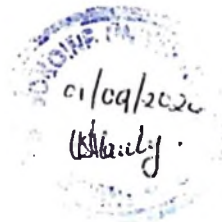


**AVAILABILITY, TRANSFER AND UTILIZATION OF SELECTED GRAIN
STORAGE PROTECTANT INNOVATIONS IN TANZANIA:
THE CASE OF MOROGORO DISTRICT**



BY

AMOS ORINDA NICOLAO



**A DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE
REQUIREMENTS FOR THE DEGREE OF MASTER OF ARTS IN RURAL
DEVELOPMENT OF SOKOINE UNIVERSITY OF AGRICULTURE.
MOROGORO, TANZANIA.**

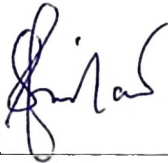
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ABSTRACT

In many parts of Tanzania locally available materials are widely used to protect grain stored produce against insect pests. However, with dissemination of modern grain storage protectant innovations, the traditional grain storage protectant knowledge has started to lose its ground. Thus, this study was conducted to assess the extent of availability, transfer and utilization of grain storage protectant innovations in Morogoro district, Morogoro region. Specific objectives were to: take an inventory of different kinds of grain storage protectant innovations available to the extension service; assess the extent of transfer of selected grain storage protectant innovations; and determine the extent of adoption/rejection of grain storage protectant innovations. Data were collected from 152 respondents including 132 farmers, four extension agents from each of the four villages in Morogoro district, and 16 key informants using questionnaires, researcher's diary and checklist. Qualitative data were analyzed using content analysis technique. Quantitative data were processed and analyzed to produce frequencies, means and percentages. The results showed that grain storage protectant innovations are generally available in forms which vary in degree to which they can be helpful to the field extension agent. The extent of transfer and adoption of grain storage protectant innovations was found to vary from type of stored grain crop to crop. It was concluded that some of the constraints to transfer such innovations are of extension nature while others are clearly beyond the responsibilities of the extension agent. The study recommended that efforts be made to refine grain storage protectant innovations; every extension worker should attend on regular basis refresher courses and other professional programs and should be provided with transport facilities; and improvement of secondary education quality, access and equity for youth who are expected to be future farmers in the country side.

DECLARATION

I, AMOS ORINDA NICOLAO, do hereby declare to the Senate of Sokoine University of Agriculture that this dissertation is my own original work and has not been submitted for a higher degree in any other University.

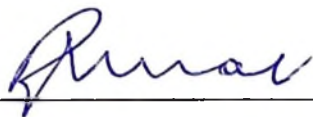


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23. 11. 2009

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The above declaration is confirmed



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(Supervisor)

23/11/2009

Date

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DEDICATION

To the beloved mother Rusalia Aoko and late parents (Nicolao Orinda, Lois Kagose) for setting down the foundation of my education, the work is also dedicated to elder late Kopuko Nyarminandala who used to keep a herd of cattle that contributed to my school fees payment from standard one onwards. Above all it is dedicated to the Almighty God the Creator who is all in all.

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LIST OF ABBREVIATIONS

AIAEE	Association of International Agriculture and Extension Education
ASD	Actellic Super Dust
ASDP	Agricultural Sector Development Program
ASLM	Agricultural Sector Lead Ministries
CIMMYT	International Maize and Wheat Improvement Center (Centro Internacional de Mejoramiento de Maiz y Trigo/Mexico)
COSTECH	Commission for Science and Technology
DALDO	District Agriculture and Livestock Development Officer
DAS	District Administrative Secretary
DE	Diatomaceous Earth
DRD	Department of Research and Development
DED	District Executive Director
DSI	Development Studies Institute
Ec	Emulcifiable concentrate
FAO	Food and Agriculture Organization
FFS	Farmer Field Schools
FFTC	Food and Fertilizer Technology Center
FGD	Focused Group Discussion
Ha	Hectares
ICT	Information Communication Technology
IPM	Integrated Pest Management
JICA	Japan International Cooperation Agency
LD₅₀	Lethal Dose that kills 50% of the test insects
LGB	Larger Grain Borer

MAFS	Ministry of Agriculture and Food Security
MC	Moisture Content
MDG	Millennium Development Goal
NARS	National Agricultural Research System
NBC	National Bank of Commerce
NCDDR	National Centre for the Dissemination of Disability Research
NEMC	National Environment Management Council
NGO	Non-Governmental Organization
OPS	Operation Technology for Smallholders
PMC	Pest Management Centre
PRA	Participatory Rural Appraisal
RSCU	Regional Soil Conservation Unit
SNAL	Sokoine National Agricultural Library
SPSS	Statistical Package for Social Science
SUA	Sokoine University of Agriculture
TAFORI	Tanzania Forestry Research Institute
TCRA	Tanzania Communications Regulatory Authority
TDT	Technology Development and Transfer
ToT	Training of Trainers
TPRI	Tropical Pesticide Research Institute
UDSM	University of Dar es Salaam
UPE	Universal Primary Education
URT	United Republic of Tanzania
WB	World Bank
ZCC	Zonal Communication Centers

CHAPTER ONE

1.0 INTRODUCTION

This is a study of the availability, transfer and utilization of selected grain storage protectant innovations. Grains experience losses that occur at one or more of the following several stages of the post-harvest chain: threshing, storage, transport, milling, wholesale and retail distribution. In many parts of Tanzania locally available materials are widely used to protect stored produce against insect pests. However, with the dissemination of modern grain storage protectant innovations, the traditional protectant knowledge has started to lose its ground. The purpose of this study was therefore to assess the extent of availability, transfer and utilization of selected grain storage protectant innovations in Morogoro district.

1.1 Background Information

Grain losses during and after crop harvest is a major problem for grain protection in developing countries. Insect pests, rodents, micro-organisms, and storage fungi comprise the larger proportion of post-harvest losses, and therefore are known to be the dominant causes of post-harvest deterioration of cereals, legumes and oilseeds in the world (Janicki and Green, 1976; Bothast, 1978).

Insects are a leading problem in stored grain throughout the world because they significantly reduce the quantity and quality of grain (Sinha and Watters, 1985; Madrid *et al.*, 1990). Farmers throughout Sub-Saharan Africa have long suffered serious losses to their stored produce due to insects' damage. For many families, such losses threaten household food security, while for others they may force early sales at lower prices. Grain losses vary from one geographic location to another and from pit to pit, depending on

original grain conditions, season, and associated organisms. Losses could be even higher if aggravated by high initial grain moisture content, direct rainwater leakage into the store, pest infestation, and poor storage sanitation. Managing stored grain wisely within minimal loss while maintaining its nutritional quality is a major concern at all stages. Post-harvest food grain losses are estimated to be 9 and 30% in developed and developing countries respectively (Janicki and Green, 1976; Bothast, 1978).

Sometimes grain loss starts right away in the field before even the crop is stored and the insect pests are found soon on the start of storage period then continues towards the consecutive period (Nicolao, 2003). For instance, the common bean weevil (*Acanthoscelides obtectus* Say) starts to infest beans in field and continue to infest them in storage (Kiula and Karel, 1985).

Before the development of chemical pesticides, farmers were reliant on using nature itself to assist in crop protection. Through local experience farmers learned which natural plants contained certain properties harmful or repellent to crop pests. Plants are well known for their medicinal and insecticidal properties that could be used for grain protection against post-harvest storage loss agents. Quite a large number of the available traditional grain storage protectant innovations that have ever been used for pest and other grain storage loss agents control are said to be beneficial (Grainge and Ahmed, 1988). Wood ashes from *Khaya senegalensis*, *Eucalyptus* spp., *Azelia africana*, *Ceiba pentrandia* and *Parkia africana* are particularly recommended for the control of development stages of Coleopterae living on grains (Gwinner *et al.*, 1996).

In most cases, farmers have been undertaking their farming practices in a traditional way as business as usual. This has involved diversification of indigenous technologies from

production, processing, preservation and/or storage of agricultural crops. Even some of the today's improved technologies have resulted from these indigenous technologies. The utilization of plant materials to protect field crops and stored commodities against insect attack has a long history. Many of the plant species concerned have been used by local communities as indigenous and/or traditional in form of leaves, roots, twigs, buds and flowers singly or in admixture as protectants whose mother plants have been collected from the field or specifically cultivated for these grain storage purposes (Delobel and Malonga, 1987).

The availability of these grain storage protectant innovations depends on the knowledge of the farmers on them and mode of their application in storage. Transfer of innovations has been from parents to children, farmer to the neighbor farmer(s) through farmer field schools, farmer groups, and government through her extension agents. Young, literate farmers who are more well-informed about modern storage methods show a greater tendency to use botanicals as grain storage protectants although the knowledge base about botanicals is more common in older males (Golob and Webley, 1980; Belmain and Stevenson, 2001). Dales and Golob (1997) noted that chemical pesticides will have applications for controlling post harvest pests well into the 21st Century, nevertheless, in some areas, the adulteration of conventional insecticides used for protection of stored grain has reached a stage that they no longer work.

In many parts of Tanzania, locally available materials are widely used to protect stored produce against damage by pests. The value of plants with insecticidal properties has been known to farmers of their native regions since ancient times (Mbuya, 1994; Stoll, 1995; INADES, 1997). Indigenous knowledge on grain storage protectants is the accumulated skills and technology of the local people, derived from the direct interaction of human

beings and their environment in terms of soils and plants (ethno-botany). This has increased their experience with nature in crop production, processing, protection or preservation and utilization. Indigenous knowledge has therefore become helpful in maintaining and enhancing the quality of the environment. However, with the dissemination of modern grain storage practices, the indigenous practices have started to loose ground and have been eroded to a large extent.

Morogoro region (where data for this study were collected) is one of the 26 administrative regions in Tanzania (Appendix 1 and 2). The region has an area of 70 799 square kilometres. Administratively it is divided into 6 districts of Mvomero, Morogoro Rural, Ulanga, Kilombero, Kilosa, and Morogoro Urban. It comprises 457 villages which are grouped into wards with population of 1 753 362 at growth rate of 2.8% (URT, 2002; Claude and Mwamfupe, 2003). Due to its fertile soil, favourable rainfall and a wide range of altitude, a considerable number of crops are grown in the region. Only limited numbers of farmers keep cattle, sheep and goats.

