AN ASSESSMENT OF THE ADOPTION OF IMPROVED FOODGRAIN STORAGE STRUCTURES IN MARA REGION

By

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ABSTRACT

This study was designed to assess the adoption of improved storage technology introduced in Mara Region by SG-2000 and UNDP projects. The study concentrated on farmers growing maize and sorghum which are the main crops grown under SG-2000 project. The study was conducted in 10 villages in Tarime and Musoma rural Districts.It involved 150 farmers and 10 village extension officers from the selected villages.

The specific objectives of the study were 1) to determine the level of adoption of improved storage structures introduced by SG-2000 and UNDP projects 2) to identify factors associated with the adoption and non-adoption of improved foodgrain storage structures 3) to determine the perception of farmers and village extension officers on the effectiveness of the improved storage structures and 4) to determine the relationship between farmers', innovation's and institutional characteristics on one hand and the adoption of improved storage structures.

Data were collected using two types of structured questionnaires: one for farmers who grow maize and sorghum, the other for extension officers. Field observations and secondary data supplemented the questionnaires. Descriptive statistics and multiple regression were used in the analyses. The results revealed that 1) only 4% adopted the technology 2) farmers' characteristics, innovation and institutional factors were important in influencing the adoption of improved storage technology. Farm size, maintenance and repair costs of the structures, involvement of farmers in the programme, and effectiveness of extension were found to be significant determinants of the level of adoption of improved storage structures.

Farmers perceived the improved storage structure as durable with low maintenance and repair costs. However, the adoption depended on other factors such as availability of resources and the information transfer process.

Policy recommendations include:

1) Direct involvement of farmers in all phases of technology-innovation process to enhance adoption.
2) Women's involvement in the programme should be increased by providing extension services directly to them.
3) Extension services have proved to be less effective in transferring the technology to farmers, hence they need to be strengthened.
4) A supervision mission should be established in the programme so as to increase contact between farmers and extension officers and to get a quick feedback.

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DECLARATION

I, ELIZA NYANGETA BWANA do hereby declare to the Senate of the Sokoine University of Agriculture that the work presented here is my own, and has not been submitted for a higher degree in any other University.

Signature ....

Date ....30TH OCTOBER, 1996....

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DEDICATION

To my father, Late Francis Buharata Kisigiro and my mother, late Anastazia Wakuru Buharata, who laid the foundation for my education.

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SG 2000	-	Sasakawa Global 2000
MTP	-	Management Training Plot
SAFE	-	Sasakawa African Fund for Extension
CIMMYT	-	International Maize and Wheat Improvement Centre
UNDP	-	United Nations Development Programme
IFAD	-	International Fund for Agricultural Development
FAO	-	Food and Agricultural Organization
CRDB	-	Cooperative and Rural Development Bank
CDTF	-	Community Development Trust Fund

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the Study

Sasakawa Global 2000 (SG-2000) in collaboration with the Ministry of Agriculture of Tanzania initiated a project directed to smallholder farmers to test and demonstrate improved cereal crop production technologies in 1989/90. The main crops grown under the project include maize and sorghum. The project was introduced in seven regions of Tanzania; Arusha, Dodoma, Iringa, Kilimanjaro, Mara, Mbeya and Rukwa. The project's main strategy for testing and demonstration of the technology has been through the use of the Management Training Plot (MTP). The MTP is one acre in size and constitutes the actual site on which improved practices are appraised by farmers. Participating farmers are clustered in groups of 10 farmers each and all agree to help the village extension officers to extend the technology to at least 10 neighbouring farmers in MTP operations the following season.

The recommended technology package for maize and sorghum advocated by SG-2000 consists of the following: 1) an improved variety 2)use of fertilizers 3) optimum plant population 4) timely planting and weeding and 5) use of chemicals for pest and disease control. Inputs required to establish the MTP are provided through the programme and the cost of these inputs are recovered from the participating farmer at the end of the season by deducting from crop sales. Concurrently efforts are made to increase availability of fertilizers, improved seed, credit and market outlets at the village level (Quinones *et al.*, 1991). Farmers can participate in the project for a maximum period of three years after which they are phased out from the project and have to look for inputs on their own.

As a result of improved crop production technologies, farmers in the project have increased their yields of maize and sorghum by up to four times compared to farmers using traditional production practices (Swegle, 1994). Because yields have increased they must be stored. Improvements must therefore be made at farm level storage to reduce post-harvest grain losses caused by insects, rodents and diseases.

A programme was introduced in 1991/92 to preserve the increased yields and to give farmers a longer period in which to market surplus grain by holding part of the crop on the farm, thus reducing seasonal price fluctuations (Quinones *et al.*, 1991). Improved storage structures called silos which are cement coated and have a storage capacity of two to three tonnes were introduced in the project regions.

In Mara Region, the program for improving rural storage structure was funded by UNDP (United Nations Development Programme) and started in 1991/92.Thirteen other regions which benefitted from the UNDP storage project are: Arusha, Dodoma, Iringa, Kagera, Kigoma, Kilimanjaro, Morogoro, Mwanza, Rukwa, Ruvuma, Shinyanga, Singinda and Tabora. The UNDP project was executed under the Prime Minister's Office. Implementation and coordination responsibilities were assigned to District Councils supported by the Ministries of Agriculture and Community Development, Women Affairs and Children.

The UNDP storage project was introduced in only three of the four districts of Mara Region: Bunda, Musoma and Tarime. It covered five villages in each district in 1991/92 and another five villages in each district in 1992/93.

Both SG-2000 and UNDP projects used the agricultural extension staff employed by the Ministry of Agriculture to transfer the new technology to farmers. The extension staff served as link persons between farmers and project organizations. Group and individual methods were used to transfer improved storage structure technology. Group methods used included meetings and demonstrations, while the individual method used was farm/home visits.

Other components in SG-2000 and UNDP storage structure projects included: a) meeting the labour cost for demonstration structures, b) conducting seminars to agricultural extension staff and farmers on improved storage practices in villages within the project, and c) training craftsmen/artisans on storage structure construction in those villages. Farmers provided building materials for the demonstration structures. However, the approach used in the planning in both SG-2000 and UNDP projects was top-down in nature. The development of the technology did not involve farmers at the beginning as there was no interaction between extension workers, farmers and project planners at that stage. The technology was developed without farmers involvement and only introduced to farmers for implementation.

1.1.2 Description of technology

1.1.2.1 Traditional technology

Storage is necessary for farmers so as to achieve three main objectives: a) to retain a supply of food for family consumption, b) to retain food for sale during periods when prices are favourable c) to retain seed for planting in the next cropping season (Makundi, 1984; Temu, 1996).

The types of grain commonly grown in Mara are maize, sorghum, and millet, and all these require similar storage structures because of their grain nature. Most of the produce for home consumption is stored in traditional structures called "Vihenge". "Vihenges" are usually round, raised above the ground about 30cm on stones or y-

1.1.2.2 Improved technology

The technology introduced was based on the improvement of traditional storage structures used by the smallholder farmers. Three types of improved storage structures were introduced by the two projects:(i) circular granary baskets made of interwoven reeds/sticks (ii) silos (cicular) built of burnt bricks and (iii) rectangular bins built using sun-dried earth blocks.

Improvements made in the design of storage structures introduced, be they reed-woven basket granary, or granary silos/bins included the following;

(i) The opening for loading at the top has been narrowed and a well-fitting lid which can be plastered or sealed into position added. The fitted lid prevents entry of birds and insects;

(ii) An opening at the bottom to unload the grain through gravity and for occasional inspection has been added, with a locking facility to reduce risk of theft.

(iii) The structure has been raised from 30 cm to 90 cm above the ground, on a strong wooden platform resting on strong poles fitted with rat guards. The higher platform and fitting of rat guards makes the structure rodent-proof, easier to inspect and clean below it, moisture migration to the structure is reduced, and unloading is made easier.

(iv) A separate well thatched overhanging roof over the structure has been added which prevents rain from wetting the walls of the silo.

(v) A robust reed/stick-woven wall was modified which may be well plastered with mud and/or cowdung (cement in case of SG-2000) inside and outside the walls, to eliminate cracks and crevices where storage pests could hide. It also becomes longer lasting (above five years) as compared to the traditional structures which lasts for about 3-5 years.

(vi) The capacity of the structures has been increased to 2-3 tonnes from the less than a one tonne capacity of the traditional structures.

Besides the improvements made to the design of the storage structures, the programme package include the use of insecticides for control of pests. The insecticides are used to treat pests already in the produce after harvest and for control of new infestation of pests when in store. The crop has to be dried and then shelled before storage. This is because cobs facilitate infestation of pests especially the larger grain borer.

1.1.2.3 Adoption of technology

Several studies show that some recommendations made by scientists may not be appropriate in field situations (Kauzeni, 1988; Ortiz and Menese, 1991; Monu, 1993). One of the most important reasons for non-adoption of new technologies is that technologies are not developed by researchers on the basis of farmers' needs or problems. This is because people who are supposed to benefit are never consulted.

Despite the various attempts and efforts of SG-2000 and UNDP projects to provide improved storage structure technology, adoption has been inadequate. Through observations, only a few farmers have adopted improved storage structures in the villages concerned.

1.1.2.4 Factors influencing adoption

The development of appropriate technology is a necessary but insufficient condition for ensuring its adoption (Byerlee and Heisey, 1992). One must also design a system of technology transfer that provide farmers with the inputs and information they need to enhance adoption. The adoption of improved storage structures, for example, is conditioned by the availability of raw materials for construction, credit to promote a technological package, skilled labour and time for construction and enough quantity of foodgrains to store. Likewise, the extent to which farmers use information related to improved storage structures depends on the effectiveness of extension services and on farmers' level of formal schooling (Byerlee and Heisey, 1992).

The ineffectiveness of extension system to influence the farmers to adopt improved technologies may be attributed to a number of reasons; ineffective extension methodology; unaffordable innovation by farmers; poor supervision and coordination in the extension organization; lack of incentives and motivation of extension officers; and financial constraints which lead to poor transport facilities, poor infrastucture and low salaries for extension officers (Kauzeni, 1988; Wambura, 1988). Axinn (1988) and Wambura (1993) assert that some of the constraints to the transfer of technology by extension officers are that wealthier farmers in any area have a tendency to dominate the activities and time of extension officers at the expense of the less powerful and more needy families. Studies have also revealed that failure of many extension programmes to reach the majority of smallholder farmers is due to neglect of extension services for women who usually contribute a major proportion of the family farm labour (Swanson *et al.*, 1984; Mollel, 1986; Due *et al.*,1987; Njiku 1991; Keregero and Biswalo, 1991; Shayo, 1991; Rwambali, 1991; Lyimo and Mnyika, 1992; CIMMYT, 1993; Rogers and Vandeman, 1993). Women contribution to agriculture has been underestimated and sometimes overlooked (Keregero, 1988; Rwambali,1991; Wambura, *et al.*, 1995). The above authors argue that women frequently have little time at their disposal to communicate with extension workers who in most cases are males.

Considering that there are many factors which influence farmers' decision to adopt or reject innovations, from the perspective of this study, these factors are classified into three major categories:

1. Farmers' characteristics which include age, level of education, gender, and farm size.

2. Innovation characteristics such as cost of inputs (i.e. purchased materials and labour), labour requirement, maintenance and repair costs, compatibility, complexity and profitability of the technology.

3. Institutional characteristics such as accessibility of the technology and extension services and availability of credit and inputs (Mattee, 1994).

