on the adoption of the BBM technology. As age increases probability of adoption tended to decrease indicating that old farmers were more reluctant to adopt the technology than younger farmers. As is often the case young farmers are fast enough to respond to new technology. It is equally true that distance from main road affected adoption negatively. The implication is that market access and proximity to the infrastructral facilities increase the probability of adoption of the technology with anticipation of better market and profitability.

Other factors such as access to farm resources were observed to affect the probability of adoption positively and significantly. In this connection, farm size and number of bulls owned were a surrogate to induce adoption of the farm technology as expected. As the farm holdings of the household increased the probability of adoption increased tending to expand the farm land under the improved technology. This is especially true for Gimbichu farmers who operate limited land under various risk situations such as unreliable rainfall, unpredictable weather change and variation of topography. Similarly, number of bulls owned affects the farmer's decision to adopt positively. Animal drawn drainage equipment requires at least a pair of oxen to draw the implement and prepare the raised bed to let the water flow out of the farm.

Training facilitates method of developing the skill of the farmer and raising the awareness. This is especially true during the initial phase of the transfer process when farmers require training on land shaping methods and proper use of the hardware component of the BBM. Among adopters 75% received training while only 11% of non-adopters received training. Eighty percent of adopters received extension visit 'often' and 20% received none compared to 60% and 40% for non-adopters. Most of the farmers who appreciated the use of the BBM have received intensive training from MOA or Global 2000 as well as research centers. Most of the farmers at Gimbichu got the exposure and training from the Debre Zeit research centre located in the vicinity.

Others factors, like credit greatly affect the adoption of technology. Adopters received Birr 437 as credit compared to 227 Birr by non-adopters. Not only availability of credit is a sufficient condition, but also the type, amount and availability in time is a necessary condition. In a situation where cash is a constraining, the question of acquiring BBM is closely linked with economies of scale. Farmers buy at a high cost and use it only once for preparing the land and its use is limited only for a specific period and purpose. Instead under this situation farmers adopt modified BBF, or some may rent in the BBM itself just for a while. Some have been observed when renting out the BBM. This might be helpful for resource poor farmers under a situation where supply is not a constraint.

5. Summary and conclusions

Empirical studies on agricultural technology adoption generally divide a population into adopters and non-adopters, and analyse the reasons for adoption or non-adoption at a point in time. In reality, technology adoption is not a one-off static decision rather it involves a dynamic process in which information gathering, learning and experience play pivotal roles particularly in the early stage of adoption. Farmers move from learning to adoption to continuous or discontinuous use over time. The characteristics of both the user and the technology are important in explaining adoption behaviour and the pathway for adoption. The sets of factors that may significantly influence decisions to acquire knowledge about BBM, to adopt and then to use it continuously or discontinuously may be different. The lag between learning and adoption, and the possibility of discontinuation and readoption imply that a longer period will require for majority of the farmers to use the technology than if adoption was a one off decision leading to continuous use.

The results presented here are based on information from few case study areas. A more detailed comprehensive countrywide study is required for an understanding of the adoption pattern and its impact on land use and farmers' welfare.

Individual adoption is important but because adoption in a scattered manner may create disadvantage to neighbouring plots, community level decision and agreement is required about construction and maintenance of tertiary and common main drains to expel water from individual plots in a watershed or landscape. Construction of such drains should be on a voluntary basis by beneficiary farmers, but where necessary extension and development agencies may assist local communities to organise themselves. Individual farmer's motivation to participate and make voluntary contribution will depend largely on the potential gains that the farmer may expect from common drain construction. It will be necessary to identify important motivating factors in each location and develop approach to participation accordingly.

References

Asfaw Negassa, Benti Tolessa, Franzel, S., Gemechu Gadeno and Legesse Dadi, 1991. The introduction of an early maturing maize (Zeamays) variety to a mid-altitude farming system in Ethiopia. Experimental Agriculture, 27:375-383.

Ashby, J. A., Quiros, C. A., and Rivers, Y. M., 1989. Farmer participation in technology development: work with crop varieties. In: R. Chambers, A. Pacy and L.A. Thrupp (eds.) Farmer First: Farmer Innovation in Agricultural Research. Intermediate Technology Publications, London.