Morogoro district farmers are among the Tanzanian farmers who grow cereal grain crops in abundance that need to be protected against loss agents. According to Claude and Mwamfupe (2003), the district (Appendix 2) covers about 1 543 787 ha inhabited with the Maasai, Wapogoro, Waluguru, Wagoogo, Wasagara, Wakaguru and Wabarbaig comprising a population of 263 920 people at an annual growth rate of 2.6%.

Brooker (1992) notes that high crop production may not always ensure food security to farmers as they may experience high grain loss resulting from damage of loss agents: rodents, insects, moulds, wind, rain, sunlight starting from the field and then proceed to storage, and premature sales of the crops due to lack of proper storage facilities.

Sometimes losses are identified at each step of harvesting, processing and storage, and therefore low-cost technology options for reducing these losses are very important. The extent of availability, transfer and utilization of grain storage protectant innovations and their policy implications remain to be clarified by this study. With this in mind, the problem outline for the study is set in perspective.

1.2 Problem Statement

Farmers in developing countries lose a sizeable proportion of their harvested grain to pests during storage and many consider this loss to be a serious problem (Nicolao, 2003). The agricultural extension system in Tanzania has come under criticism as being ineffective in stimulating farmers' agricultural production practices (Wambura, 1992). This criticism has focused partly on the performance of extension agents in rural areas as being unable to influence farmers' reduction of high grain storage loss which results from damage by loss agents. These are undoubtedly real problems. However, little attention has been given to periodic assessment of the availability, transfer and utilization of grain storage protectant innovations. This study therefore was intended to concentrate on the innovation dimension. In particular the study sought to determine the availability, transfer and utilization of grain storage protectant innovations in selected villages of Morogoro district.

1.3 Research Objectives

1.3.1 General objective

To assess the availability, transfer and utilization of selected grain storage protectant innovations in Morogoro district.

1.3.2 Specific objectives

1. To take an inventory of different kinds of grain storage protectant innovations available to the extension service.
2. To assess the extent of transfer of selected grain storage protectant innovations.
3. To determine the extent of adoption/rejection of selected grain storage protectant innovations.

1.4 Research Questions

1. What grain storage protectant innovations are actually available to the extension service in Morogoro district?
2. Do the farmers receive any advice on selected grain storage protectant innovations from field extension agents or other sources? If so in what way(s) does the advice reach them?
3. What is the state of farmers with regard to knowledge, trial and adoption of selected grain storage protectant innovations?
4. What are the characteristics of innovations and how do these characteristics affect the transfer and adoption of selected grain storage protectant innovations?

1.5 Operational Definition of Terms

The terms that will be used frequently in the text are defined here to provide a common basis for conveying meaning. These include: poverty alleviation; grain storage protectants; innovations and the key variables used in the study.

1.5.1 Poverty alleviation

Poverty alleviation or poverty reduction is any process which seeks to reduce the level of poverty in a community, or amongst a group of people or countries. Its programs may be

aimed at economic or non-economic poverty through education, economic development, and income redistribution. Its efforts may also be aimed at removing social and legal barriers to income growth among the poor. According to URT (2005a), poverty alleviation is a Millennium Development Goal (MDG) aiming at reducing poverty and hunger by 50% by 2015 in Tanzania. It is therefore one of the coping strategies against food insufficiency. In this study poverty alleviation means improved livelihoods of farmers resulting from increased food security through adoption of grain storage protectant practices.

1.5.2 Grain storage protectants

Grain storage protectants are defined as contact pesticides that are mixed with the grain before it enters storage to provide pest control (Digvir, 1995). These are pesticides from plant and soil origin, or artificially manufactured from industries. Plant protectants include different parts as leaves, roots, twigs and flowers that are admixed for this purpose, while soil group comprises the Diatomaceous Earths (DEs). The industrial ones are conventional synthetic chemicals found in different forms of granules, powders and liquid applied purposely as pesticides for grain storage protection. Grain storage protectants also include mechanical practice/means of using air tight devices made or re-used ones, these include: sealed clay pots, bins, steel drums, tins to prevent stored grain loss resulting from the action of loss agents. In this study grain storage protectants will therefore mean use of traditional pesticides, conventional synthetic pesticides and mechanical processes or devices.

1.5.3 Innovations

An innovation is defined as "the successful exploitation of a new idea". This implies that it is not just the invention of a new idea, but that this idea is actually "brought to market",

used, put into practice, exploited in some way, and may be leading to new products, processes, systems, attitudes or services that improve something or add value. There are different kinds of innovations (Rogers, 1983). The main ones are: a) incremental innovation (where something is adapted or modified)-which may mean that an old idea is transferred to a new setting or that existing ideas are embedding in a new setting; b) radical innovation (which involves completely new ideas). This study focuses on availability, transfer and adoption of grain storage protectant innovations.

1.5.4 Key variables

The definitions of various key variables (background, independent and dependent variables) as used in the study are given in Appendix 3. The following Chapter reviews the empirical literature in areas of types of grain storage protectants; availability of innovations, transfer of innovations and adoption/rejection of innovations.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Introduction

This Chapter reviewed literature from other study findings in order to provide a theoretical framework which guided the development of the study model on which the data analysis of the present study is based. It focuses on: types of grain storage protectants; availability of innovations; transfer of innovations; adoption/rejection of innovations.

2.2 Types of Grain Storage Protectants

Grain storage protectants are divided into three main categories (Grainge and Ahmed, 1988; Odogola and Henrickson, 1991): (i) traditional pesticides; (ii) synthetic pesticides; and (iii) mechanical processes.

2.2.1 Traditional pesticides

Several studies have contributed a lot of information about natural plant protection with particular reference to Eastern and Southern Africa. Many different plant species are utilized traditionally as natural pesticides and/or have been explored experimentally. Some plants seem to be more popular or tested more often than others. For instance, species of the family *Euphorbiaceae* and experiments on the effect of plant extract from *Tephrosia* appeared to be commonly used in different places in Tanzania and Zambia (Golob *et al.*, 1999).

Today there is considerable interest among biochemists and botanists to screen plants for secondary chemical compounds, which could be used for developing medicines and pesticides, particularly in the tropical rain forests where plant species are numerous but

threatened with extinction (Downum *et al.*, 1993). However, it is an expensive and difficult process to isolate and identify the active ingredients and further to produce them in formulations which can be commercialized. Latum and Gerrits (1991) further noted that natural pesticides are not uniform products but rather consist of different active ingredients which often vary in concentration from sample to sample. This makes toxicological tests difficult and costly to run. Therefore one can expect that the interest of the chemical industry in developing new bio-pesticides is rather limited.

Plant materials with insecticidal properties provide small-scale farmers with a locally available, biodegradable and inexpensive method of pest control for storage. There is a common tradition among farmers at the subsistence level to use natural products such as ashes instead and these alternatives appear to have increased their importance. An enquiry in Zimbabwe showed that the number of farmers who used natural pesticides in addition to chemicals changed from 20% before 1989 to 80 % after (Giga and Katerere, 1986).

The use of plant extracts to control pests is not a new innovation, as it has been widely used by small-scale subsistence farmers (Fivawo, 2008). Fivawo (2008) further observed that the powder of the following botanicals: *Ocimum canum* Sims (Asteraceae), *Tagetes minuta* (Asteraceae), *Eucalyptus globus* Labill (Myrtaceae), *Ricinus communis* L.(Euphorbiaceae), *Neutraunenia mitis* (Leguminoceae) (tuber) are effective and have potential for protecting stored beans against bean weevils (*Zabrotes subfasciatus*) and kill by 100% after 14 days of treatment. According to Delobel and Malonga (1987) the vogel tephrosia (*Tephrosia vogelii*) has many protection activities. Powder of *Tephrosia* leaves can also be used to protect stored products. In Congo, powder mixed with groundnuts at a ratio of 1:40 gave a 98.8% mortality of the Groundnut Borer (*Caryedon serratus*) after 13

days. Some researchers (Kis-Tamas, 1990) are even seeking plant extracts, which can become the focus of the local pesticides industries.

According to Sharaby (1989) the use of *Eucalyptus globus* lethal dose that kills 50% of the test insects (LD₅₀) for exposure to leaf powder for seven days was 4.1g/100g of rice for adult *Sitophilus oryzae* and 4.86g/100g of rice for *Sitophilus granarius*. Also Strivastava *et al.* (1988) noted that oil of *Eucalyptus globus* (0.4% v/w) admixed with red gram prevented emergence of F₁ adults in *Callosobruchus chinensis* after an exposure period of 90 days. Dried ground leaves of castor bean plant (16g/kg) admixed with cowpea caused 100% mortality in adult *Callosobruchus maculatus* within seven days and reduced F₁ emergence (Okonkwo and Okoye, 1992). In addition Salas and Hernandez (1985) noted that 10ml/kg admixed with pigeon pea caused 100% mortality in adult *Acanthoscelides obtectus* and *C. maculatus* within 18 hours.

According to Fivawo (2008), the protection of stored products such as rice, wheat, maize, and beans with vegetable oils is another simple, convenient and cost-effective method. Furthermore Rheenen *et al.* (1989) observed that 2.5ml/kg of sunflower oil applied to *Phaseolus vulgaris* protected the bean against attack by *Acanthoscelides obtectus* for six months. Salas and Hernandez (1985) further noted that 10ml/kg of soybean oil applied to pigeon pea seed caused 97% mortality in *Acanthoscelides obtectus* within 1 hour and also prevented egg laying, and 10ml/kg of coconut oil admixed with pigeon pea caused 97.5% mortality in adult *Acanthoscelides obtectus* and 100% mortality in *C. maculatus* within 1 hour which also prevented reproduction and F₁ emergence. On the other hand, it has been observed (Golob and Webley, 1980; Cockfield, 1992) that 10ml/kg of groundnut oil admixed with cow pea reduced damage by *C. maculatus* over 24 weeks storage.