1.2 Problem statement

Because of seasonality of agricultural production, increased yields resulting from the SG-2000 production technologies, and to give farmers a longer period in which to market surplus grains, foodgrains have to be stored before being consumed or sold. During storage, foodgrain losses occur due to a number of factors. These factors include insects, moisture, temperature, rodents, birds etc. The traditional storage structures used by farmers do not give adequate protection against various factors responsible for spoilage of foodgrains (Makundi, 1984; Girish et al., 1985). On the other hand, improved storage structures play a major role in minimizing losses occurring in storage as evidenced by the projects' demonstration structures.

SG-2000 and UNDP projects introduced improved grain storage structures at the smallholder level in 1991/92 after realizing the inadequacy of the traditional storage structures. Although the introduced structures are storage efficient in terms of storage pests' protection, the fact that it is a new innovation demands empirical evidence to assess their adoption by smallholder farmers. As of now, no empirical studies have been conducted to assess the adoption of introduced storage structures in Mara region.

1.3 Significance of the study

Despite the various attempts and efforts to introduce the improved storage structures, my observations show that only a few farmers have adopted improved storage structures in the villages concerned. The results of this study will be of assistance in the identification of factors associated with adoption/non adoption. The results will also serve as a basis for formulating new strategies for increased adoption.

1.4 Objectives

The primary objective of this study is to assess the adoption of improved foodgrain storage structures in Mara Region.

1.4.1 Specific objectives

1.4.1.1 To determine the extent of adoption of improved food grain storage structures introduced by SG-2000 and UNDP projects in Mara Region.

1.4.1.2 To identify factors associated with the adoption and non-adoption of improved foodgrain storage structures.

1.4.1.3 To determine the perception of farmers and village extension officers on the effectiveness of improved foodgrain storage structures.

1.4.1.4 To determine the relationship between farmers', innovation's and institutional characteristics and the adoption of improved storage structures.

Limitations

Adoption is a process occuring across time. Cross-sectional data based largely on questionnaire and perceptual measures are inadequate for measuring adoption. In his study on adoption of conservation technologies, Nowak (1987) indicated that perceptual measures of conservation practices are insufficient in explaining the farmer decision processes. Future studies should therefore adequately conceptualize and measure the adoption process.

CHAPTER TWO

2.0 Literature Review

This section reviews some of the factors which influence adoption of improved foodgrain storage structures in Tanzania and other developing countries.

2.1 Traditional Technologies

About 80% of the grain produced in Tanzania is stored at the producer level (Makundi, 1984). Storage structures at the producer level are essentially traditional and vary depending on such factors as climate, duration of storage, availability of construction materials at local level etc. The storage period may vary from a few days to a few months depending on the needs of the farmer and the amount of the grain produced.

The major pests of stored foodgrains in Tanzania include; *Sitophilus spp, Rhizopertha dominica, Tribolium spp, and Sitotroga cerealella* (Mphuru,1986; Temu, 1996). The invasion of the larger grain borer-*Prostephanus truncatus* in Tanzania in 1982 (Makundi, 1984) has focused attention to the country's storage system. The storage of maize in particular, apart from being affected by above pests, has become seriously threatened by *P.truncatus*. The pest problem becomes more serious when farmers have adopted high yielding varieties (HYV) which have proven to be more susceptible to storage pests and outbreak of larger grain borer-*Prostephanus truncatus* (Mphuru, 1986).

The design of storage structures differ from area to area within the same region depending on the availability of raw material. However, most structures commonly used for storage of maize and sorghum in Tanzania are "Kihenge"- ventilated interwoven baskets, clay pots, gourds, gunny sacks, "Dari"-roof system, "Dungu"-a free standing storage house on stilts and others (CDTF, 1977; Makundi, 1984; Ashimogo, 1988; Ringia, 1990; Temu, 1996).

The traditional storage structures used by farmers do not give adequate protection against storage pests (Girish et al. 1985; Ashimogo, 1988; Ringia, 1990; Mamiro, 1991). The extent of losses occurring in traditional storage structures depend on such factors as moisture content of the stored grains, air tightness of the storage structures, use of insecticides etc (Thakre and Bansode, 1988). Sometimes producers are forced to sell immediately after harvest when prices are low because of inadequate storage facilities.

In developing countries like Tanzania, governments have continued to advocate the use of modern systems of grain storage. A number of improved structures and pesticides have been developed and recommended for use. But farmers still use the traditional systems of grain storage whereby huge food losses are being experienced. It is estimated that 30-35% of food crops produced in Tanzania annually get wasted because of poor food processing as well as poor storage technology (Nkonoki, 1994).

Traditionally, the failure by farmers to adopt new technology has been blamed on farmers' socio-cultural milieu of beliefs, attitudes, values and traditional practices (Mvena and Mattee, 1988). More recently it has been recognized that there are alternative explanations to the failure of farmers to adopt new technologies. Constraints to rapid adoption of technologies have been identified as lack of credit, limited access to information, lack of technical know how at village level, inadequate farm size, and inadequate incentives associated with farm tenure arrangements (Feder et al., 1985; Shakya and Flinn, 1985; Nowak, 1987; Mattee and Mvena, 1988; Polson and Spencer, 1991; Adesina and Zinnah, 1993; Adesina and Baidu-Forson, 1995). Several studies suggest that the complexity, compatibility, and profitability of a technology influence whether it is or it is not adopted (Rogers, 1983; Kauzeni, 1988; Njoku, 1991; CIMMYT, 1993). In his study in Sumbawanga district Ashimogo (1994) reported that farmers were not using storage pesticides because they had no cash to buy pesticides and some farmers had little grain to store. Another study done in Moshi had similar results; that farmers did not use pesticides since they were too expensive to buy (Mamiro, 1991).

Many development projects have sought to remove some of these constraints by introducing facilities to provide credit, information, orderly and timely supply of necessary and complementary inputs, etc. Examples of these projects include: the SG-2000, the World Bank; the International Fund for Agricultural Development (IFAD); the Food and Agricultural Organization (FAO); the Cooperative and Rural Development Bank of Tanzania etc. Removing these constraints was expected to result in increased adoption of improved practices but expectations have been only partially realized.

2.2 Factors Influencing the Adoption of Improved Foodgrain Storage Structures

As noted above, there are several factors that influence adoption, including: the degree to which the technology is appropriate for farmers conditions; the compatibility of the technology with the local farming system; how the technology is presented by extension and other information systems; and how it is supported by other institutional structures for supplying inputs, credit and prices for the produce (Van den ban and Hawkins, 1988; Russel and Dowswell, 1992; CIMMYT, 1993). Other factors include those associated with farmers, such as their education, age, gender, farm size and income (Rogers,1983; Nowak, 1987; Anosike and Coughenour, 1990).

2.2.1 Characteristics of an innovation

Adoption decision-making is a process extending over a period of time. Time elapses between introduction of the innovation and its 100 percent adoption in a given population. The adoption process consists of a series of stages from first becoming aware of the innovation to ultimately adopting that innovation for use. There are five distinct phases: a) awareness of innovation, b) interest in the innovation, c) trial of innovation, (d) evaluation of innovation, and e) adoption or rejection of innovation (Rogers, 1983; Van de Ban and Hawkins, 1988; Fliegel, 1993). The above authors argue that, to achieve a high degree of adoption, some prerequisites have to be met: the technology recommendations must be delivered in a way that farmers can understand; the practices must be superior over the current practices; they must fit into the farming system of the farmer and the necessary inputs for adopting the technolgy must be available.

2.2.1.1 Compatibility

Compatibility is the degree to which the technology is consistent with existing values, past experiences, and needs of potential adopters (Rogers, 1983). Technologies must be compatible with the farming system if they are to find acceptance by farmers. Research has shown that many times a technology that appears as a reasonable innovation for an extension agency is rejected by farmers not because of any intrinsic quality of the technology itself, but because it conflicts with other elements of the farming system (CIMMYT, 1993). Keregero et al. (1977) found that some cotton package components were widely adopted, while others had low adoption. The main constraint identified for low adoption was suitability to the farmers' situation. That is some components of the technology were not adapted to the existing farming system. They concluded that the adoption of the whole cotton husbandry package might mean serious disruption of the existing farming system.

2.2.1.2 Complexity

Rogers (1993) defines an innovation as complex if it is difficult for farmers to understand and use. Some innovations are readily understood by members of a social system; others are more complicated and will be adopted more slowly. In general, innovations that are simpler to understand will be adopted more rapidly than innovations that require the adopter to develop new skills and understandings other factors being the same (CIMMYT 1993).

2.2.1.3 Relative advantage

Relative advantage is the degree to which an innovation is perceived as better than what it is intended to replace, advantageous to the adopter relative to the old way of doing things (Rogers, 1983). Advantage may include reduced labour costs, reduction in demand for labour to do unpleasant tasks. Technologies are adopted by farmers if they are perceived as being beneficial, more visible and have positive attributes. If returns are not worth the investments of money and labour then it is going to be rejected. Therefore, the greater the perceived relative advantage of an innovation, the more rapid its rate of adoption. In the case of this study , the traditional storage structures are not likely to be abandoned unless it can be demonstrated that improved storage structures introduced will be sufficiently convincing that they will produce reasonable returns in the foreseeable future; and that they will not result in intolerable strains on social structures and income levels.

2.2.1.4 Involvement of farmers

As stated earlier, the blame for non- adoption of new technologies, until recently, have been put on farmers. The explanation of non-adoption has been sought in the socio-demographic characteristics of the farmers, their ignorance, illiteracy and unwillingness to change (Monu, 1993). Although the fact cannot be denied that certain socio-cultural beliefs and practices of farmers could hinder change, a more important factor is the non involvement of farmers in the technology generation- dissemination process (Madeley, 1987; Kauzeni, 1988; Ruvuga, 1992; Rwambali, 1992; Biswalo, 1992; Ibrahim, 1992;

Nanai, 1993; Monu, 1993). Those who call for farmers' involvement argue that some of the socio-cultural beliefs and practices would not pose obstacles to the adoption process if farmers were involved at the beginning of the technology development process.

Examining twenty five World Bank projects, Cernea (1988) found thirteen of them to be non-sustainable. The major reason given for non-sustainability of these projects is the neglect of socio-cultural factors, mainly farmer organizations and participation. Esman and Uphoff (1984) in their review of non-World Bank financed projects have come to the same conclusion.

Starley (1984) contended that the slow rate of progress in adoption is frequently an indictment of project methodology rather than unwillingness of farmers to adopt technology. Far too often agricultural projects have been simply offering inappropriate packages. On the contrary, farmers have had little interest in the systems which seem technically or economically inappropriate for their areas. In an effort to determine the extent of adoption of the recommended cotton husbandry techniques, Perez (1988) found that the major reasons given by farmers for non-adoption were that some of the recommendations were not compatible with the farmers' priority of concern for food.

Ngasa (1979) looked at the adoption of oxen by small scale farmers, an innovation which has been vigorously promoted by the Tanzanian government as the answer to the high cost of tractorization. The study concluded that the adoption of oxenization was lower than expected. According to him the main reasons for the poor response of farmers to the technique were inadequate training of the farmers, and lack of interest on the part of the village leadership.