Feder, G., and Umali, D., 1993. The adoption of agricultural innovations: a review. Technological Forecasting and Social Change, 43: 215-239.

Fisher, A.J., Arnold, A.J. and Gibbs, M., 1996. Information and the speed of innovation adoption. American Journal of Agricultural Economics, 78:1073-1081.

Gezahegn Ayele. 1999. Economic analysis of innovation and adoption of vertisol technology: a study of smallholder mixed farming in the highlands of Ethiopia. Verlag Ulrich E. Grauer, Stuttgart, Germany. 156pp.

Jabbar, M. A., Larbi, A., and Reynolds, L., 1996. Alley Farming for improving small ruminant productivity in West Africa: ILRI's experiences. Socio-econ. and Policy Res. Working Pap. 20. International Livestock Research Institute, Addis Ababa, Ethiopia. 96 pp.

Jabbar, M A, Hailu Beyene, Mohamed Saleem, M A, and Solomon Gebreselassie.1998. Adoption pathways for new agricultural technologies : An approach and application to Vertisol management technology in Ethiopia. Socioeconomic and Policy Research Working Paper No 23. International Livestock Research Institute, Addis Ababa, Ethiopia, 27pp.

Rogers, E.M., 1983. Diffusion of innovations. 3rd Ed. Macmillan Co., New York.

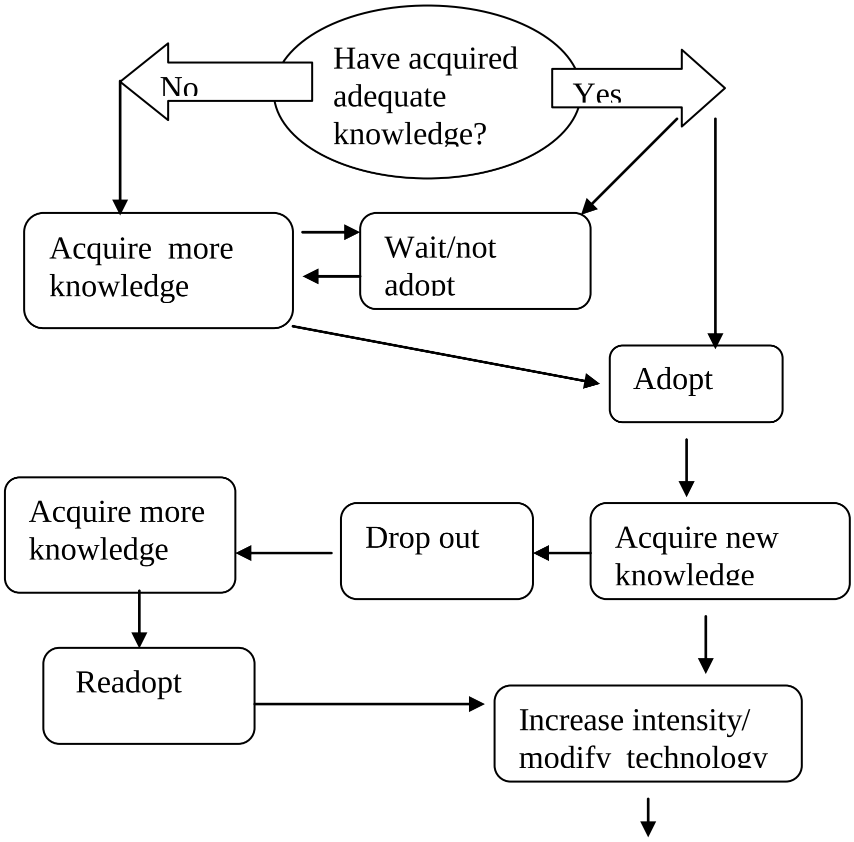
Saha, A., Love, H. A., and Schwart, R., 1994. Adoption of emerging technologies under output uncertainty. American Journal of Agricultural Economics, 76:836-846.

Sharif, M. N., and Kabir, C., 1976. System dynamics modelling for forecasting multilevel technological substitution. Technological Forecasting and Social Change, 9:89-112.

Stoneman, P., 1983. The economic analysis of technological change. Oxford University Press, London.