Tierto (1989) identified some insects controlling plants as: castor bean seeds 10% ethanolic extract; neem seed 5-10% slurry <10% damage; neem oil 1.5% (v/v) 16% damage; pyrethrum flower 0.5% powder (w/w) highly effective; velvet leaf, root 2.5-10% slurry 10% damage. Tierto (1989) further found out that using plant material in the form of slurry produces better results than plant powders. In his research the slurry was made by weighing out powder into 150 ml containers and adding sufficient water to give a 10% concentration (w/w), and stirring until a smooth paste was obtained. The treatment was performed by pouring the grain into prepared slurries and stirring with a rod until all grains were coated. However, the slurry of the velvet leaf is extremely bitter, therefore this treatment is suggested for application on planting seed. According to Saxena (1993), the preparation of neem can involve any part of the plant as follows: leaves are stripped off ready for sun drying; the dry seeds are pound to give powder and sometimes other parts of tree as twigs, stems, fruits are chopped together then boiled ready for utilization.

Barbosa *et al.* (1994) noted that diatomaceous earths (DEs) which are soft whitish powders formed from the fossils of tiny planktons (diatoms) live in oceans, rivers and lakes. These fossil deposits can be mined, ground to powder, dried and admixed with grain in storage to kill the insects that infest and attack it. When DEs come into contact with insects, they absorb the wax from the skin and cuticle of the insect, causing water loss, dehydration and subsequent death.

2.2.2 Synthetic pesticides

According to FAO (1999) synthetic pesticides include: acaricides, arboricides, herbicides, insecticides, fungicides, molluscides, nematocides, hormonal sprays and defoliant used or intended to be used, either alone or together with other material substances for: a) protection of any food intended for human consumptions; b) control of the external vectors

of veterinary or medical disease and external parasites of man or domestic animals; and c) control of weeds, pest and disease in plants. Anon (2003) observed that conventional insecticides are dilute dust formulations which are admixed with commodities, ones recommended for use on stored grains. The most commonly used chemicals in storage are methacrifos (Damfin; Ciba Geigy), fenitrothion (Sumithion, Sumitomol), pirimiphos methyl (Actellic 2% Zeneca Agrochemicals) at the rate of 200-500g per bag and permethrin (Actellic Super Dust) at the rate of 100g per bag and for a long time have been effective and the most important in grain storage. Chemical application especially dusting in particular is easily applied method and can be implemented with cheap tools as perforated metal cans or jute bags. Dust is thoroughly and evenly distributed while mixed with the grain.

It has been noted (Mulungu *et al.*, 2007) that pesticides used in stored products can prolong the viable life of the produce and prevent huge post-harvest losses from pests and diseases. These primary benefits bring many secondary benefits. Clearly if harvestable yields and quality are increasing, farm revenues are also likely to increase. Therefore there will be assurance of availability and accessibility to sufficient food at the required time for contribution to poverty reduction.

It has been reported (Golob *et al.*, 1999) that, the majority of farmers do little to protect their grain during storage, largely because resource-poor farmers find conventional synthetic pesticides too expensive and difficult to obtain; and inappropriate use of synthetic chemicals may lead to human and environmental health risks and promote insecticide resistance. Healthy products and clean storage structures are therefore essential to prevent pest damage under resource-poor farmers' situations where the storage period is long.

2.2.3 Mechanical processes

Storage of grains in air tight containers as gourds, earthen ware clay pots, jars, plastic or metal tins, pails, metal drums make unfavorable conditions for weevils and other insects to reproduce (Sindi and Henry, 2004). Bodholt and Diop (1987) argued that plastic drums are used intact or after having the upper part cut off to facilitate loading and unloading. Otherwise, plastic lends itself poorly to adaptation because it is relatively weak- at most, a lockable outlet can be added. If the lid is tight fitting and the drum is completely filled with grain, any insects present will deplete the oxygen in the drum and die. The size of the systems can range from 3 litres-300tons and can be used for paddy, milled rice and other cereal crops such as maize and also beans (Sindi and Henry, 2004).

Bodholt and Diop (1987) realized that metal drums can be adapted for domestic grain storage in a similar way. A removable lid permits easy loading; but it is also possible to weld half of the lid to the rim of the drum, and provide a riveted hinge on the remaining half of the lid so that it alone can be opened. Fitted with a padlock, such a modified drum is more secure. To make a store of greater capacity, two metal drums can be welded together end to end and fitted out as described above. Well modified and/or fitted with gaskets, metal drums can also be made airtight. Inaccessible to rodents, efficient against insects, sealed against entry of water, drums make excellent grain containers. However, they should be protected from direct sunshine and other sources of heat to avoid condensation by being located in shaded and well ventilated places.

Bodholt and Diop (1987) further noted that basically metal drum can also be called empty bitumen drum. After the road construction authority has used the coal tar, the drums are discarded as junk or are sometimes used for protecting roadside plantations. The drum is heated by open fire to remove any excess tar. A layer of tar remains inside, and serves as

an insulator as well as a protective coating for the galvanized iron sheet. The local artisan can bring this drum to an attractive shape and can also fabricate a lid and a discharge chute. A drum holds 150 kg of cereals whereas a metal bin may have the same capacity depending on the size of the galvanized iron sheet used. The local artisans have been trained to fabricate these bins to suit village requirements and have thereby generated gainful employment for them. Nicolao (2003) mentioned single drum bin, modified oil and coal-tar drums as improved storage systems and management methods to be employed for safe storage of grains.

Farmers in the semi-arid zones of sub-Saharan Africa, such as Mauritania, Senegal, Mali, Niger and Chad, use a mixture of clay or mud and straw called "*Banco*" to build concealed granaries. *Banco* granaries can be four-cornered, spherical, with a straw roof containing a protecting lid, or in the shape of a cone with the tip pointing downwards and resting on a foundation of stones. Grains inside these *banco* granaries are well protected against rains and the invasion of insect pests. If the structure is well built and maintained, insect pests would find it very difficult to survive inside due to the lack of oxygen. Granaries made out of mud or clay provides a cool environment that keeps grains viable for germination (Odogola and Henrickson, 1991). Furthermore Sindi and Henry (2004) found that jars have a narrow opening and are hermetically sealed with a stone on top. Hermetic storage leads to depletion of oxygen and accumulation of carbon dioxide inside the container, which eventually lead to elimination of insect pests. Hermetically sealed grain storage systems improve grain quality and seed viability because they maintain the original storage moisture content and reduce pest damage without using pesticides. Seed viability can be increased from 6-12 months. The system works because the insects and grain respire which reduces the oxygen levels in the grain to 5-10% at which time insect activity stops. Bird and rodent damage are also reduced.

In the management issues the following should be noted: intermittent opening and closing allows oxygen re-entry which can lead to the rapid re-infestation of some insects such as lesser grain borer which can pierce plastic liners; in containers that are only partially filled, the large air space to grain ratio may not allow oxygen levels to reduce to a level that will control insects; large commercial plastic storage can be damaged by rodents if not managed correctly; and the plastic liners should be pulled tight and a clear space be kept around the containers (Sindi and Henry, 2004).

Sindi and Henry (2004) noted that sun drying is a mechanical process which is a traditional method of drying the harvested grain crops. Any proper grain storage must be preceded by thorough grain drying to lower the moisture content to reach 12%. Thermal disinfestations (seeds laid out in the midday sun for 3hrs) proved to be very valuable. However, sun drying is sometimes accompanied with grain contamination due to poor drying facilities, for example mats that are just laid on the bare grounds. To avoid this it is better to dry the grains on the raised platforms. In general traditional sun drying practice involves spreading of the grain on plastic sheets, mats, laid on the ground where sun-energy is maximally received.

2.3 Availability of Innovations

Bond (1984) and Snelson (1987) noted that synthetic insecticides, such as malathion, pirimiphos-methyl, chlorpyrifos-methyl, pyrethrum, deltamethrin, methoprene and the fumigant phosphine, are currently the main products used to protect stored grain¹ from insects. Practically worldwide, farmers have a wealth of traditional and modern practices for the control of grain pests and diseases. These focus mainly on protection against storage pests which cause serious losses and are the major threat to food security.

Different world scientists (Saxena, 1993; Prakash and Rao, 1997; Kyong-joo, 2001) have documented on how some grain storage protectants are used against grain loss agents within farming communities which have been used in different forms including smoke, mixed with water then sprayed over the food grain, dusting with ash; as such representing a sample or portion of potential indigenous or already introduced plants that might be used for pest control in future. Higher plants are a rich source of novel insecticides. The insecticidal activity of many plant derivatives against several stored-product pests has been demonstrated (Jilani and Su, 1983; Malik and Mujtaba Naqvi, 1984; Regnault-Roger and Hamraoui, 1993; Golob *et al.*, 1999; Weaver and Subramanyam, 2000). Azadirachtin from the Indian neem tree (*Azadirachta indica*, Meliaceae) (Saxena *et al.*, 1988; Jilani and Saxena, 1990) and pyrethrum from chrysanthemums (Prakash and Rao, 1997) have received the most attention. In addition wood ash, as well as sand, tobacco dust and dolomite, provided a good protection when mixed with stored maize for six months (Golob, 1984). Much of the loss results from invasion of the grain mass by micro flora, arthropods, and vertebrate pests.

According to FAO (1990); Barbosa *et al.* (1994) and Andrea (2003), there is available information from research centers in form of booklets, brochures, leaflets, pamphlets, video cassettes for farmers and extension agents on various botanical pesticides such as plant parts/extracts or pastes; twigs, leaves, stems, roots, barks; DEs; mechanical processes as air tight devices as sealed clay pots, drums, tins, bins, application of sun heat for drying grains, smoke application (smoking the grains); and application of synthetic pesticides. Poor farmers who cannot afford commercial pesticides stick only to the traditional practices. Women are knowledgeable in this area because of their dominant role in the grain storage process.

Farmers need information for their day to day activities as it helps them to become aware of new ideas and practice and either adopt or reject them (Mbwana, 1994). Farm magazines together with other printed materials are now the most favorable and widely used media for communication. Their effectiveness depends on the extent of literacy and communicative nature of the people. In areas of high literacy, this medium is very effective if certain preconditions including a good level of education among the farmers are met (Wambura, 1992). Magazines are important in explaining and interpreting news and development (Mntambo, 2007). In Tanzania, *Ukulima wa kisasa* (modern farming) is the main agricultural monthly magazine for farmers. It is vital source of information pertaining to modern methods of cultivation, price trends, processing. Mbwana (1994) further noted that most farmers benefit from *Ukulima wa kisasa*, monthly Kiswahili magazine, despite its production and distribution barriers.