Madeley (1987) and Kauzeni (1988) argued that projects tended to be lowly adopted because the people who were supposed to benefit were never consulted. The authors felt that projects would likely be more successful in the long run when local officials, organizations, and people are involved in the design, decision making, implementation and evaluation of activities intended to improve their livelihood. The approach used in the planning of projects both in SG-2000 and UNDP was rather top-down. The system did not involve farmers in the generation of this new technology. It should be remembered that, intended users are also important generators of knowledge which could and should be utilized by research/planners and extension. They should not be looked upon as only receivers of knowledge but also as contributors of knowledge.

2.2.1.5 Labour availability and skills

Technologies have different labour requirements and skills; some reduce the amount of labour required in the farming system, while others significantly increase it. The new technology may require a significant amount of extra labour, new skills or may require availability of hired labour during the period relevant to the recommended technology.

The improved storage structures introduced in Mara Region require skills in weaving, plastering, roof thatching, and additional labour for shelling/threshing of maize and sorghum into grains and pesticides application. Fitting this new technology into the existing farming systems may be a limitation on the time and labour available on the farm. Further, the adoption of improved storage structure may not be a priority for the farmer, making the farmer therefore unwilling to devote extra time and labour to the innovation. Thus, changes may be perceived as a threat and resistance to it may be strong.

2.2.1.6 Availability of raw materials

Closely related to credit facilities is the availability of purchased raw materials. A farmer may understand the value of using a technology developed and be willing to adopt it but if the right raw materials are not easily available at a price he can afford or not available at all, the farmer will not adopt the technology. Thus, lack of raw materials or their high costs may hinder the adoption of the technology (CIMMYT 1993).

2.2.2 Farmers characteristics

Much of the literature on adoption assumes that the new technology is necessarily good and concentrates on analyzing those characteristics of individual farmers that make them more receptive to these innovations (CIMMYT, 1993). For the purpose of a technology generation programme, however, it is much better to examine the correspondence between the recommendation and farmers' conditions, without assuming that the technology is perfectly appropriate or that those farmers who adopt ought to be called progressive. Characteristics of individual farmers that can be used as explanatory variables in understanding adoption patterns include such factors as education, gender or age that may predispose a farmer to take interest in a new technology and resources such as size of land, income or access to credit that may make it easier or more profitable for a farmer to change practices. (Ponje, 1979; Keregero, 1988; CIMMYT, 1993; Nkonoki, 1994).

Not everyone adopts innovations at the same rate (Van den Ban and Hawkins , 1988; Fliegel, 1993). Initially, a new idea is adopted by a very small but highly innovative group. These individuals are able to take the necessary risk because of their high economic status. From these innovators, the new idea then spreads throughout the social system until most of the members adopt it. Thus, mass communication is an important information source to develop and/or increase awareness of an innovation while interpersonal sources of information are crucial in the trial and adoption of an innovation (Ashby, 1982; Rogers, 1983; Fliegel, 1993; Monu, 1993). Because SG-2000 and UNDP projects have a maximum duration of four years in the region, it appears that this is a short period for most farmers to adopt. Lal and Srivastava (1985) found that a poor adoption pattern of new storage structure technology due to the short time interval of 3-5 years between the introduction of the technology and evaluation of impact.

2.2.2.1 Farm size

Farm size is a common variable for determining adoption (CIMMYT, 1993) and is often a good proxy for wealth (Feder et al., 1985 Polson and Spencer, 1991). With respect to the adoption of new techniques, it has been recognized that small and large farm operators differ in the speed of adoption (Ashby, 1982; Coughenour, 1984; Heffernan and Green, 1986; Polson and Spencer, 1991). Research has verified that large scale farmers are more likely to adopt a technology, especially if the innovation requires an extra cash investment than small scale farmers. Farmers who own large farms enjoy a higher socio-economic status, have ample mass communication opportunities, and are more innovative in adopting new agricultural technologies (Ashby, 1982; Rogers, 1983; Thomas *et al.*, 1990; Ockwell *et al.*, 1991 and Fliegel, 1993). Large scale farmers can easily obtain credit, information, and other inputs that enhance the adoption of technical innovations.

Most farmers in developing nations, including Tanzania, lack resources and either cannot adopt innovations or else must adopt relatively later (Wambura, 1988). Thakre and Bansode, (1990) indicated that more farmers with large farms or who produce more food-grains adopted improved grain storage practices than those with small food-grains to store. However, it is farmers with small farms who are hit by the higher prices during the lean period because it is they who are unable to retain much in store when foodgrain prices are relatively low. Farmers in Mara region are no exception in this respect.

2.2.2.2 Income

Wealthier farmers may be the first to try a new technology, especially if it involves purchased inputs. This may be because wealthier farmers have better access to extension information or to credit, or they may be able to use their own cash resources to experiment with a new technique (CIMMYT 1993). Many times, it is farmers with more resources in the form of either land, labour, or capital who are able to take advantage of a new technology. In other cases a farmer's wealth may be a proxy for education or connections with extension. For example, a study on the assessment of transfer and utilization of selected innovations in Musoma district found that the extension system tends to favour certain categories of farmers (Wambura, 1988). He found that richer, younger and better educated farmers within the surveyed villages had higher levels of extension contact than poorer, older, and less educated farmers. In some cases, farmers with a more commercial orientation, who sell a large proportion of their harvest are the ones who adopt particular technologies.

2.2.2.3 Education

Educational background of the farmer is also an important factor in determining the readiness to accept and properly apply an innovation (Swanson, *et al.*, 1984). Acceptance is one thing; use and application of innovations is another. If the innovation is not properly utilized acceptance becomes meaningless. Better educated farmers have more contact than other farmers with information sources and change agencies (Rogers, 1983; Nowak, 1987; Anosike and Coughenour, 1990). Moreover, better educated farmers have enhanced information processing abilities allowing them to use complex technologies. Therefore, the more complex the technology, the more likely it is that education will play a facilitative role in technology adoption. Thus a higher education level is associated with a higher level of adoption of a new technology. For this innovation one needs at least basic literacy education.

2.2.2.4 Gender

Because women play a key role in most agricultural systems (*Due et al.*, 1987; Keregero and Biswalo, 1991; Njiku, 1991; CIMMYT, 1993), it is important that adoption studies consider the degree to which a new technology reaches women farmers, despite the fact that women farmers are less likely to command the resources such as land, credit or information to take full advantage of the technology.

To understand the decision-making process among small-scale farm families the unit of analysis must be the family household rather than individual farmers (Monu 1993). Using the household as the unit of analysis allows us to examine the distinct roles and multiple goals of individuals within the household. Usually, in smallholder households, women perform many of the tasks in grain handling and storage. They do almost all the processing, handle 60% of the marketing and do at least half the tasks involved in storing food (Gittinger et al, 1990; Malima, 1993). For, while it is the men who are responsible for building storage structures, it is the women who look after the produce once it is placed in store as part of their role of maintaining the household. It is imperative that women take a leading role in decision making that concerns improved storage structures so as to lead to high adoption rates.

2.2.2.5 Age

Another farmer characteristic that is often examined in adoption studies is age. A farmers' age may influence adoption in one of several ways. Older farmers may have more experience, resources, or authority that would allow them more possibilities for trying a new technology. On the other hand, it may be that younger farmers are more likely to adopt a new technology, because they have had more schooling than the older generation or perhaps have been exposed to new ideas as migrant labourers (CIMMYT, 1993). Young people are less conservative in adopting innovations than elders (Polson and Spencer, 1991; Nanai, 1993). They like to experiment, and are more venturesome. This suggests that if extension agents concentrated more on young people, adoption of innovations could be enhanced. For this study, age will be an important variable for examining the adoption of improved storage structures among smallholder farmers.

2.2.3 Institutional characteristics

2.2.3.1 Access to knowledge

Accuracy, clarity and timeliness of information are major aspects determining adoption of new practices (Wambura, 1988; CIMMYT, 1993). Time and support to show farmers how new practices work, sufficient research, adequate result demonstration and field days also determine adoption. Acceptance or rejection of a new idea largely depends on how the information was relayed from its source to recipients. To achieve a higher adoption, sources of information must be properly tuned to actual needs and problems of the later adopters in the system (Wambura, 1988; 1993).

Factors that affect the transfer of agricultural technology and hence the overall performance of the agricultural extension service are many and very much interrelated (Kauzeni, 1988; Wambura, 1988; Wambura, 1993). Knowledge is a factor in explaining adoption pattern. For farmers to adopt a technology, they must first know about it. The information may come from several sources, thus it is important to explore the degree to which farmers have received the necessary information. This will help in analyzing the degree to which low adoption may not be a function of the technology itself, but rather of the information that is available.

2.2.3.2 Credit availability

Agricultural production in Tanzania is carried out by smallholder farmers (Benard, 1988; Kauzeni, 1988; Wambura, 1993; Ashimogo, 1994), most of these farmers need finance before adopting some innovations for the purchase of raw materials and insecticides and pay for labour costs if any. Under such conditions credit facilities need to be tied to the adoption of innovations. Therefore, the performance of the extension service in inducing farmers to adopt the innovations will depend upon the availability of credit facilities. Rather than facilitating access to new technology, credit programmes are sometimes responsible for obligating farmers to use a particular technology. The credit may be offered as a package that provides a set of inputs to farmers. The SG-2000 and UNDP projects have no credit facilities attached to improved storage structure innovation. Lack of credit may therefore hinder most farmers from adopting the technology because they cannot buy the needed resources easily.

2.2.3.3 Farmers incentives

Lack of incentives to farmers indirectly affect the performance of the extension service. The agricultural production of farmers must be considerably increased to provide the marginal surplus for economic and social development of the people (Ashimogo, 1988). These incentives include good producer prices which can then be used to substitute the technology costs, thus encouraging farmers to adopt a recommended technology. For instance, Parveen and Depositario, (1991) analysing reasons for non-adoption of the recommended package of tomato technology indicated that reasons for non-adoption were lack of knowledge of recommended tomato varieties due to inadequate extension services and lack of economic resources due to low tomato prices, which limit the purchase of inputs. Therefore good prices for maize and sorghum may substitute the technology costs, thus encouraging farmers to adopt.

2.2.3.4 Extension contacts

From literature, another constraint to adoption is that extension service tends to focus on farmers who appear more receptive to new ideas. Extension resources are focused on "early adopters" who are usually the richer, better educated, more progressive farmers with larger than average farms, who are in a better position to follow extension advice (Ponje, 1979; Axinn, 1988; Mvena and Mattee, 1988; Wambura, 1988). These farmers were found to have higher levels of extension contact than others. Therefore, the influence of this factor in the adoption or non-adoption of the introduced technology will be examined.

CHAPTER THREE

3.0 METHODOLOGY

3.1 Location of the Study

For assessing farmers' adoption of improved storage practices introduced by SG-2000 and UNDP projects, two districts in Mara Region were selected: Tarime and Musoma. Choice of the two district was dictated by the presence of SG-2000 and UNDP projects, and maize and sorghum production which are the main foodgrains grown in Mara Region.

3.2 Research Design

The design of this study involved a cross sectional survey. In cross-sectional survey, the data are collected at a single point in time. Cross sectional survey data can be used for simple descriptive interpretations as well as determination of relationship between and among variables.

3.3 Sampling Procedures

3.3.1 The population

The population for this study consisted of farmers from villages in the projects and their respective village extension officers in Tarime and Musoma Districts. The criteria for selecting villages was their involvement in the SG-2000 and UNDP projects for four continuous years since 1991/92 and villages which farmers grow maize and sorghum as major crops.