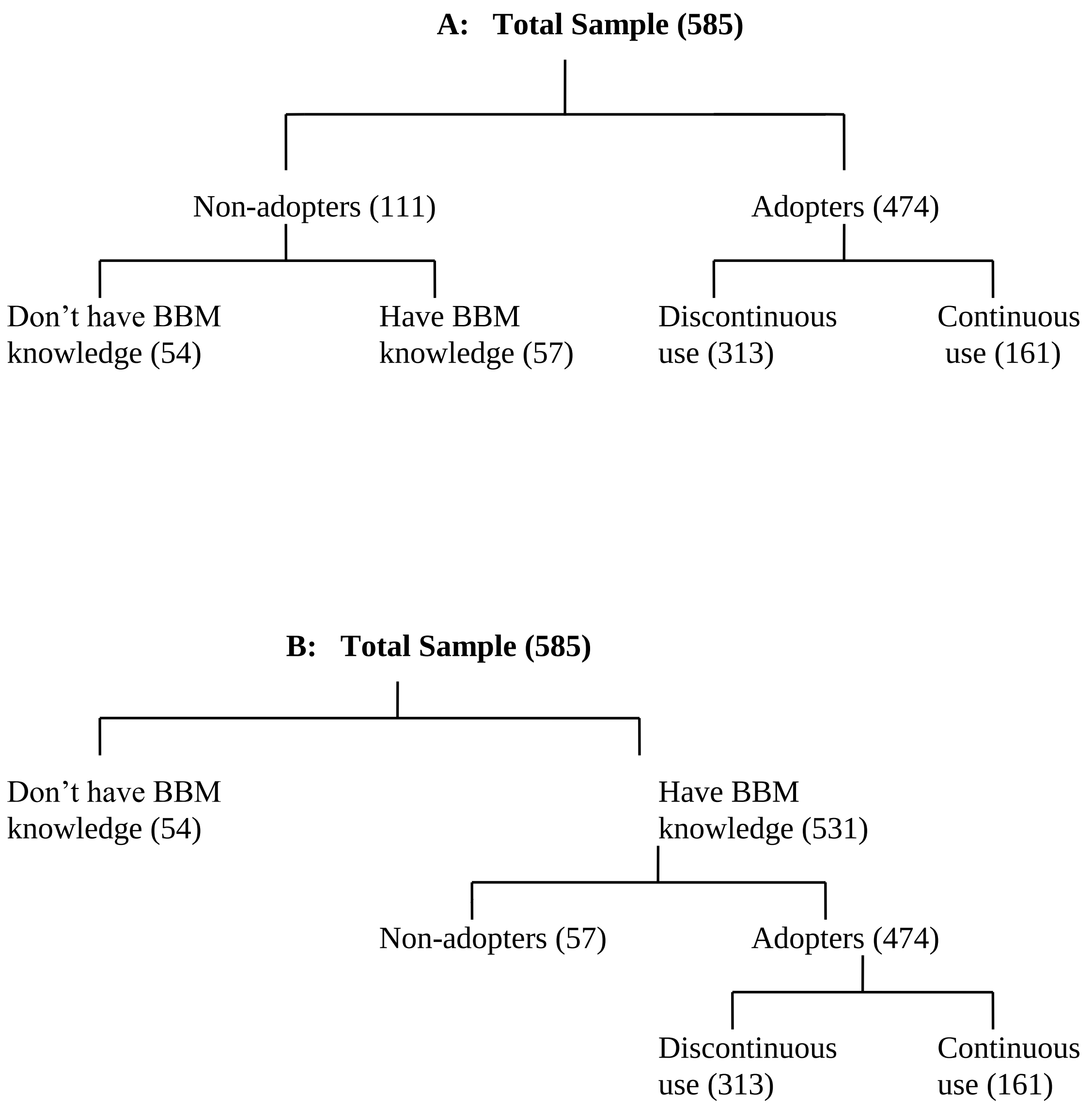
Thirtle, C. G., and Ruttan, V.W., 1987. The role of demand and supply in the generation and diffusion of technical change. Harwood Academic Publishers, London.

Figure 1 : Learning and adoption pathways for a new technology



Source: Jabbar et al. (1996)

Figure 2: Distribution of sample households according to BBM knowledge, adoption and use pattern in three research sites



Source: Jabbar et al. (1998)