Innovations originate from the research centers, universities and some Non-Governmental Organizations (NGOs) that are connected through National Agricultural Research System (NARS) (URT, 2005b). Tanzanian NARS comprises public organizations such as the Department of Research and Development (DRD), Tropical Pesticides Research Institute (TPRI), Universities, Tanzania Forestry Research Institute (TAFORI), National Environment Management Council (NEMC), local government councils, NGOs and private sector that include crop research institutes for tobacco, coffee, and tea. According to COSTECH (2004), Sokoine University of Agriculture (SUA) is a close academic collaborator and partner that has currently been mainstreamed into the NARS and deemed a centre of research status with both national and zone mandates, including training of needed massive personnel, and conducting research appropriate to the farming community. The University of Dar es Salaam (UDSM), through Institute of Resource

Assessment contributes to agricultural research through training and collaborative research programs with other NARS institutions.

The future looks for harnessing Information Communication Technologies (ICTs) from what researchers have developed in their laboratories and kept in shelves, to the needs of end- users - farmers. The current trends of many farmers and other agricultural information users, frequent visits to research stations with specific technical and scientific queries, and increased use of the Question and Answer Service, indicate the value they now attach to information. This reminds providers for the need to put at farmers' disposal, more accurate and reliable information system (Nielinger, 2003).

2.4 Transfer of Innovations

The transfer of innovations has been an obligation of extension agents through extension services and packages they receive from the government and send to the clientele (farmers). The agricultural extension system in Tanzania has always been challenged with the task of transmitting agricultural innovations from the researcher to the farmers. The major role of extension system is therefore to facilitate such a link. This is viewed as a three-step-process passing scientific information in agriculture from the research scientist to the extension worker then to the participating farmer (Kirway *et al.*, 2003). For effective performance of extension worker it is imperative that he be conversant with the communities at both ends, which are the research and farming communities, he himself be a liaison between research and farmer for transfer of innovations from research centres to farmers and farmers to research centres, especially traditional and mechanical processes. A successful extension worker therefore needs to acquire the knowledge of better communication methods (Wambura, 1992).

The main problem on extension service provision in Tanzania is that, majority of smallholder farmers (55%) are not reached by agricultural extension services (Mwandry, 1992). That is why most farmers do not apply new technologies that are exhibited because extension agents do not reach every farmer at required time. However, a system of transfer of indigenous knowledge from older to young generations is well established and reinforced among farmers who since time immemorial have used localized out of school knowledge to solve most of their farming problems (Rogers, 1983). As a result, the names of different types of soils, indigenous soil quality indicators, uses of different shrubs, trees and grasses used as protectants have been adopted. Parents do incorporate the youth early at their tender age in their daily work programs provided they can perform physical work. Mbwana (1994) observed that in Tanzanian villages farmer to farmer contacts have served as an instrument of diffusing technological knowledge. However, Manda (2002) on the other hand noted that major negative aspect of farmer to farmer contacts in relation to information flow is that social and personal characteristics and lack of educated farmers hinders the impact especially in developing countries.

Dixon (2000) noted that initial transfer of knowledge is often rapid and can be achieved in an intensive training workshop where there is even distribution of leaflets, pamphlets, brochures and handouts. The implementation process is gradual and requires sustained, long term follow up. Inadequate follow up is the reason why many efforts to transfer technology fail. Dixon (2000) further noted that dissemination (transfer) speaks primarily to the process of knowledge transfer involving who, what, when, and how of moving ideas and information from the source(s) to intended recipient(s). Nevertheless, dissemination activities must be planned and conceived to reach the specific user for efficient and ultimate success.

According to Kirway *et al.* (2003), information technologies developed by scientists and transferred to farmers will trigger agricultural development (Fig. 1). The model assumes that farmers' problems identified by scientists can be solved by research organizations and their modern scientific approaches. In this model the role of agricultural research institutes and its researchers is to generate knowledge and technologies. After receiving knowledge from formal training or research institutes, the role of extension services is to handle the subsequent dissemination of technologies and to provide a link between researchers, policy-makers and farmers.

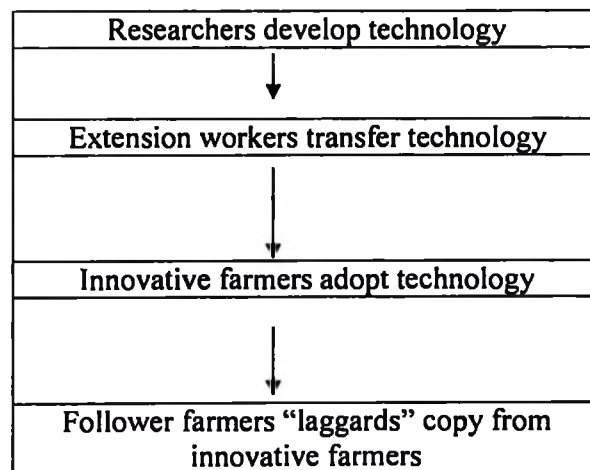


Figure 1: Conventional transfer of technology strategy
Source: Kirway *et al.* (2003).



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In order for extension agents to be effective channels for the diffusion of information, they must be aware of their clients' innovativeness. Farmers' attitudes towards dissemination institutions and trust in the institutions are some of the key factors in facilitating or hindering dissemination process (Meinzen-Dick *et al.*, 2003). The model assumes that once the innovators adopt new technologies, other farmers will learn from them and progressively adopt it. The model therefore does not really provide an opportunity for researchers, extension staff and farmers to work together.

Conventional approaches to technology transfer within small-scale farming systems, whether intended to increase productivity and/or address poverty, have generally failed (Kirway *et al.*, 2003; Hall *et al.*, 2004). Kapange (2002) noted that, the current research and extension system in Tanzania is mainly public funded, although, decentralizing and rightsizing the research establishment, has relieved the government's budget strain through complete privatization of major cash crops. Decentralization has put extension under local government authorities to enhance greater client participation in Technology Development and Transfer (TDT) and making these processes participatory as opposed to the previous, centralized top-down set up. It has in addition, brought closer research and extension to better serve the end-users. Public funded extension service, which is facing many challenges, has a declining public support due to financial crises; shift to private enterprises over government intervention as reflected in structural adjustment program; dissatisfaction with perceived lack of impact by agricultural extension. Participatory research and use of expert farmers and farmer research groups promise to partially replace, complement or at least, relieve the conventional extension system.

According to Hassan (2005), the linkage between the parts of technology generation and technology transfer in a national agricultural system often involves more than two partners. These include external linkage factors that are policy environment, technical assistance, public organizations, and the private sector/farmers. The internal linkage factors are institutional factors and operational linkage strategies. Most of the factors are linked among each other through a shared interest in national technology generation and transfer programs. The increasing orientation of agricultural research and extension efforts towards small farmers makes these activities focus more on regional problems at a grass-roots level. Extension on the other hand, should start from the stage of technology testing and continue until the innovation

has been adopted by the farmers. Technical linkage factors that could possibly be included under this category are: on-farm research and extension techniques (R & E); and farming systems research and extension approach (FR & E). The on-farm research and extension technique is an important linkage strategy to promote applied or adaptive research. It allows direct contact between the researchers, and the farmers. It also permits the participation of extension staff in field level research through implementing research surveys, conducting trials and integrating extension programs with on-farm research (Fig. 2).

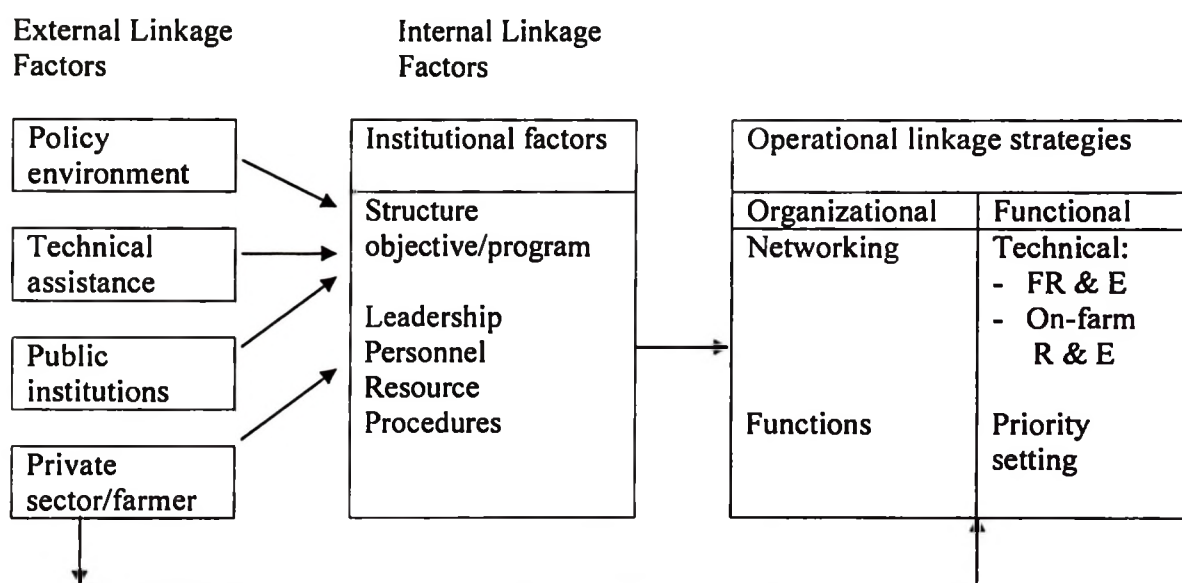


Figure 2: Research and extension linkage model for institutions

Source: Hassan (2005)

It can be concluded (Hassan, 2005) that, for agro technologies to be relevant to local needs, researchers, extension workers and farmers must play important roles in identifying research problems, adapting the recommendations to local conditions and providing feedback to researchers about the innovations that have been developed.