3.3.2 The sample

The sample frame was the list of farmers in villages which met the criteria specified above. Ten villages from the 32 villages in SG-2000 and UNDP projects in 1991/92 season were randomly selected; five villages from Tarime District, and five villages from Musoma rural District representing various agro climatic zones in the region.

Stratified sampling technique (Borg and Gall, 1983) done in three stages was used. Firstly of villages in the Projects in the Districts, secondly of villages in different ecological zones in the district and thirdly of respondents in the villages. The sample was obtained by simple random sampling of 15 farmers from each of the 10 villages making a total of 150 farmers. The respective extension officers from the 10 selected villages were studied. Unit of analysis was the individual farmer in the household, while the sampling units were the village households which have been in the project for four or more years.

3.4 Instrumentation

The following instruments were used to collect data for this study.

3.4.1 Questionnaire

Two structured questionnaires were developed and used as instruments for data collection. These were farmers' and extension officers' questionnaires respectively. The instruments were structured with close and open-ended questions. The questionnaire were formulated in English and then translated into Kiswahili to allow easy communication during data collection. The questionnaires were supplemented with direct observations by the research team of the farmers activities on improved storage structures using a checklist.

Measurement of Variables

Ambiguous variables which stand a chance of different interpretation are as follows:

(i) The extent of adoption of improved storage technology: the percentage of respondents who have fully adopted improved storage structures in surveyed farmers. The extent of adoption was measured by using an adoption scale. Cumulative responses to twelve components of the storage structure (see appendix 3) were used. If a respondent affirmed that he/she had adopted an improved component, he received a score of '1' otherwise '0'. Then we summed the number of components adopted by each farmer to produce an improved storage technology adoption scale. Scores ranged from 0 to 12 with values of '0' for no adoption and 12 for full adoption.

(ii) Farmers' involvement: refers to the participation of farmers in the technology development from the beginning; that is before the technology was introduced. Farmers' involvement was measured by using a score on the level of participation of farmers in the technology. Scores ranged from 3 (high) to 0 (not involved). Farmers were asked to indicate if they were involved in the technology development from the beginning. Responses were scored as follows: '3' highly involved; '2' moderately involved, '1' less involved and '0' not involved.

(iii) Effectiveness of extension: The number of times that an extension worker contacted a farmer is a proxy for the effectiveness of extension services to the farmer. Effectiveness of extension was measured by rating the communicational contacts that each farmer has had with extension activities. Farmers were asked to indicate whether (a) they were visited by an extension agent, (b) the extension agent held meetings,(c) they attended any demonstrations conducted by extension agent in the project period. This was taken as the effectiveness of extension services. For each type of contact (visits, meetings, demonstrations) responses were scored as follows: '3' highly effective (3 contacts); '2' moderately effective (2 contacts); '1' slightly effective (one contact); and '0' not effective (no contact). Total scores ranged from 0 to 9 with values "0" for not effective to "9" highly effective.

(iv) Adoption factors: These were factors expected to contribute to farmers adoption or rejection of improved storage structures. These factors were measured by using a scale to rank each factor according to its importance. Responses from the farmers were obtained by using a questionnaire that ranks the importance of particular factors expected to contribute to the adoption or rejection of improved storage structures. That is, if the respondent's rating of a particular factor that contributed to non-adoption was "very important", then a score of 3 was assigned, 2 for "moderately important" and 1 for "slightly important" ratings and

0 for " not important".

(v) Perception: refers to farmers' attitudes towards the storage structure innovation characteristics and approach. It was measured by using an opinion scale along the storage structure innovation characteristics (see appendix 4). Furthermore, extension methods and information sources were studied to give an indication of the farmers perception of the approach. The opinion scale ranged from 1 to 4; 4 for "high", 3 for "moderate", 2 for "low" and 1 for a "very low" rating.

3.4.1.1 Pre-testing

The questionnaire was pre-tested in the field to the target group. The necessary corrections were made to the questionnaire before collecting data. Ten farmers were used in the pre-testing exercise. The ten farmers were excluded from the sample farmers who were interviewed.

3.4.2 Documents and records

Another source of data for this study, was from the regional coordinators' offices of the projects and other official documents from the Ministry of Agriculture headquarters and the Prime Minister's office. Information such as number of villages and farmers in each village under the projects, technology development and transfer to the farmers, was obtained from these offices.The gathered information was used to supplement the primary data.

3.5 Data Analysis

Responses from the questionnaires were coded, summarized, and then entered into a computer. Analysis was done with respect to the objective of the study, using SPSS.

i) Extent of adoption of improved storage structures:

The relationship of adoption with respect to variables like age, education, gender, farm size and income were analysed as frequency distribution tables showing number of respondents falling in particular attributes and respective percentages.

ii) Factors associated with adoption and non-adoption of improved structures: Different variables related to farmer, innovation, and institutional characteristics which contribute to the adoption or non-adoption of the storage structures were analyzed by descriptive statistics such as frequencies and percentages.

iii) Perception of farmers and extension officers on the approach used to transfer the technology: In order to reach this objective, mainly descriptive statistics eg frequencies and percentages were calculated with respect to the approach used.

iv) To determine the relationship between farmers', innovation and institutional characteristics and adoption of improved storage structure: Regression analysis was used to establish the effects of these variables on the adoption of the technology.

In analysing the determinants of adoption of improved storage technology, the ordinary least square regression model was used.

This model is specified as follows:

$Y = B_o + B_1 x_1 + \ldots\ldots B_{14} x_{14} + e$

Where Y = Level of adoption of improved storage technology

B_o = constant

AGE = Age of respondent (years)

GEN = Gender (0 = female; 1 = male)

EDUC = Highest education level attained

FS = Farm size in hectares

CT = Compatibility of technology

LR = Labour requirement

AR = Availability of raw materials

CI = Cost of implementing technology

P = Profitability of technology

COT = Complexity of technology

MC = Maintanance and repair costs

IF = Involvement of farmers in technology

CS = Cost of storage chemicals

EE = Effectiveness of extension

e = Error term

B_1 - B_{14} = Partial regression coefficient

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

This chapter discusses the results under five sections as follows 1) farmers' characteristics 2) the adoption of improved foodgrain storage structures 3) factors associated with the adoption and non-adoption of improved foodgrain storage structures 4) farmers perception of improved storage structure innovation characteristics and approach and 5) Extension officers' perception of improved storage innovation.

4.1 Farmers' Characteristics

Among the more important farmers' characteristics dealt with in this study were: farmers age, education level, gender and farm size.

4.1.1 Age

The distribution of respondents involved in the technology by age is presented in Table 1. Age grouping was based on Tanzania's 1978 population census (URT, 1982).

Table 1. Respondents distribution by age (n=150)

Age (years)	Number	Percent
20-35	50	33.3
36-45	53	35.3
46-55	23	15.3
Above 55	20	13.3
Unknown	4	2.6
Total	150	100.0

Four respondents did not know their age.

Results in Table 1 show that 33.3% of the respondents were between 20-35 years, 35.3% were between 36-45 years, 15.3% were between 46-55 years and 13.3% were above 55 years. Four respondents did not know their age. While young farmers are said to have greater likelihood in accepting new ideas and in dealing with risks, it is not clear what upward bounds can be set on this age level. One reason is that in subsistence agriculture children are exposed to farming at a very early age and often assume decision-making roles much earlier in life (Polson and Spencer, 1991). These young "progressive" farmers should be the primary target of extension information regarding new technologies. In this study, farmers between 20 to 45 years are assumed to satisfy this requirement.

4.1.2 Gender

Because women play a greater role in agricultural systems, it is important that adoption studies consider the degree to which a new technology reaches women farmers (CIMMYT, 1993). Taking into consideration women's many responsibilities, they are often not available for training on new technologies. Men therefore benefit most from the extension work. In polygamous families where a man has many wives, which is a common practice in Mara region, wives are normally responsible for the production and storage of their own food (Nkonoki, 1994). Because not many husbands can afford to assist or support the preparation of all their wives storage structures. Women often have full control of crops for household consumption which normally do not enter formalized marketing systems. Produce from the husbands farm is usually sold for income which they pocket.

Table 2. Respondents' distribution by gender (n=150)

Gender	Number	Percent
Male	136	90.7
Female	14	9.3
Total	150	100.0

Table 2 shows that men had greater representation than women. Women stand at only 9.3% and the rest were men (90.7%). The low percentage of women involvement in the projects imply that women had relatively less access to the innovation than men. Thus making women relatively less likely to adopt the improved storage technology. Failure to involve women effectively in storage technology as evidenced by the above data could have contributed to low adoption of introduced technology. Because the produce from the husband's farm is usually marketed immediately after harvest, therefore it is the produce of the wife which has to be stored for consumption and sold later to get income for household sustenance. In that sense women decisions in storage technology was very important for increased adoption rate.

On the other hand, food-crop processing is one of the activities which traditionally is done by women. The introduced improved storage technology demand for increased women's labour for maize shelling, threshing sorghum, drying and treating grains with insecicides before storage. This could be one of the factor contributing to low involvement of women farmers in the technology, feeling that it was labour intensive for them.

4.1.3 Education level

It was expected that the extent to which respondents were educated would influence their adoption of improved storage technology in the villages. The assumption is that schooling facilitates learning, which is in turn presumed to instill favourable attitude towards the use of improved farm practices. Further, better educated farmers have more contact than other farmers with information sources and change agents

(Nowak, 1987; Rogers, 1983). The respondents were therefore asked to indicate their final level of education. The findings are given in Table 3.

Table 3. Farmers education level (n = 150)

Education Level	Number	Percent
None	1	0.7
Literacy education	17	11.3
Primary education	111	74.0
Secondary education	18	12.0
Post secondary education	3	2.0
Total	150	100.0

The data indicate that the majority of respondents had the highest education level of primary school (74.0%) and 14% were above primary education level. The literacy education level was 11.3% and only 0.7% of the respondents reported that they had not obtained any formal education. The data in this table indicate that the majority of the respondents were able to read and write.

4.1.4 Farm size

It was assumed that the total number of hectares owned by a respondent would influence his/her adoption of storage structures. Operators of large-scale farms are flexible in their decision making. They have access to new practices on a trial basis, and more ability to deal with risk and uncertainity associated with innovations. Farm size was measured in total hectares currently in the operation, owned or rented. The respondents were asked to indicate the total hectares of their farms. Farm size categories were based on Tanzania Statistical Abstract 1992, which is nationally used (URT, 1994).

Table 4. Distribution of respondents' farm size (n=150)

Farm size (hectares)	Number	Percent
0.5 - 2.0	46	30.7
2.1 - 5.0	58	38.7
5.1 - 10	31	20.7
Above 10	15	10.0
Total	150	100.0

The table indicates that the farm size of the respondents involved in improved storage technology ranged from 0.5 to above 10 hectares. Most farmers (69.3%) had farm sizes of less than 5 hectares and 30.7% had farm sizes above 5 hectares.

4.1.5 Income

Apart from farm income,it was expected that engagement in off-farm activities or employment would generate extra income to support the respondents' adoption of improved technology. Respondents were asked to indicate types of off-farm income generating activities which they were engaged in. The findings are presented in Table 5.

Table 5. Farmers engagement in off-farm activities

Off-farm activity	Number	Percent
Shop owner	11	32.4
Mansonry/carpent.	10	29.4
Brewing	7	20.6
Tailoring/sew.	3	8.8
Brick making	1	2.9
Others	2	5.9
Total	34	100.0

The data show that 34 respondents involved in improved storage technology, were also involved in off-farm activities such as shop owner, brewing, masonry, tailoring and brick making. The indications were that participation in these activities could lead to respondents' participation in the SG-2000/UNDP projects.