According to Kapange (2002) strong linkage between major institutional actors in agricultural knowledge and information systems has been given recognition as essential

for an effective flow of technology and scientific information between research, extension, and farmers. Information and Communication Technologies (ICTs) are crucial in facilitating communication and access to information for agricultural and rural development. Kapange (2002) further observed that quarterly and monthly training sessions at district level provide a leverage for farmers to send their research and extension needs through Village Extension Officers who attend the sessions. Agricultural shows, public demonstrations, and the fact that *Kiswahili* is one language spoken by all in Tanzania, add up to relative ease of dissemination. Zonal Communication Centers (ZCCs) are indeed, medium of excellence for disseminating research outputs to the grassroots clientele. With very few exceptions, agricultural research institutes in Tanzania are faced with limited effectiveness of information networks owing to poor telecommunications and information infrastructure, low level of information management skills, insufficient financial resources, and poor linkage to extension services and farmers.

According to Kapange (2002) and TCRA (2005), traditional broadcasting media still have the largest coverage to most people, particularly the disenfranchised rural communities, women and the youth and are a more cost-effective and appropriate medium for simple information dissemination. However, they lack interactive features and programmed choice is limited. Nevertheless, effective use of radio and TV broadcasting can meet a range of Information Communication Technology (ICT) applications beyond regular news and entertainment. These include community radio stations that broadcast information about food security and health, and the use of satellite broadcasting for distance education. Most such facilities are privately owned but a few are owned by local district councils, universities, churches or communities. The rational use of ICTs in extension services in Tanzania has enhanced the speed and delivery of information. However, standards for sharing and exchanging information and data need to be critically considered before every

district Agricultural and Livestock Development Office (DALDO) is provided with computers, faxes, photocopiers, and an email facility where there are points of Internet presence.

According to COSTECH (2004), access through mobile service has made communication by phone more available and affordable than fixed services due to the attractiveness of prepaid pricing, which is more convenient and appropriate to low-income users, who are the majority in Tanzania. Mobiles almost always have wider coverage than fixed networks; their coverage is growing faster, and increasingly they are reaching rural areas. Kapange (2002) noted that road shows can reach mass audiences of all incomes and age groups. *Jamii Yako* ('your community') is a program designed with the specific intent of reaching women to inform them about new products and technologies and get their feedback.

Furthermore, Kapange (2002) noted that NGOs have assisted researchers to identify and collaborate with particularly knowledgeable farmers; documenting and disseminating research findings; and facilitating exchange of information and ideas between groups. NGO research has been mainly applied and adaptive, reflecting determination for rapid and tangible results.

COSTECH (2004) observed that information and communication technologies (ICTs) have made it possible to cheaply access real-time information at high speed and over vast distances. This capability has affected the way researchers, extension workers and farmers conduct their work. When trained to use ICTs optimally, users are able to access and send information very quickly and connect with distant knowledge resources at low costs.

There is great potential in Tanzania to bridge the gap between the information haves and have-nots, particularly farmers.

2.5 Adoption/Rejection of Innovations

Feder *et al.* (1985) defined adoption as the degree of use of a new technology in a long run equilibrium when a farmer has full information about the new technology and its potential application. Nicolao (2003) observed adoption as the process through which an individual passes from first knowledge of innovation to forming attitude toward innovation to a decision of adopting or rejecting the implementation of the new idea and confirmation. The adoption process has been broken down into five stages as follows (Rogers and Shoemaker, 1971; Rogers, 1983): (1) awareness, (2) interest, (3) evaluation, (4) trial, and (5) adoption. Rogers (1983) further asserted that in the awareness stage "the individual is exposed to the innovation but lacks complete information about it". At the interest or information stage "the individual becomes interested in the new idea and seeks additional information about it". At the evaluation stage the "individual mentally applies the innovation to his present and anticipated future situation, and then decides whether or not to try it". During the trial stage "the individual makes full use of the innovation". At the adoption stage "the individual decides to continue the full use of the innovation". According to Rogers (1983) after the farmer has decided to adopt an innovation, only 2.5% are rapid innovators, 13.5% early adopters, 34% early majority, 34% late majority and 16% are the laggards. As it can be viewed, the adoption process is a systematic way before diffusion occurs (Fig. 3).

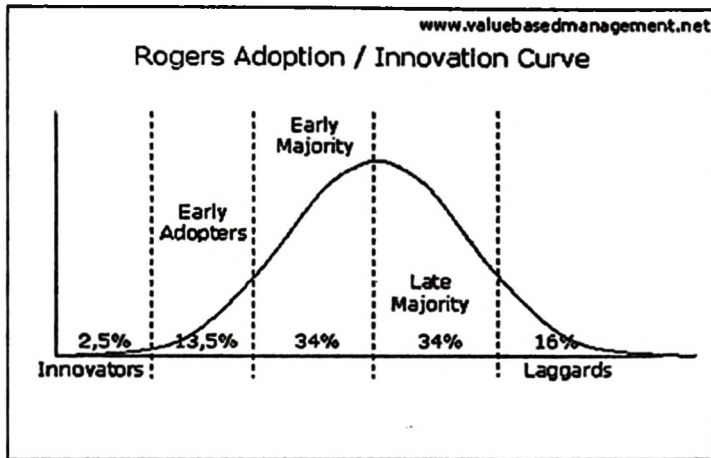


Figure 3: The Adoption process model

Source: Rogers (1983)

Nicolao (2003) observed that the extension service as an agency that communicates innovations must be cautious on the various factors that do affect the way innovations are finally accepted. According to Rogers and Shoemaker (1971) and Rogers (1983) the level of adoption of innovation depends on the following factors: (a) source of information; (b) intrinsic characteristics of information itself and its appeal to clients (complexity, probability, riskness, compatibility with other activities); (c) characteristics of the unit concerned (resources, size, type of activities, degree of specialization); and (d) preparation of innovation client. Utilization speaks primarily to purpose and to impact—why you want people to get the research outcomes you put forth, what use you want people to make of the ideas, information, or products, and how people are actually using them (Dixon, 2000). An innovation may be rejected during any stage of the adoption process (Rogers, 1983).

Rogers defines rejection as a decision not to adopt an innovation. Rogers (1995) observes that one of the greatest pains to human nature is the pain of a new idea and therefore acceptance of new ideas may face rejection, or after noting any difficulties and side effects. It makes you think that after all, your favorite notions may be wrong, your firmest

beliefs ill-founded. Naturally, therefore, common men hate a new idea, and are disposed more or less to ill-treat the original man who brings it. Similarly, rural people are less likely to resist adoption of an innovation when the new technique is based upon a concept or procedure they are already familiar with or are currently using. Rogers identifies two types of discontinuances: (1) disenchantment discontinuance - a decision to reject an idea as a result of dissatisfaction with its performance, and (2) replacement discontinuance - a decision to reject an idea in order to adopt a better idea. One must learn by doing the thing, though you think you know it, you have no certainty until you try. The relatively later adopters had twice as many discontinuances as the earlier adopters. Asina (1998) argued that some innovations are more rapidly adopted than others because the farmers perceive them to be better than conventional methods.

Fliegel (1993) argued 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 technology must be available. In order to change pre-existing understandings, groups or individuals first must recognize a certain "need." A reason has to be perceived in order to make a shift in thinking. Backer (1994) said that people and organizations develop the energy to change when faced with real pain. According to Rogers (1995), the decision to adopt usually takes time; some people are more conservatives, and hence they do not adopt at the same time. Final adoption is not always permanent one. Adoption decision almost always involves other individuals as sources of information.

Rogers (1995) recently presented four additional adoption/diffusion theories. Potential adopters of a technology progress over time through five stages in the diffusion process.

First, they must learn about the innovation (knowledge); second, they must be persuaded of the value of the innovation (persuasion); they then must decide to adopt it (decision); the innovation must then be implemented (implementation); and finally, the decision must be reaffirmed or rejected (confirmation). The focus is on the user or adopter. Individuals who are risk takers or otherwise innovative will adopt an innovation earlier in the continuum of adoption/diffusion. Rate of Adoption diffusion takes place over time with innovations going through a slow, gradual growth period, followed by dramatic and rapid growth, and then a gradual stabilization and finally a decline.

Rogers (1995) further notes that certain innovations will be adopted more rapidly than others if they have the following characteristics: that it can be tried out (trialability), that results can be observed (observability), that it has an advantage over other innovations or the present circumstance (relative advantage), that it is not overly complex to learn or use (complexity), that it fits in or is compatible with the circumstances into which it will be adopted (compatibility). Innovations are diffused more readily if individuals in the community perceive them as having greater relative advantage. Byakugila (2007) observed that choice of channels for communicating an innovation is a key to its successful diffusion. Most individuals evaluate an innovation on the basis of the experience of peers who have adopted it or people perceived as influential and not on the basis of scientific research by experts.

According to Perret and Stevens (2003) farmers cannot adopt technologies if they do not have all relevant information about the technology and what scope of return could be expected after adoption. Doss (2003) noted that farmers must have access to information about new technologies before they can consider adopting them. Since extension services are one of important means for farmers to gain information on new technologies, access to

extension is often used as a measure of access to information. For example, studies (NCDDR, 1996) often consider the number of extension visits received by the farmer, whether or not the farmer received any extension visits, or whether the farmer attended a field day. None of these measures captures whether the information was available to the farmer; instead, they indicate whether the farmer took advantage of the resources. Doss (2003) further noted that more rarely, an effort is made to look at the effectiveness of extension; for example, by measuring whether farmers are aware of the relevant recommendations. This measure actually captures both whether the information resources were effective and whether the farmer took advantage of them (Kapange, 2002).