4.2 The Adoption of Improved Storage Structure Technology

The extent of adoption of improved storage technology is defined as the number of farmers using improved storage technology as a percentage of the total number of surveyed farmers for a period of four years in which evaluation was done. In this study, a farmer is considered to have adopted an improved storage structure technology if he/she constructed it and uses it to the full extent. The introduced storage technology package had twelve components which were considered for adoption. Farmer respondents were asked to indicate which of the package components have been adopted. Their views are expressed in percentages in Table 6.

Table 6. Respondents' distribution by adoption of improved components of storage technology (n=150)

Component	Adopted		Not adopted	
	n	%	n	%
Grains dried and cleaned	52	34.7	98	65.3
Top outlet narrowed	40	26.7	110	73.3
Grains insecticide treated	37	24.7	113	75.3
Wall woven, plastered inside	33	22.0	117	78.0
Platform raised offground	32	21.3	118	78.7
Correct wall materials	32	21.3	118	78.7
Wall woven, plastered outside	26	17.3	124	82.7
Rat guards present	25	16.7	125	83.3
Wall woven/brick made only	22	14.7	128	85.5
Bottom outlet present	22	14.7	128	85.3
Overhanging thatched roof	18	12.0	132	88.0
Wall woven, plastered both sides	7	4.7	143	95.3

Results in table 6 show that the grain drying and cleaning component of the package was the most adopted as 34.7% of farmers had adopted the component. Grain drying and cleaning was followed by narrowing top opening (26.7%); treating grains with insecticide (24.7%) and plastering inside of the structure (22%). Other adopted components included using the correct materials for the structure (21.3%); and raising the platform off the ground (21.3%). The least adopted components were plastering both sides (4.7%) and an overhanging thatched roof (12.0%).

Respondents who had adopted at least a component of improved storage technology were asked to indicate which of the adopted improved components were difficult to implement. Findings are shown in Table 7.

Table 7. Components identified by respondents as difficult to implement (n=32)

Component	n	%
Overhanging thatched roof	13	41.0
Plastering both sides of wall	6	18.8
Correct wall materials:		
Collecting building materials	5	15.6
Making burnt bricks	5	15.6
Weaving and narrowing top	2	6.0
Raising platform off ground	1	3.0
Total	32	100.0

Findings from the Table indicate that the 32 respondents who had adopted at least a component found difficulties in implementing some of the components. Overhanging thatched roof was the most difficult component to implement (41.0%). Through observations most of the incomplete structures had no overhanging thatched roof. Some farmers had placed a cover/lid only on top of the opening and were using these structures. Other components found to be difficult to implement were plastering both sides of the structure (18.8%); collecting building materials (15.6%) and making burnt bricks for silos (15.6%).

Farmers who had adopted were asked to suggest modifications on the structures that would make the structures more appropriate for them. Responses are shown in Table 8.

Table 8. Farmer identified modifications to the structures

Modification	n	%
Modification of outlets	8	36.4
Remove thatched roof and replace cover/lid	6	27.3
Include drying floor (for UNDP)and storage insecticides in the package	6	27.3
Omit cement and use cow dung/earth	2	9.0
Total	22	100.0

Findings from the Table reveal that of the 32 respondents only 22 had suggestions for modifications. The bottom and top outlets were shown to be the concern for most farmers (36.4%). The construction of the doors was not preferred by farmers and most farmers were worried on security of the grains. Some farmers were more specific, indicating that the thatched roof should be removed and replaced with a cover/lid only on the top opening (27.3%). Another modification suggested was the inclusion of a drying floor (in case of UNDP project where it is absent) for crop processing, that is drying, shelling/threshing and insecticide treatment. These processes are now done on bare ground which contaminate the produce.

Storage chemicals are not easily available and when available they were very expensive (Tshs 4000/= per kilo). Therefore farmers (27.3%) suggested that it should be included in technology package so that they are available when needed and at an affordable price. Farmers (0.9%) suggested that cement for plastering (in case of SG-2000 project) should be replaced with locally available materials like cow dung and /or earth. Cement is very expensive and not easily available in villages.

Advantages of using improved storage structure

Respondents using improved structures were asked to give their opinions as to why they preferred using improved storage structures rather than traditional structures; and whether after adopting the structures it has helped in their storage. Their opinions expressed in percentages are shown in Table 9.

Table 9. Advantages of using improved storage structure (n=27)

Advantages	n	%
Can store enough food safely until next season	11	41.0
Can store foodgrains longer and sell when prices are high	9	33.0
Control in food uses as number of bags stored is known	3	11.0
Reduced the cost of buying bags for storage each season	2	7.5
Can store seeds safely for next season	2	7.5
Total	27	100.0

The results in Table 9 indicate that 27 farmers responded to this question. Responses were that: structures can store enough food and seeds safely until next season (41%); farmers can store food grains longer and sell when prices are high (33%); and there is control in food uses as the number of bags stored in known (11%). Other advantages included: reduced costs for buying bags for storage each season (7.5%); and one can store seeds safely for next season (7.5%).

4.3 Factors Associated With The Adoption and Non-adoption of Improved Storage Structure Technology

Considering that there are many reasons why farmers were not adopting improved storage structures, respondents were asked to rank, according to importance particular factors which were expected to contribute to the adoption or rejection of improved structures. The findings in percentages are shown in Table 10.

Table 10. Factors contributing to adoption/non-adoption of improved storage technology

Factors contributing	Very important		Moderate important		Slightly important		Not important	
	N	%	N	%	N	%	N	%
Innovation factors								
Raw materials not easily available	37	5.6	28	6.4	10	2.3	75	7.6
High labour requirements	28	4.2	42	9.6	36	8.1	44	4.5
High costs of implementing technology	34	5.2	61	14.0	34	7.7	18	1.8
Profitability not easily observable	23	3.5	27	6.2	45	10.1	52	5.3
Incompatible with traditional structure	11	1.7	10	2.3	16	3.6	112	11.4
Complexity of technology	15	2.3	14	3.2	51	11.5	62	6.3
Farmers not involved in technology	65	9.9	17	3.9	36	8.1	36	3.7
High maintenance and repair costs	7	1.1	19	4.4	13	2.9	111	11.3
High cost of storage chemicals	85	13.0	29	6.7	19	4.3	16	1.6
Farmers Factors								
Limited farmer's education level	40	6.1	11	2.5	56	12.6	43	4.3
Limited income to implement technology	41	6.2	20	4.6	21	4.7	68	6.9
Women not involved in decision making	79	11.9	28	6.4	12	2.7	36	3.7
More older people involved	18	2.7	5	1.1	22	5.0	105	10.6
Small quantity of produce to store	16	2.4	41	9.4	29	6.5	64	5.6
Institutional Factors								
Inadequate information from extension workers	115	17.5	22	5.1	8	1.8	5	0.5
Lack of credit facilities	25	3.8	54	12.4	11	2.5	53	5.3
Low produce prices to cover construction costs	19	2.9	7	1.6	25	5.6	86	8.7
	658	(100.0)	435	(100.0)	444	(100.0)	986	(100)

The results in Table 10 indicate that the most important factors contributing to the adoption or rejection of improved storage structures were: inadequate information from extension officers (17.5%);high costs of storage chemicals (13.0%);women not involved in the decision making (11.9%); and farmers not involved in technology development (9.9%).

The least important factors contributing to adoption or non-adoption of improved storage structures include: incompatibility of improved structures with the traditional structures (11.4%); high maintenance and repair costs (11.3%); more older people involved in the technology (10.6%); and low produce prices to cover construction costs (8.7%).

4.4 Farmers' Perception of Improved Storage Structure Technology

In understanding farmers' perception of improved storage structure technology, an opinion scale on the intrinsic characteristics of innovation was used. Farmers' responses to structured questions involving these characteristics were analysed. The findings, summarized in percentages of respondents for each of the intrinsic characteristics, are shown in Table 11.

From the table, it is evident that farmers' perception of the introduced storage innovation is as follows: involvement of farmers in technology development was very low (35.5%) while cost of storage chemicals was high (21.5%). The profitability of the technology was high (19.8%) and maintenance and repair costs was low (19.2%). Labour requirement was low (17.9%) and complexity of the technology was considered moderate (17.4%). Availability of unpurchased raw materials was very low (15.3%) while cost of implementing technology was generally considered low (13.3%). Compatibility with traditional structures when considered with other factors was very low (13.3%), but regarded individually was moderately compatible.

Table 11. Respondents' perception on improved storage technology (in percentage)

Innovation characteristics	High		Moderately		Low		Very low	
	n	(%)	n	(%)	n	(%)	n	(%)
Campability	45	(16.2)	49	(12.9)	29	(8.3)	27	(14.9)
Labour requirements	25	(9.0)	54	(14.2)	66	(18.9)	5	(2.7)
Availability of raw materials	30	(10.8)	40	(10.5)	49	(14.0)	31	(17.1)
Cost of adopting technology	39	(14.0)	49	(12.9)	49	(14.0)	10	(5.5)
Profitability	70	(25.2)	60	(15.8)	13	(3.7)	4	(2.2)
Complexity of Tech.	18	(6.5)	71	(18.7)	42	(12.0)	16	(8.8)
Maintenance/repair costs	29	(10.4)	33	(8.7)	71	(20.3)	16	(8.8)
Involvement of farmers	22	(7.9)	24	(6.3)	31	(8.8)	72	(39.8)
	278	(100.0)	380	(100)	350	(181)	181	(100)

4.4.1 Extent of adoption

In many adoption studies, the adoption variable is dichotomaly categorized simply as 'adoption' or 'inadoption'. However, knowing that a farmer is using an improved storage structure technology may not provide much information, because he may be using 1% (depending on whether the technology is a package or multicomponent) or 100% of the technology as introduced by an extension agency.

On the basis of a comprehensive review of adoption studies, the major technology issues relate to extent and intensity of use at the individual farm level rather than the initial decision to adopt a new practice (Feder *et al.,* 1985). Adoption of some innovations cannot be represented adequately by a dichotomous qualitative variable in many cases. For example several studies of adoption have been undertaken using chi-square contingency table to perform non-parametric hypothesis testing of the importance of certain explanatory variables. While the outcome of these tests may suggest a significant effect in statistical terms, there is no way of knowing from this type of analysis whether the economic importance of the effect is worth considering. Further, considering adoption dichotomously does not adequately capture the dynamics of a multicomponent innovation.

Several other studies have used correlation analysis to examine the interrelatinships of several factors affecting adoption (Feder *et al.*, 1985). However, this approach also produces only qualitative information regarding the effect of various explanatory factors while no information regarding the quantitative importance of various factors is obtained. Other studies have attempted to determine econometrically the quantitative importance of various explanatory variables, ordinary regression models have been in most common use. Nowak (1987) used multiple regression to analyse adoption of conservation technologies in Iowa. Ashby (1982) used a multiple regressin model to analyse the adoption of appropriate technology in peasant agriculture in Nepal. Regression analyses have also been performed by the following in their studies: Shakya and Flinn (1985) examined factors influencing adoption of modern rice varieties and fertilizer adoption in Nepal; Heffernan and Green (1986) estimated soil loss on various soil-conservation practices in Missouri; Thomas et al. (1990) analysed the adoption of integrated pest management practices in Texas; and Zey and McIntosh (1992) considered the characteristics of agricultural technology.

In the 1990s econometric literature, estimation methodology has been developed for investigation of the effects of explanatory variables on the dichotomous dependent variable. The most commonly used quantitative response models are the Logit model, which corresponds to a logistic distribution function, and the probit model which assumes an underlying normal distribution relation between the probability of adoption and various explanatory variables. For example, Thomas *et al.*, (1990) used logistic regression to assess the adoption of Integrated Pest Management technologies in Texas. Polson and Spencer (1991) used Probit and Logit models to assess the technology adoption process in subsistence agriculture in Nigeria. While Green and Ng'ong'ola (1993) used a Logit model to analyse factors affecting fertilizer adoption in Malawi, Adesina and Baidu-Forson (1995) used Tobit models to analyse farmers' perceptions and adoption of new technology in Burkina Faso and Guinea.

However, many such studies have attempted to explain only the decision of adoption versus non-adoption rather than the extent or intensity of adoption. In this study an attempt has been made to explain the extent of adoption of improved storage structures. An ordinary least squares (OLS) regression is used to model adoption, where the dependent variable is measured as a continuous variable. Regression analysis is appropriate over the chi-square test, when the dependent variable is continuous.

The level of adoption of improved storage technology was measured by cummulative responses to twelve components (see appendix 3). If a respondent affirmed that he/she was using the component, he/she received a score of '1' otherwise '0'. Then the number of components adopted by each farmer, were summed to produce an improved storage technology adoption scale. Scores ranged from 0 to 12 with values of '0' for no adoption and 12 full adoption. Results are presented in Table 12.

Table 12. Level of adoption of the improved storage structure technology (n = 150)

Values	n	%
0	96	64.0
1	5	3.3
2	13	8.7
3	0	0
4	2	0.8
5	4	2.7
6	3	2.0
7	2	0.8
8	4	2.7
9	6	4.0
10	5	3.3
11	4	2.7
12	6	4.0
Total	150	100.0

Results in Table 12 indicate that only 4% of respondents scored 12 points indicating that these farmers had fully adopted the innovation as introduced by the projects. Sixty four percent (64%) of the respondents scored 0 points indicating they had not adopted any component. Thirty two percent (32%) of the respondents had scores from 1-11 points. From these results one can conclude that the adoption level was only 4% and 96% was non-adoption.

4.4.2 Factors influencing the Adoption of improved storage structure

One way of assessing adoption is to look at those factors that influence the adoption rate of the introduced technology. In this study multiple regression was used to examine the relationship between a set of independent variables and adoption as the dependent variable. Factors identified and investigated were: farmers' characteristics, innovation and institutional factors.

A rating scale of 1 to 4 was used to measure perception of 9 technology attributes (see appendix 4). In addition to these factors, the following farmers charactistics and institutional factors were included as explanatory variables in the model: the age of the farmer (AGE), education level (Educ.), farm size (FS), gender (GEN), and effectiveness of extension (EE). It is expected that education and farm size are postively related to adoption decisions. Based on the innovation diffusion literature, it is expected that effectiveness of extension is positively related to adoption by exposing farmers to "new information". Following earlier empirical findings, the maintained hypothesis is that age is negatively related to adoption (Polson and Spencer, 1991).

The individual ratings of the innovation attributes were pooled in order to obtain a composite measure of attributes on adoption. Farmer characteristics and institutional variables were incorporated to test whether perception variables as a group, influence adoption decisions. The ordinary least square regression model was used.

The model is specified as follows:

$$Y = B_o + B_1\, AGE + B_2 GEN + B_3\, Educ. + B_4 FS + B_5 Inno + B_6 EE + e$$

Where Y =	Level of adoption of improved storage technology
B_o =	Constant
AGE =	Age of respondents (years)
GEN =	Gender (0 = female; 1 = male)
EDUC =	Highest education level attained
FS =	Farm size (hectares)
Inno =	Index reflecting the combined effect of perception on the innovation
EE =	Effectiveness of extension

Table 13: Regression of farmers characteristics, institutional and combined innovation attributes on adoption

Independent variables	Standardized coefficients	Unstandardized coefficients	significant t
Age (years)	.0448	.0145 (.0306)	.6357
Gender	.0081	.1083 (1.154)	.9255
Education Level	-.0162	-.0820 (.539)	.8558
Farm size	.1893	.1330 (.6564)	.0450*
Innovation attribute	-.0659	-.0779 (-1150)	.0129*
Effectiveness of Ext.	-.2360	-.8335 (.3661)	.0246*
R^2 = .79130			
Adj R-square = .62615			
F-statistics $F_{12,121}$ (for R^2) = .0083**			
Constant		4.695 (3.584) .	.1927

* = significant at .05 level

**= significant at .01 level

( ) in parantheses are standard errors

Results in Table 13 show that the regression was significant ($p < .01$) and the six indepedent variables account for 63% (adjusted R^2 .62615) of the variation in adoption. The table also shows that three of the six independent variables included in the analysis have significant ($p < .05$) regression coefficients. Effectiveness of extension was the highest predictor of adoption of improved storage structures (beta of -.23602, significant ($p < .05$) and unstandardized regression (b) coefficient of -.8335). The negative regression coefficient implies that extension services and adoption of improved storage structures are negatively related. A high score on extension contacts lead to low level

level of adoption of improved storage structures. This is unexpected relationship because more contact with extension services should lead to high adoption level independent of other factors. This may be because extension officers had little knowledge of the improved storage structures to transfer to farmers.

Farm size had a standardized regression coefficient (beta) of .1893, significant ($p < .05$) and unstandardized regression (b) coefficient of .1330. The positive regression coefficient for farm size implies that an increase in farm size leads to increase in adoption. Farmers with large farms are more likely to adopt structures than farmers with smaller farms.

The combined innovation attributes had a standardized (beta) regression coefficient of -.06586. Its unstandardized (b) regression coefficient of -.0779 that is statistically significant ($p < .05$) implies that high scores of innovation attributes on adoption of improved storage structures leads to a low level of adoption. The negative relationship between combined innovation attributes and adoption of the storage structures may be explained as due to inclusion of many variables which are related negatively to adoption, for example high costs of storage chemicals, high labour costs, costs of adopting technology etc, thus suppressing the positively related factors to adoption like profitability, compatibility etc.

The composite measure of the innovation attributes was decomposed into individual innovation attributes which were then used to estimate the effects on adoption of improved storage structure. Results of the regression of decomposed attributes of the innovation, farm characteristics and institutional variables on innovation are presented in Table 14.

Table 14: Regression of farmers characteristics, institutional and individual innovation attributes on adoption

Independent variables	Standardized coefficients	Unstandardized coefficients	significant t
Age (years)	.0138	.01370 (.1784)	.9390
Gender	-.0665	-.2193 (.4414)	.6125
Educational level	-.0652	-.1155 (.2477)	.6431
Farm size	.1624	.17460 (.2014)	.0402*
Compatibility	-.0904	-.0934 (.2019)	.6431
Labour requirement	.0846	.11620 (.2323)	.6190
Availability of raw materials	.1527	-13930 (.1843)	.4532
Cost of technology	.1698	.14620 (.1555)	.3517
Profitability	-.0358	-.0516 (.2584)	.8425
Complexity	-.1732	-.2071 (.1844)	.2666
Maintenance and repair costs	-.1012	-.0962 (.1625)	.0363*
Involvement of farmers	.0827	.07640 (.1744)	.0500*
Cost of storage chemicals	-.0567	-.6710 (.1870)	.7210
Effectiveness of Extension	.0719	.07310 (.2041)	.0218*
R^2 = 58118			
Adj: R-square = .54743			
F-statistics for $F_{15,50}$ (R^2) = .0470*			
Constant		1.9762 (1.758)	

* Significant at P <.05

() in parentheses are standard errors

Multiple regression results in Table 14 show that the fourteen variables included in the regression model explained 55% (adjusted R^2.54743) of the variation in the adoption of improved storage technology. The regression is statistically significant at .05 level of significance. Among the fourteen variables only four were statistically significant: farm size; maintenance and repair costs; non involvement of farmers in the technology development and effectiveness of extension.

Farm size had the highest (beta .162463) effect on adoption among the statistically significant variables. With a standardized (beta) regression coefficient of -.101200 and an unstandardized (b) regression coefficient of -.096230 that is statistically significant ($p < .05$), maintenance and repair costs had the second highest predictive effect on adoption among the statistically significant variables. The negative sign on maintenance and repair cost indicates an increase on the scores of high maintenance and repair costs is accompanied by a decrease on adoption level. The negative effect of maintenance and repair costs is expected based on the assumption that low costs of maintenance increases the profitability of the technology which in turn increases adoption.

Non involvement of farmers in the technology had the third highest predictive effect on adoption among the statistically significant variables. It had a standardized (beta) coefficient of .082665 and unstandardized (b) regression coefficient of .076428 which is significant ($p < .05$). A positive regression coefficient implies a positive effect of involvement of farmers in the adoption of storage technology.

Effectiveness of extension had the fourth highest predictive effect on adoption among the statistically significant variables. Effectiveness of extension had a standardized (beta) coefficient of .071941 and an unstandardized (b) regression coefficient of .073103 which is significant ($p < .05$). A positive regression coefficient implies a positive effect on adoption. An increase in effectiveness of extension is accompanied by an increase in the adoption level.

Among farmers characteristics, only farm size was significantly associated with the dependent variable. Because farm size is an indication of the level of economic resources available to subsistence farmers (Polson and Spencer, 1991). A number of other studies report a positive relationship between farm size and adoption of new technologies (Ashby, 1982; Coughenour, 1984; Heffernan and Green, 1986; Polson and Spencer, 1991).

The regression analysis also show that two technology characteristics had significant effects on adoption. These were non involvement of farmers in the technology development and low maintenance and repair costs of the storage structures. Effectiveness of extension which is an institutional characteristics was positive and significant.

Therefore, this study showed that institutional factors contributed to the adoption process as also reported by Rogers (1983); Shakya and Flinn (1985); Nowak (1987); and Thomas te al. (1990).

4.4.3 Farmers perception on the approach used in transferring improved storage structure technology

Knowing where farmers got information about a new technology was important. This is because one of the purposes of this study was to evaluate information transfer of the technology. Table 15 shows farmers answers to a question on how they learned about an improved storage innovation.

An attempt was also made to identify the extent to which the selected extension methods were used by the sources of information to disseminate improved storage structure technology in the project villages. Sources of information were SG-2000/UNDP district supervisors, village extension officers, community development technicians, village chairmen, village secretaries and sponsors of the programme (SG-2000/UNDP officials). Three common methods were examined: home/farm visits, group meetings and demostrations. The percentages of respondents who indicated that they used particular extension methods are given in table 15.

Table 15. Extension methods used by different sources of information in transferring improved storage technology

How learned/ source of information	Type of extension method					
	Home Visits		Meetings		Demostrations	
	N	%	N	%	N	%
D/Supervisor	46	28.6	100	51.0	43	48.3
Ext.worker	62	38.5	62	8.0	33	37.1
Com. worker	16	9.9	9	32.0	9	10.1
V. Chairman	27	16.8	9	1.0	1	1.1
V. Secretary	6	3.7	1	4.7	-	-
P. sponsors	4	2.5	12	4.7	3	3.4
Total N	161	100	193	0.5	89	100
%	36%		44%		20%	

The data in Table 15 show that all respondents perceived SG-2000/UNDP district supervisors as being the most important source of information for improved storage structure. Average SG-2000/UNDP district supervisors contacts were 42.9% and village extension officers contacts were 35.9%, followed by community development technicians 8.2%. Other sources were village chairmen 7.5%, village secretaries 1.4% and sponsors of the programme 4.0%.