Byakugila (2007) argued that some precondition factors for innovation adoption include: the policy environment, regulations, institutional support and outreach, farmers capacity for adoption of technology (i.e. the technology is easy to use), cost effectiveness (i.e. benefits of technology transfer exceed its cost), technology performance, and ownership by the end users. Byakugila (2007) further noted that some innovations relate to the community or individual, some of the situations community or individual is in, and some to the nature of the practice. Some innovations are subject to the control and manipulation of change methodology while others are not (Lionberger and Gwin, 1991). Rahm and Huffman (1984) found that farmers' education and experience played a crucial role in enhancing the efficiency of adoption decision. Tessmer (1990) stresses the need to analyze the environment in which the potential adopter is expected to use the technology. This process includes identifying the relevant physical and use characteristics of both the instructional situation and the support system. The approach is intended to ensure actual, correct and continual product use. Therefore adoption of an innovation does consider not only technological aspect of the innovation transferred, but also socio-cultural and socio-economic activities of the community (Tessmer, 1990).

Previous researchers (Rogers, 1995) had assumed that later adopters were relatively less innovative because they did not adopt or were relatively slow to adopt innovations. However, the later adopters may adopt, but then discontinue at a later point in time. Vanclay and Lawrence (1994) analyzed reasons for the failure of farmers to adopt new practices and revealed the following factors: i) complexity of the technology, ii) institutional factors, iii) conflicting information, iv) risk associated with the new techniques, v) implementation in terms of both capital outlay and intellectual outlay, vi) lack of flexibility, and vii) incompatibility with other aspects of farm management or farm objectives, physical and social infrastructure (farming subculture or farming style). Rogers (1983) defines an innovation as complex if it is difficult to understand and use. According to Rogers (1983) compatibility is the degree to which technology is consistent with values, past experiences and need of potential adopters. Byakugila (2007) emphasizes that factors affecting adoption of innovations can be grouped and referred to depending on the following: communication methods, technological pathway used, nature of technology, institutional factors, geographical and different socio-economic factors of the society.

Furthermore, Vanclay and Lawrence (1994) argued that some extension agents are reported to ignore aspects of social and cultural values (e.g. taboos and norms) of a particular society before communicating agricultural information. The failure to recognize and address the psycho-social component of technology adoption as part of education process has served to illustrate that generating knowledge is not always synonymous with diffusing and adopting knowledge (Rollins, 1993). In many cases there is low level of confidence in public agencies and officials, including those responsible for dissemination of agricultural technologies. Moreover government agencies sometimes pay insufficient attention to the role of women in agriculture and their specific extension needs.

Byakugila (2007) noted that there are insufficient continuous efforts to supply technologies that could be adapted with regard to prevailing environmental conditions. These make technologies less relevant to farmers to be adopted. Byakugila (2007) concluded that if the adoption of innovation does not provide a perceived advantage for some farmers, then it is unlikely to be robust. Research shows that many times technology that appears as a reasonable innovation for an extension agent is rejected by farmers not because of intrinsic quality of technology itself, but because of conflict with other elements of the farming system (CIMMYT, 1993). Also Asfaw and Admassie (2002) argue that there is a certain threshold age beyond which the ability of farmers to take risk and adopt innovations decreases. This means that the young farmers are more likely to face the risks associated with innovations (uncertainty in yield and unfamiliarity in technology) and to adopt them than their older counterparts.

2.6 Conceptual Framework for Analysis of the Study Data

The literature from the present Chapter has been reviewed from a wide perspective of grain storage protectant innovations. The reflections drawn in this review provides the basis for assessing the availability, transfer and utilization of grain storage protectant innovations in Tanzania. In the context of present study the purpose of which was to assess the availability, transfer and adoption of grain storage protectant innovations in Morogoro district, the conceptual framework shown in (Fig. 4) was developed.

This conceptual framework is for analyzing a large volume of data and is oriented towards establishing findings which fulfill the objectives of the study. It allows drawing implications on possible ways that would be used to improve the availability, transfer and utilization of grain storage protectant innovations in farming communities.

The conceptual framework suggests that the dependent variable poverty alleviation is influenced by farmers' background variables (personal and situational characteristics) and independent variables under availability of innovations from research, transfer and adoption/rejection of innovations by bettering farmers' livelihoods through improved food security in Tanzania. The definitions of key variables used are given in Appendix 3. The research methodology is presented in the following Chapter.

Background variables Independent variables Dependent variables

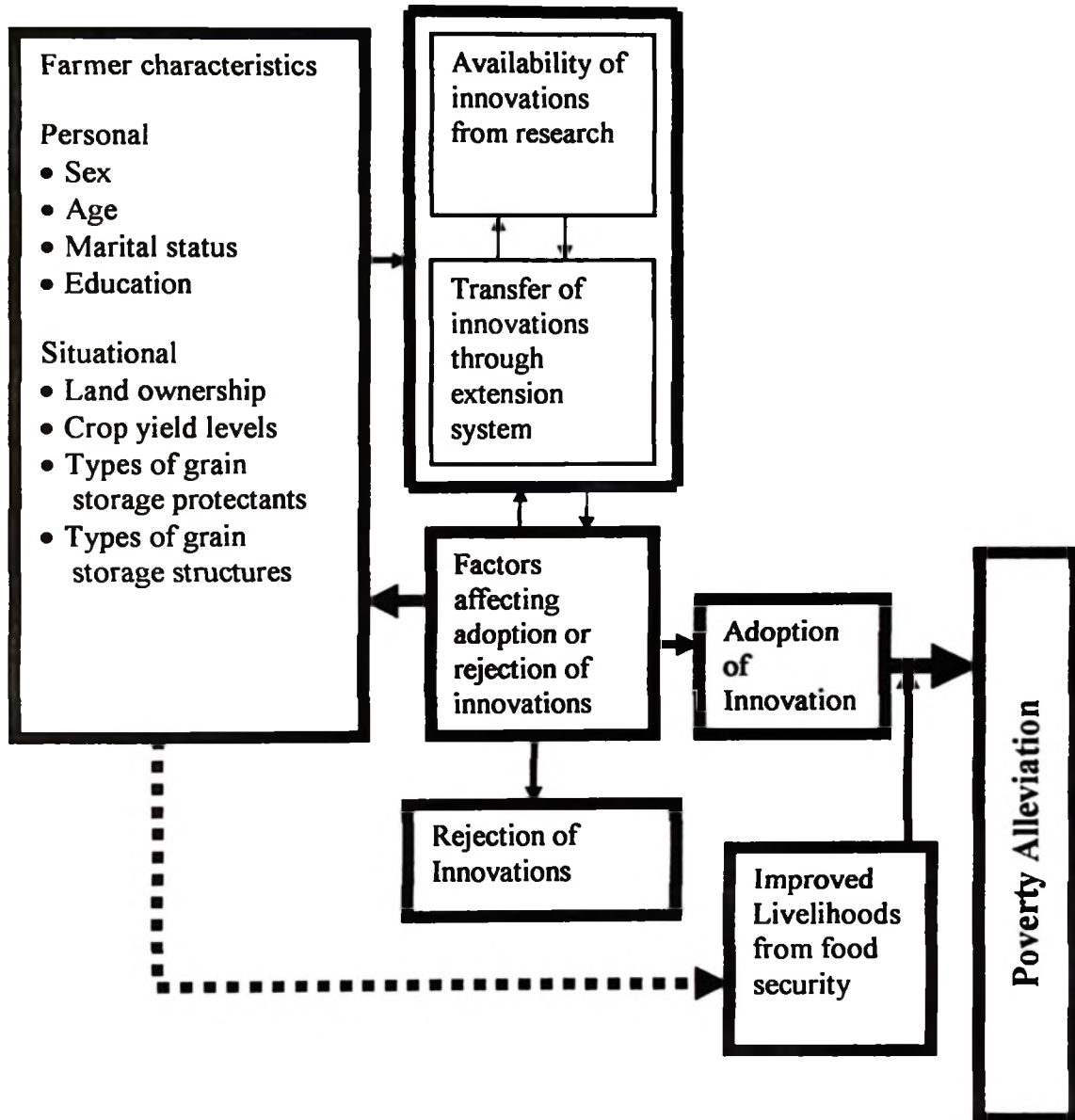


Figure 4: Conceptual framework for analysis of the study data: the availability, transfer and utilization of grain storage protectant innovations

Source: Research Study (2009)

Key: Relationship for primary analysis
 Relationship for secondary analysis

CHAPTER THREE

3.0 METHODOLOGY

3.1 Introduction

This study sought to assess the availability, transfer and utilization of grain storage protectant innovations in Morogoro district. This Chapter discusses the methodology adopted under seven parts: (a) study area, (b) study design, (c) sampling procedures, (d) sample size, (e) data collection instruments, (f) data collection procedures, and (g) data processing and analysis.

3.2 The Study Area

The study was conducted in Morogoro district in Morogoro region. The district was purposively selected basing on farmers being food grain producers, experience post harvest grain losses and do apply different kinds of grain storage protectants for controlling insects and rodents. The study took place in 4 villages in the district, namely: Kikundi, Mkambarani, Lubungo and Mkuyuni as shown in Appendix 2.

3.3 The Study Design

A case study cross-sectional design in which data were collected in one point at a time was adopted. The method is cheap, quick and effectively utilizes limited resources in terms of cash, labor, transport and time. The design is useful for descriptive purposes and the data collected is used to determine the relationship between different variables focused in the field of study (Babbie, 1990; Bailey, 1997).

3.4 Sampling Procedures

Sampling procedure involved multistage sampling technique. It mainly involved purposive selection of study area, villages and respondents based on availability, transfer and utilization of grain storage protectant innovations. This technique is convenient for a large sampling unit (Kothari, 2004). The technique was done under two main stages:

Stage 1: First sampling stage involved purposive selection of study area at regional, district, ward and village levels. There were 25 wards and 132 villages during the time of data collection for this study in Morogoro district. Each ward had more than 5 villages. Four wards (Mikese, Mkambarani, Mkuyuni and Kiroka) were purposely identified and in turn, one village was also purposively selected from each ward (Kikundi, Lubungo, Mkambarani, and Mkuyuni).

Stage 2: Second sampling stage involved selection of study respondents. A sample of 132 farmers was selected from the 4 selected villages. Purposive sampling and stratified sampling techniques were used to get the names of male and female farmer respondents from the corrected register of farmers from each of the 4 villages. The farmers were selected from each village from a list of farmers who in the village extension workers judgment were using grain storage protectants. Each of the selected villages had one extension agent who was involved in the study. The key informants (that is, essentially knowledgeable individuals who were in position to provide relevant information, ideas and insights on aspects related to grain storage protectant innovations) were selected using snowball technique. After interviewing a respondent, the study author asked him/her to recommend other respondents considered very knowledgeable about the study subject. In this way 16 respondents were identified and involved in the study.

3.5 Sample Size

Sample size of 152 respondents comprised of group of farmers, village extension agents and key informants. A summary of the distribution of all respondents involved in the study is given in Table 1.

Table 1: Distribution of all respondents (N=152) involved in the study

Type of respondent	Number		Total
	Males	Females	
Farmers	91	41	132
Extension agents	3	1	4
Key informants	11	5	16
Total	105	47	152

3.6 Data Collection Instruments

Data collection instruments used for the study were questionnaires, researcher's diary and checklist, as follows:

- (a) *Questionnaires*: Two types of questionnaires were used to collect primary data, namely: (i) farmers' questionnaire, and (ii) extension agents' questionnaire (Appendix 4 and 5). All the questionnaires were completed by means of personal interviews conducted by the author and two research assistants.
- (b) *Researcher's diary*: This was used to collect secondary data from relevant documentary sources including Internet websites, Sokoine National Agricultural Library (SNAL), district and village files, and observation of farmers activities related to grain storage protectant innovations.

(c) *Checklist*: This type of tool was used to collect primary data from key informants (Appendix 6) to supplement information gathered through researcher's diary and interview schedules.

3.7 Data Collection Procedures

Field work was conducted during the period of November to December, 2007. The permit for data collection was obtained from the District Administrative Secretary (DAS) for Morogoro district after getting an introductory letter from the Director of Research and Post-graduate Studies at Sokoine University of Agriculture (SUA). Much care and foresight were given to legitimizing the research in the eyes of the relevant village leaders, farmers as well as government officials in the district. This was first done by reconnaissance survey to allow the researcher orient and familiarize to the study area and then acquire general information on the availability, transfer and utilization of grain storage protectant innovations through directed discussions with farmers, village leaders and extension agents. The farmers' questionnaires were translated from English to Kiswahili then pre-tested among few farmers who were not involved as study respondents for reliability and validity, and then corrections and modifications were done accordingly.

Of the 160 interview schedules meant for farmer respondents, 132 were properly completed constituting a return rate of 83 percent. Likewise all the 4 (100 percent) interview schedules meant for extension agents were also completed. As far as possible, the interviews were conducted in private in farmers' farm environment and each lasted for about 30-40 minutes. When interview was completed in one village, the author moved to the next, usually spending about 4-5 days in each village. In addition, data were collected from the 16 key informants through directed discussions. The author also reviewed relevant information from the district agricultural files related to grain storage protectant

innovations. Furthermore, website from internet, Sokoine National Agricultural Library (SNAL), and Pest Management Centre (PMC) were rich sources of information for the study. Observations made on farmers activities related to utilization of grain storage protectant innovations in the sample villages were also recorded.

3.8 Data Processing and Analysis

3.8.1 Data processing

Data from the completed 132 farmers' interview schedules were coded for computer analysis. Each schedule had 57 variables. In addition, data from the bulky extension agents schedule, researchers' diary and checklists were summarized manually to single sheets of paper. In summarizing the data great care was taken to ensure that it accurately reflected the original meanings of the statements made.

3.8.2 Data analysis

Data from farmer interview schedules coded for computer analysis were analyzed using program from the Statistical Package for Social Science (SPSS). The method of analysis involved univariate and bivariate analysis. It used the technique of frequency counts, means and percentages. Furthermore, data processed from other sources were examined. Qualitative data were analyzed using "content analysis" technique which mainly involved transcription of recorded notebooks and then clustering information into sub-themes. Quantitative data were processed and analyzed to produce frequencies to facilitate assessment of the availability, transfer and adoption of grain storage protectant innovations in the study villages.

3.9 Limitations of the Study

- (a) Farmer respondents were involved in on-farm and off-farm activities which mostly took them far off the living areas. Since the interview was conducted during working hours (day time), when they were at work, the author had to either follow them in their working fields or reschedule the timetable for late hours in the evening at their leisure or resting time after work. This forced the researcher to use extra effort, energy and limited resources to proceed with research schedule.
- (b) Some respondents had problems with the names of protectants in Kiswahili; as a result some protectants were recorded in their vernacular languages and later translated in English.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Introduction

This Chapter presents the major results and discussion arising from the data analysis related to availability, transfer and adoption of grain storage protectant innovations in Morogoro district. These were discussed under three main sections. First section dealt with farmer respondents' characteristics. Second section focused on farmer respondents' opinions related to availability, transfer and adoption of selected grain storage protectant innovations. Finally, the third section dealt with extension agents' characteristics and their opinions on availability, transfer and adoption of selected grain storage protectant innovations.

4.2 Farmer Respondents' Characteristics

Farmers' characteristics were those personal and situational characteristics in farming which were expected to influence their adoption of grain storage protectant innovations. These characteristics were examined under two main parts. The first part under personal characteristics involved: sex, age, marital status and education level. The second part dealt with situational characteristics. Those examined were: area of farm owned; types of crops grown; levels of average grain crop yields; type of grain storage protectants used; and type of grain storage structures.

4.2.1 Personal characteristics

Among the more important personal characteristics dealt with in this part were: sex, age, marital status, and level of education. Examination of farmer respondents' sex revealed that 69% were males and females were 31% (Table 2). Further examination of farmer

respondents' personal characteristics is organized under headings: age, marital status, and level of education.

Table 2: Percentage distribution of farmer respondents (N=132) personal characteristics

Variables	Number	Percentage
Sex		
Male	91	69
Female	41	31
Age group		
18-30	58	44
31-50	37	28
51-65	25	19
> 65	12	9
Marital status		
Married	94	71.2
Single	17	12.9
Divorced	4	3
Widow	17	12.9
Education level		
None	37	28
Primary	91	69
Secondary	4	3

(a) Age

The age distribution of farmer respondents was between 18 and 65 years. The majority (72%) were below 50 years of age, this is the active and working group as shown in Table 2. However, the results suggest that, in general, the study respondents were drawn from different age groups of farmers in the villages.

(b) Marital status

It was expected that marital status of farmer respondents would influence adoption of grain storage protectant innovations. The farmer respondents' marital status is given in Table 2. Data in Table 2 show that the majority (71.2%) of the respondents were married. This is more likely to positively affect their participation in grain storage protectant practices where innovation can easily be carried out by a couple, and readily implemented by one in the absence of the other.

(c) Level of education

It was assumed that the extent to which farmers were educated would tend to influence their ability to gain knowledge. This may also affect their participation in the utilization of grain storage protectant innovations. The farmer respondents were therefore asked to indicate their level of education, as given in Table 2. The data show that 72% of the farmer respondents had attained level of formal education. This is a reflection of Tanzania's universal primary education. Thus implying that farmer's level of education was not an important criterion in adoption of grain storage protectant innovations.

4.2.2 Farmer respondents' situational characteristics

The situational characteristics examined involved factors related to: (a) land ownership; (b) levels of average crop yields; (c) types of grain storage protectants used; and (d) types of grain storage structures used.

(a) Land ownership

It was expected that the total number of acres owned by the farmers would influence the adoption of grain storage protectant innovations. The farmer respondents were therefore asked to indicate the size (acreage) of private farm that they own in their villages. The results revealed that farm size of the respondents ranged from 2 to 5 acres, giving an average of 2.5 acres per farmer. The farmer respondents' farm size lies in between the Morogoro district farmers' acreage farm size which ranges from 1.25 to 5 acres (Mohamed and Teri, 2002) and the average farm size is slightly lower than that of Morogoro region and the country which has been reported (URT, 1997) to be 3 acres. This implies that the farm size situation of study respondents was not different from that of smallholder farmers in the country.

(b) Levels of average crop yields

The general yield levels of major grain crops (maize, paddy, sorghum and beans) for 2006/2007 from the study villages given by the farmer respondents are indicated in Table 3. The data in Table 3 show that on average the study respondents do store more grain crop yields (52.5%) compared with what they sell (47.5%). The data further show that more than 50% of farmers maize and sorghum grain produce (64 and 76 percent respectively) compared with paddy (45 percent) and beans (25 percent) are stored and the rest is used as source of income. This implies that different crop produces need grain storage protectants at various levels.

Table 3: Levels of farmer respondents (N=132) 2006/2007 crop yields by percentage sales and storage

Types of crops	Yields kg	Sales percent	Storage Percent
Maize	106 631.25	36	64
Paddy	17 923.13	55	45
Sorghum	4 537.5	24	76
Beans	8 456.25	75	25
Average	34 387.03	47.5	52.5

(c) Types of grain storage protectants used

The level of technology of grain storage protectants used was considered to be key factor in reduction of food security in the study area. The farmer respondents were asked if they were using any particular types of grain storage protectants. The percentage of farmer respondents who indicated that they use particular types of grain storage protectants is given in Table 4. The results from Table 4 indicate that in general more than 50% of the farmer respondents use at least one particular type of grain storage protectant. It was further noted that 100% of farmer respondents used to dry the grains. This is because sun drying is a natural and easy practice done by all farmers as a necessary method of preparing any grains before storage. In addition, by super shumba (10%) was least utilized because it was not so familiar to the farmer respondents. However, the results generally imply that farmers utilize different types of the grain storage protectants in the study area at difference levels.

Table 4: Number and percentage distribution of farmer respondents (N=132) using particular type of grain storage protectants

Type of grain storage protectants	Farmer respondents	
	Number	Percent
Traditional pesticides		
Neem	70	53
Ash	83	63
Synthetic pesticides		
Actellic super dust	95	72
Actellic 50 Ec	25	19
Super shumba	13	10
Mechanical processes		
Steel drum	41	31
Sun drying	132	100

(d) Types of grain storage structures used

The type of grain storage structures used was considered to be key factor in grain loss reduction for food security in the study area. The farmer respondents were asked if they were using any particular types of grain storage structures. According to Table 5 the distribution of number and percentages of types of storage structures by the farmer respondents indicate that each of them at least used either traditional or improved storage structures. It was further noted that the sulphate bags were found to be used by all of the farmer respondents (100%) compared other traditional storage structures. This would imply their availability at the cost that farmers could afford. However, the sulphate bags are weak structures that cannot offer an effective protection against storage pests.