The data in the same table indicate that, the individual method used was farm/home visits at 36%. On the other hand, group methods used were found to be group meetings at 44% and method demonstrations at 20%. Generally, the findings reveal that the most frequently extension method used for both sources of information was group meetings. This is in line with Kauzeni (1989) who advocated that group methods are cost- effective because more farmers are reached at a given time. They are especially effective in persuading extension's clientele to try a new idea or practice.

4.5 Extension Officers' Perception on Improved Storage Structure Innovation

The major research interest in this section was to identify the extension officers' perception on the introduced improved storage structure innovation. The following areas were covered under this section:

a) Problems which constrained the transfer of improved storage innovation.

b) Reasons for low adoption of improved storage structures by farmers.

c) Opinions of extension workers on SG-2000/UNDP storage structure innovation.

a) Problems which constrained the transfer of improved storage innovation

An analysis of the problems that constrained village extension officers in transferring the improved storage innovation was carried out. The findings are shown in Table 16.

Table 16. Constraints in transferring improved storage innovation

Constraints	Village Extension officers n	%
No incentive to extension workers	5	28
Little knowledge of extension workers	4	22
No cooperation with village leaders	4	22
High construction cost	2	11
Farmers being reluctant	2	11
Few artisans in village	1	5.5

Data revealed that the major constraint for village extension officers in transferring the improved storage innovation was lack of incentives and motivation. This was revealed by 28% of all respondents. Little knowledge of extension officers on the introduced technology (22%) and lack of collaboration with village leaders in organizing meetings (22%) were also identified as major constraints. Village leaders have authority in their villages and have been selected by their communities based on their leadership qualities and spirit of service to the community. Therefore village leaders play a key role in the transfer of information by achieving a wider dissemination because they have the "know-how" to get the message across in a clear and appropriate language and a well established credibility in their communities.

Lack of incentives such as proper working tools, supportive technical services, suitable accommodation and training facilities reduce the effectiveness of field extension officers. The researcher noted that in additional to their normal extension duties, these village extension officers are also involved in many other duties. With these many additional tasks, unless incentives are provided, there may be dilution of efforts and poor performance.

Village extension officers had little knowledge of the introduced improved storage technology. This is because they did not attend any inservice training specifically on storage technology. Mostly (70%) have a basic certificate training in general Agriculture and 30% had a diploma training in crops and livestock. They only attended one seminar on storage management together with farmers, which was conducted by the district supervisors at village level.

The data also revealed that village leaders have been uncooperative in organizing farmers meetings. Therefore if few farmers attend the meeting, then the coverage of the village extension officer is reduced. Other constraints included: high construction costs of the structure (11%); farmers being reluctant to change (11%); and artisans in the villages are not easily available (6%). These artisans have the skills for constructing the structures especially weaving skill.

b) **Reasons for low adoption of improved storage structures by farmers**

An analysis of the perception of village extension officers on the reasons that constrain farmers in adopting introduced improved storage technology was carried out. The findings are indicated in Table 17.

Table 17. Reasons for low adoption of improved storage technology (n = 10)

Reasons	Village Ext. officer	
	n	%
Uncooperative village leaders	3	30
High cost of innovation	2	20
Poor field supervision	2	20
Poor harvest in 1993/94	1	10
Conservatism to change	1	10
Market available	1	10
Total	10	100

Village leaders being uncooperative to organize farmers to attend meetings was identified by 30% of village extension officers. Therefore few farmers were involved in seminars, meetings and demonstrations conducted by SG-2000/UNDP district supervisors and village extension officers. Village extension officers also felt that the costs for construction and insecticides were unaffordable (20%); and poor field supervision from extension officers were identified by 20%.

c) Opinions of extension officers on SG-2000/UNDP improved storage technology

Village extension officers were asked to give their opinions on how effective was the introduced improved storage technology as perceived by farmers. Opinions were as follows:

1) Circular baskets were mostly preferred by farmers. This was indicated by 70% of the village extension officer respondents. Circular baskets look like the traditional kihenge and is therefore compatible with traditional structure. The structure can be placed inside the living house for security and is also easy to make and carry in case of migration.

2) The burnt brick silos were preferred by farmers to some extent. According to village extension officers opinions (30%), these are durable and more modern than the baskets which they were familiar with. They have a high carrying capacity for shelled maize.

3) Rectangular bins were not preferred by farmers because they are not durable although safe from thieves.

Some comments were sought from village extension officers on some improvements to be made to make them more appropriate for adoption. Comments were as follows: there was a need to look into the grain outlets, most farmers show concern on security of their grains. The village extension officers also suggested that overhanging thatched roof either should be removed and replaced with a cover/lid or should rest on the silo/basket for more security rather than overhanging. Most farmers could not afford the use of cement for plastering (in case of SG-2000 project) and therefore preferred the use of locally available materials like cow dung and earth. This may hamper quick adoption of the structure because cement besides being very expensive is not easily available in villages. Another comment was that storage structures especially the circular baskets should be modified to suit placement inside the living house for security purpose of the produce.

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

On the basis of the findings of the study, the following conclusions can be made:

1) The adoption of the improved storage technology was low because of the shortfalls in the transferring of the technology to farmers. The approach used in planning in the SG-2000 and UNDP projects was rather top-down in nature, whereby farmers were persuaded to accept the programme as planned from above. Change agents could have helped farmers prioritise their needs, and from this point, the farmer and change agents could have worked together to determine the ways of tackling the problem. This type of interaction should have been maintained at all stages of programme planning, implementation and evaluation. Direct involvement of farmers in all phases of technology-innovation process will enhance technology adoption much more than merely developing technologies and making them available.

2) The study showed that men were more actively involved in the programme than women. This could be in line with the observations that information about new technologies developed in agricultural programmes tends to be communicated only

technologies developed in agricultural programmes tends to be communicated only through male information networks (Keregero and Biswalo, 1991). This affects their level of involvement in development activities. Change agents were supposed to have foreseen this problem and a way sought on how to improve women's involvement. One way would have been by increasing extension services to women.

3) The study shows that ineffective extension services to farmers contributed to failure of farmers to adopt the innovation. It has been shown that the greater the differences between the farmer and actual sources of information, the longer the period the farmer will require before adopting an innovation (Feeder *et al.*, 1985). Poor supervision, lack of incentives and motivation to extension officers were identified to be the major setbacks affecting innovation transfer on improved storage technology.

4) The programme will be better if a supervision mission would be established. Effective supervision increases contact between farmers and extension officers. It also helps to get quick feedback and give possible solutions to problems that may be present before it is late.

5) There is a need to look into the plastering materials. Most farmers could not afford the use of cement for plastering, instead, the use of the locally available materials like cow-dung and/or earth should be encouraged. Cement is very expensive and not easily available in villages.

6) The grain outlets has shown to be the centre for farmers concern in the structure. The construction of the outlets is not satisfying in terms of safety. Probably it will be better to visit other storage programmes and learn on door/outlet construction.

5.2 Recommendations

This section provides recommendations derived from findings of this study. In order to increase the adoption of the SG-2000/UNDP improved storage technology and other related programmes to be introduced in future, it is recommended that:

1) It was determined that the role of extension activities among farmers is crucial in the technology adoption process. Increased farmer exposure to extension services was deemed important in affecting adoption decisions. Thus, National policies for strengthening the extension capabilities through technical support, providing incentives such as reasonable salaries to meet living standards and

training programmes (for both the short and long term) are important.

2) The bottom-up approach should be used from the beginning, that is from planning, implementation and evaluation. The direct involvement of farmers in all phases of the technology-innovation process, requires the active participation rather than educating them. Peoples participation helps to get knowledge about the needs priorities potentials and interest among the people. Involvement of the people at early stage is likely to improve the programme or project design by ensuring that local social structure and organizations are considered in project planning and implementation.

3) Participation in monitoring and evaluation should be built in the programme in order to obtain knowledge about the farmers views of the intended effects of the project or programme. This helps to make them feel committed and responsible for the activities.

4) The effective introduction of improved storage technology could have been enhanced by fully involving women farmers in the programme; for example providing extension services directly to women.

5) Joint visits of extension officers and project planners to farmers before the start of the project, to analyse their problems and experiences with storage is a

necessary condition. Project planners should not focus their projects on "blanket recommendations" for the whole country but at levels/situations which most farmers can afford to use.

The central issue of technologies should be to develop technologies that are aware of farmers' scarce resources, can be transferred with the available extension and other institutional support, and are sustainable over the long term. To generate and disseminate such technologies will require location-specific research, more effective extension services, and reliable systems of input supply, all of which must be closely tuned to farmers' priorities.

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APPENDICES

APPENDIX 1: FARMERS' QUESTIONNAIRE

SOKOINE UNIVERSITY OF AGRICULTURE

DEPARTMENT OF AGRICULTURAL EDUCATION AND EXTENSION

An Assessment of Adoption of Improved Foodgrain storage structures in Mara Region.

Farmers' Interview Schedule

Respondent No.-------------Village-----------District------------

A. Farmers characteristics

1. what is your age-------(years)

2. Gender: 1. male

   2. female

3. What is your highest level of education

   1. None

   2. Adult education

   3. Primary education

   4. Secondary education

5. Other (specify)----

4. What is your farm size? ------ hectares

5. Which crops do you grow in your farm?

maize 1. yes--- 2. No---

sorghum 1. yes--- 2. No---

6. Out of the farm area cultivated in 1994/95 how many hectares were under: a) maize--------hectares

b) sorghum------hectares

c) other crops (specify)----hectares

7. What was the production from the cultivated area in 1994/95

a) maize----------bags

b) sorghum--------bags

c) other crops (specify)---bags/tons

8. Do you generally have a ready market for the produced grains

1. yes ------ 2. No---

9. If yes what is the market?

1. Neighbours

2. Businessmen

3. Others

10. If no in (8) above what do you do with the produced maize and sorghum: 1. consumed only

2. stored and sold later

3. brewed only

11. What is the major source of income for your family?

1. salary/wages

2. Farming/livestock keeping

3. Income generating activity

4. others (specify)------

12. If farming, in which activity are you engaged?

1. cattle raising

2. goat/sheep rearing

3. poultry keeping

4. cotton growing

5. coffee growing

6. other (specify)---

13. If income generating activity, what type of activity?

1. shop owner

2. brewing

3. pottery

4. masonry/carpentry

5. Tailoring/sewing

6. Brick making

7. Other (specify)---

B. Extent of adoption

14. When did you join SG-2000/UNDP project? ------- (year)

15. Who selected you to join the SG-2000/UNDP project?

1. Village government

2. Village extension worker

3. Both

16. How do you store your food-grains?------------

17. Do you know anything about improved storage structures?

1. yes ---- 2. No----

18. If yes from whom did you get the information

1. village extension worker

2. village leaders

3. SG-2000/UNDP district supervisors

4. others (specify)----

19. Are you using an improved storage structure?

1. yes ------- 2. no -----

20. Why did you prefer using improved storage structure from traditional storage stucture?

----

21. What is the capacity of your storage structure? -----bags

22. Who built it for you?

1. SG-2000 2. UNDP 3. Family

23. Where is the storage structure located with reference to the main living house

1. inside--- 2. outside---

24. Where did you dry the harvested maize/sorghum before storing

1. on the ground
2. On drying platform
3. As a heap in the living house
4. I did not dry

25. If you dried maize/sorghum before storing for how many weeks did you dry it?

----- (weeks)

26. What type of treatment did you use to preserve maize/sorghum from pest damage during storage?

1. Chemical pesticide
2. Natural deterrent materials
3. I did not treat it

27. What was the total price of the pesticide? Tshs-----

28. If you did not use chemical pesticides, give reasons

1. Lack of funds
2. Pesticides not available
3. Lack of knowledge
4. Small quantity of grains to store

29. How many farmers have adopted your structure after seeing it? 1. fully adopted---

2. partially--- 3. none---

30. Itemize the total material and labour cost needed to construct an improved storage structure

Cost component	Cost (Tshs)	Cost component	Cost (Tshs)
		g) Stones	
a) Stakes		h) Bricks	
b) Pillars		i) Labour(hrs)	
c) Rafters		j) Labour(Tshs)	
d) Rope		Total	
e)Straw			
f)cement			

31. Which of the following improvements of the storage structures have you adopted?

Plan: (a) circular basket--- (b) burnt bricks silos---

(c) rectangular mud blocks----

1. Platform raised off the ground----

2. Wall: correct materials -------

3. Wall woven only------------

4. Wall woven and plastered Inside---

5. Wall woven and plastered outside---

6. Wall woven and plastered both sides-----

7. Bottom outlet present ----------

8. top opening narrowed-------

9. Separate well thatched roof --------

10. Presence of rat guards --------

11. Grains dried and cleaned -----

12. Grains insecticide treated -----

32. Considering the above improvements, which modifications do you think are necessary to make storage stuctures more efficient?

----

33. Which of the above mentioned improvements do you find difficult to implement?

----

34. After adopting the improved storage structure do you think it has helped you in your storage?

C. Factors associated with adoption and non-adoption of improved storage structures

35. Rank according to importance of the factors contributing to adoption/non-adoption from the following ratings:

3. very important

2. moderately important

1. slightly important

0. not important

Innovation Factors

1. Raw materials are not easily available	0 1 2 3
2. High cost of storage chemicals	0 1 2 3
3. High labour requirements	0 1 2 3
4. High costs of implementing the technology	0 1 2 3
5. Profitability not easily observable	0 1 2 3
6. Not compatible with traditional structures	0 1 2 3
7. Farmers not involved in technology development	0 1 2 3
8. Complexity of the structure	0 1 2 3
9. High maintenance and repair cost	0 1 2 3

Farmers factors

1. Limited educational level of farmers --------
2. Limited income to implement technology ----
3. Women not involved in decision making --------
4. More older people involved who are conservative ----
5. Small quantity of produce to store ---------

Institutional factors

1. Inadequate information from extension workers -------
2. Lack of credit facilities -----------

3. Low producer prices to cover construction costs -----

D. Farmers perception

36. I would like to get your opinion on the following components:

(write the number from the opinion scale in the corresponding space of the chosen statement).

1. high 2. moderately 3. low 4. very poor

a) Improved storage structure innovation

Compatibility with traditional structures	1 2 3 4
Labour requirement	1 2 3 4
Availability of raw materials	1 2 3 4
Cost of implementing the technology	1 2 3 4
Profitability	1 2 3 4
Cost of storage chemicals	1 2 3 4
Complexity of technology	1 2 3 4
Maintenance and repair costs	1 2 3 4
Involvement of farmers	1 2 3 4

b) Farmers perception of the approach

37. Did you attend any meeting(s) where somebody discussed on improved storage structures. 1. yes---- 2. No-----

38. If yes, how many times did you attend such meetings

1.once------2. twice-----3. three times ----

39. Who was dominating the discussion?

1. sponsors of the programme

2. village extension worker

3. village leaders

4. community development technician

5. SG-2000/UNDP district supervisor

40. Has any member of the above mentioned made effort to visit you at home and talked to you on issues concerning improved storage structures? 1. yes---2. no---

41. If yes, do you remember how many times you have been visitedon similar issues?

1. once--- 2. twice--- 3. three times ---

42. Have you ever worked with any of the above mentioned members on the construction of improved storage structures.

1. yes----- 2. no------

43. If yes, state the number of times you have worked with any of the above mentioned members

1. once-- 2. twice---- 3. three times ---

44. State the number of times you have interacted with any of the following functionaries in the settings given:

	No. of Times		
	Home visits	Meetings	Demo
1. Village extension worker			
2. Community development technician			
3. Sponsors of the programme			
4. Village chairman			
5. Village secretary			
6. SG-2000 District supervisor			

45. Are you satisfied with the contacts made by the above mentioned members?

    1. very satisfied
    2. fairly satisfied
    3. not satisfied

46. How are your village leaders involved in the implementation of the programme?

    1. They only do supervisory work
    2. They are involved in performing assigned tasks
    3. They only give directives
    4. I don't know
    5. They are not involved in any way

APPENDIX: 2 EXTENSION OFFICERS' QUESTIONNAIRE

An Assessment of Adoption of Improved Foodgrains Storage Structure in Mara Region

Agricultural Extension Officers' Questionnaire

Mara Region

Respondent number ------- District --------- Village ------------

A. Characteristics of Extension Officers

1. What is your age? ----------- years
2. What is your gender? 1. Male --------- 2. Female --------
3. What is your marital status? 1. Single ----- 2. Married--
4. What is your highest level of education?
   1. Standard VII
   2. Standard XII
   3. Standard XIV
5. What professional training have you obtained and what was the duration of training and year obtained?

Professional	Duration (Years)	Year obtained
1. Certificate		
2. Diploma		
3. Degree		

6. If you have attended any inservice training what was the type and duration of the training

Training Duration Dates

1. ---------------- -------------- ---------

2. ---------------- -------------- ---------

3. ---------------- -------------- ---------

7. How long have you been working as an extension officer in this village?

---------years

B. Information on improved storage practices

8. What extension methods do you use to pass improved storage practices to farmers?

1. --

2. --

3. --

9. Describe your involvement with farmers on storage structures for the past four years since (1991/92)

1. Organising farmers' meetings ----------------------

----

2. Holding seminars/workshops for or with farmers ----- ---------------- ----------------------------------

----

3. Holding field days for farmers --------------------

----

4. Conducting demonstrations to farmers --------------

----

10. What factors facilitated your effective transfer of improved storage structure technology to farmers?

1. ---

2. ---

3. ---

11. List problems that makes it difficult for you to adequately transfer the innovation to farmers.

1. ---

2. ---

3. ---

12. Were you involved in any way in the process of developing improved storage structures?

1. Yes--- 2. No----

13. If no how would you have liked to be involved?

----

14. Were farmers involved in the development of improved storage structures?

1. Yes 2. No 3. I don't know

15. If your answer is yes, describe their involvement

----

16. If your answer is no, how could they have been involved

C SG2000/UNDP Storage Structure Innovation

17. In your opinion what do you think are the reasons for low adoption of improved storage structures introduced by the farmers?

1. ---
2. ---
3. ---

18. Which of the three storage structure(s) is/are mostly adopted and what are the reasons for adoption?

1. --

2. --

3. --

19. Which modifications do you think are necessary?

1. --

2. --

3. --

20. What is your opinion on the SG-2000/UNDP improved storage structure innovation? (Choose from the opinion scale)

Opinion scale

1. Strongly agree 2. Agree

3. Disagree 4. Strongly disagree 5. Undecided

1.	SG-2000/UNDP had closer supervision	( )
2.	SG-2000/UNDP had more incentives to extension officers	( )
3.	es not encourage farmers participation	( )
4.	They use top-down approach	( )
5.	Credit is not available	( )
6.	Raw materials are not available	( )
7.	The whole technology is appropriate	( )

8.	The technology needs modification	(	)
9.	Raw materials are costly	(	)
10.	Laborious exercise of construction	(	)
11.	Extension service is not effective	(	)
12.	Chemicals for storage are costly	(	)

Appendix 3: Items used to measure the extent of adoption

- Correct wall materials
- Top outlet narrowed
- Bottom outlet present
- Platform raised offground
- Overhanging thatched roof
- Presence of rat guards
- Wall woven/Brick made only
- Wall woven, plastered inside
- Wall woven, plastered outside
- Wall woven, plastered both sides
- Grains cleaned and dried before storage
- Grains treated with insecticide before storage

Appendix 4: Technology attributes used to measure respondents' perception on the technology

- Compatibility
- Labour requirement
- Profitability
- Compexity of technology

- Cost of implementing technology
- Maintenance and repair costs
- Availability of raw materials
- Cost of storage chemicals
- Involvement of farmers in Technology development

Appendix 5. Correlation Coefficient matrix of farmers characteristics, institutional and combined innovation attributes influencing adoption.

Correlations	X_1	X_2	X_3	X_4	X_5	X_6
X_1	1.000					
X_2	-.2316*	1.000				
X_3	-.2366*	.0640-	1.000			
X_4	.3911**	.1799-	-.0677	1.000		
X_5	-.0231-	.0319	-.0803	.0547	1.000	
X_6	.1927	.0019	-.0531	-.0842	.1216	1.000

1-tailed signif:*-.01 ** -.001

Key:

X_1 = Age

X_2 = Gender

X_3 = Education level

X_4 = Farm size

X_5 = Combined innovation attributes

X_6 = Effectiveness of Extension

Appendix 6. Correlation coefficient matrix of factors affecting adoption of improved storage technology.

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}
X_1	1.0000													
X_2	-.1998	1.8000												
X_3	-.2402*	.0702	1.0000											
X_4	.2137*	-.1879	-.0680	1.0000										
X_5	-.0464	-.8126	-.0133	.0099	1.0000									
X_6	-.0510	.0626	-.1010	-.8724	.5063**	1.0000								
X_7	.0132	-.1087	-.1598	.1716	.2647*	.3094**	1.0000							
X_8	-.1920	.0813	-.0619	-.1218	.5466**	.3721**	.2636*	1.0000						
X_9	.0873	-.0418	.1174	.0296	.1219	-.0698	.1597	.2342*	1.0000					
X_{10}	.0084	.0067	-.0375	.0876	-.2009	-.0951	-.1483	-.1943	-.0614	1.8000				
X_{11}	.2247*	-.0242	.0529	.0303	-.2670**	-.2217*	-.3507**	-.4657**	-.2053*	.0952	1.0000			
X_{12}	-.1659	-.0685	-.1854	.0836	.3443**	.3497**	.3799**	.3675**	-.3138**	-.1034	-.2077*	1.0000		
X_{13}	-.1954	-.0069	-.0555	-.0785	.3389**	.4119**	.4506**	.4278**	-.0049	-.2454*	-.2113*	-.2469*	1.0000	
X_{14}	.1800	-.0756	.1417	.2847**	-.1629	-.1286	-.0739	-.3857**	-.0461	.0554	.2275*	-.1226	-.3370**	1.0000

N of cases: 133 1-tailed signif:*-.01 ** -.001

Key:

X_1 = Age

X_2 = Gender

X_3 = Education level

X_4 = Farm size

X_5 = Compatibility

X_6 = Labour requirement

X_7 = Cost of implementing technology

X_8 = Availability of raw materials

X_9 = Profitability

X_{10} = Complexity of technology

X_{11} = maintenance and repair costs

X_{12} = Involvement of farmers

X_{13} = Effectiveness of extension

X_{14} = Cost of storage chemicals