Table 5: Number and percentage distribution of farmer respondents (N=132) using particular type of grain storage structures

Type of storage structures	Farmer respondents	
	Number	Percentage
Traditional structures		
Ceiling under roof	4	3
Tying and hanging	8	6
Clay pots	4	3
Sulphate bags	132	100
Improved structures		
Reed granary	17	13
Steel drums	41	31

The results from Table 5 further show that the use of steel drums as air tight devices was mentioned by 31% of the respondents. However, they were found to be too expensive for small holder farmers to afford. Reed granary which is effective against rodents if it is accompanied with rat guards was mentioned by 13% of the farmer respondents. In general these results show that the farmer respondents were using both traditional and improved grain storage protectant structures at different levels.

4.3 Farmer Respondents' Opinions on Availability, Transfer and Adoption of Selected Grain Storage Protectant Innovations

4.3.1 Introduction

This part will be discussed under the following sections: availability of grain storage protectant innovations to the extension service; nature of farmers' advice and adoption of grain storage protectant innovations; and factors contributing to success or failure of grain storage protectant innovations.

4.3.2 Availability of selected grain storage protectant innovations to the extension service

The study sought to find out whether there are recommended innovations to extension services for grain storage in Morogoro district. The results from district official record files revealed that there are innovations that have existed since colonial times. The major sources of such innovations were Sokoine University of Agriculture (SUA), Department of Research and Development (DRD) of Ministry of Agriculture and Food Security (MAFS), Tropical Pest Research Institute (TPRI), and other research institutions. Table 6 gives indication of existing innovations in the district available to the extension service.

Table 6: Existing innovations by type of grain crop in Morogoro district

Type of innovation	Type of crop			
	Maize	Paddy	Sorghum	Beans
Use of traditional pesticides				
Neem	X ^a	- ^b	X ^a	X ^a
Ash	X ^a	- ^b	X ^a	- ^b
Use of synthetic pesticides				
Malathion	X ^a	- ^b	- ^b	- ^b
Actellic super dust	X ^a	- ^b	X ^a	- ^b
Actellic 50 Ec	X ^a	- ^b	- ^b	- ^b
Super shumba	X ^a	- ^b	- ^b	- ^b
Use of mechanical processes				
Steel drum	X ^a	X ^a	- ^b	- ^b
Sun drying	X ^a	X ^a	X ^a	X ^a

X^a Available innovations

-^b Unavailable innovations

It was also observed that available grain storage protectant innovations had been organised into specific recommendations for extension agent to transfer and for the farmer to use.

The recommendations have been organized in operations under three main categories as follows: (a) use of traditional pesticides, (b) use of synthetic pesticides, and (c) use of mechanical processes.

(a) Use of traditional pesticides

Traditional pesticides are natural in origin that are found locally or have been brought from other places. They are expected to remain in their natural form or slightly modified before utilization. The existing specific recommendations on traditional pesticides were two main categories, namely: neem (*Azadirachta indica*); and ash.

(i) Neem (*Azadirachta indica*)

Neem can be used to protect insects acting on maize, sorghum and beans as indicated below:

- (1) *Maize*: Strip leaves off the twigs and branches of neem tree ready for normal drying for 30 minutes on hot sun shine hours then place them under shade for gradual drying till they become dry. Apply half a kg of dried neem leaves to the 25 kg of maize grain; then slowly add 25 kg second, third up to fourth times to make 100 kg of maize grain, lay neem leaves between every 25 kg of maize grain accordingly. The grain will stay for 6 months without any damage.
- (2) *Sorghum*: Take fresh neem seeds and leaves then dry them thoroughly in hot sun shine hours, lastly pound them to give powder, eventually mix 1 kg of neem powder with one bag (90-100 kg) of sorghum.
- (3) *Beans*: Pound 1 kg of fresh neem leaves, and then soak in 1 litre of water. Take 600cc from the solution and spray to 20 kg of beans.

(ii) Ashes

Ashes originating from different source of plants including maize cores, milk bush (*Euphorbia tirucalii*), and other tree plants are used to control insects acting on maize and sorghum.

- (1) *Maize*: Mix 20 kg of ash from maize cores thoroughly with maize or add to the stored maize in various layers, starting from the bottom of storage device to the top of the heap or sack accordingly. Or use a beam or weighing balance by taking 3 kg of ash then mixing to every 10 kg of maize grains.
- (2) *Sorghum*: Apply one tea-cup full of milk bush (*Euphorbia tirucalii*) ash to protect one tin of sorghum grains.

(b) Use of synthetic pesticides

The specific recommendations on synthetic pesticides found at the district office included: malathion 57 Ec, malathion 1%, actellic super dust, actellic 50 Ec, super shumba.

(i) Malathion

Malathion as a synthetic pesticide is divided into two categories according to concentration that are Malathion 57 Ec (57%) and Malathion 1%. Both categories of malathion act against insects damaging maize grains as follows:

- (1) *Maize*: Take 1-100cc of Malathion 57 Ec (57%) mix to 40-4000cc of water then spray to 160kg-15 tonnes of maize as shown below;

Malathion	Water	Maize
1cc	40cc	160 Kg.
10cc	400cc	1.5 tonnes
100cc	4 000cc	15 tonnes

In case of Malathion 1% mix 110 g with one sack of maize weighing 90-100 kg to prevent various insects including Larger Grain Borer (LGB). This will protect grains without any insect attack for 2-3 months.

(ii) Actellic Super Dust (ASD)

(1) *Maize*: Spread one packet of ASD of 100 g on top of 100 kg of maize grain; by use of spade mix the protectant with the grain thoroughly by shifting grain from one side to another making a complete mixture; pack the grain ready for storage. The grain can also be stored in granary without packing in sacks.

(2) *Sorghum*: Mix Actellic Super Dust at the ratio of 100 g to 100 kg of sorghum.

(ii) Actellic 50 Ec

Liquid actellic 50 Ec has been found acting against maize insect pests.

(1) *Maize*: Mix 100-150cc of actellic 50 Ec to 1 liter of clean water then the mixture is sprayed to 10 bags of maize.

(iii) Super Shumba

Super shumba dust has been found acting well against maize insect pests.

(1) *Maize*: Mix 50 g of Super Shumba with 90 kg of maize. Sometimes the drugs are packed at weight of 200 g this is enough to be mixed with 4 bags of maize grain weighing 90-100 kg each.

!

(c) Use of mechanical processes

Mechanical processes ever used involve: use of air-tight devices that do not allow moisture, water or air entrance during storage of grains; and processes that neither need synthetic pesticides nor traditional protectants utilization. The prominent device ever used

is empty sealed oil steel drum. Before the grains are stored in the mechanical devices, they have to be dried thoroughly in order to prevent growth of moulds and expel pests in grains. Thus sun drying is a very important process.

(i) Steel drum

(1) *Maize*: Fill the empty steel drum to the top with well winnowed maize grains leaving no space for insects to play in or freely move around. Lastly close the drum tightly with lid to prevent any flow or entrance of air, moisture and insects. The grain will remain safe to the time is required for utilization.

(2) *Paddy*: Fill the empty steel drum to the top with paddy already removed from their panicles. Then close the drum tightly with lid to prevent any kind of moisture. The grain will stay safe for more than six months.

(ii) Sun drying

Sun drying is the traditional method used by small farmers for reducing the moisture content (MC) of grains (maize, paddy, sorghum and beans in this study) by spreading the grains to the sun exposure. The sun heats up the grains and also the surrounding air. This causes the water to evaporate from the grains. There is a slight difference of drying practice from individual grains depending on the weather, the thickness of the grain layer, and the amount of stirring as follows:

(1) *Maize*: Tie harvested maize cobs by their sheaths into small bundles and hung on trees or exterior house rafters to dry. Alternatively, spread shelled maize no more than 5 cm deep on the plastic sheet, mats or well compacted ground in hot sunny shine for 3 hours daily after harvest to dry completely. Rake the maize from side to side while it is drying. Do not allow night dew or mist and rainfall to fall on the maize. Either cover the maize or put it inside the house at night or during showers.

- (2) *Paddy*: Essentially, spread the paddy out in sufficiently thick layers ideally 2-4 cm, raking the grain to mix it continuously. In addition, turn or stir the grain at least once per hour, better every 30 minutes to achieve uniform moisture content. Cover the grain at mid-day to prevent over-heating that can raise the grain temperature above 50-60°C on hot days. Cover the grain immediately if it starts raining. Prevent contamination of grain with other materials and keep animals off the grain.
- (3) *Sorghum*: Stack bundles of sorghum panicles in the field and allow them to dry in the sun. Alternatively, keep off the ground grain on the sorghum panicles or threshed ones on raised platforms, mats, or trays whilst it is being dried in open hot sun shine hours.
- (4) *Beans*: Spread the bean grains out in a shallow layer on the ground for sun exposure for 3-6 hours depending on the weather, the thickness of the grain layer, and the amount of stirring for good drying results. Do not prolong drying as this can induce a hard-to-cook condition.

These results may be evidence that district agricultural offices have access to information about grain storage protectant innovations from research stations. However, the study does not provide clues about effective linkage between research and extension service with regard to grain storage protectant innovations. Evidence suggests that available synthetic pesticide recommended grain storage protectant practices appear to be more simplified and therefore easily usable by the extension service. The traditional and mechanical processes recommended grain storage protectant practices are, however, complex and not so easily understood by the farmers, let alone the extension workers. It would appear that the elaborateness of recommended synthetic pesticides grain storage protectant practices reflects the fact that modern pesticides have much been researched upon. On the other hand, lack of refineness of traditional and mechanical processes grain storage protectant

practices is a reflection of the extent of research that has been done, particularly in relation to farmer-oriented grain storage protectant practices.

4.3.3 Farmers perceptions on extension methods used to disseminate recommended grain storage protectant innovations

Based on the list of grain storage protectant innovations identified in Table 6, the study sought to determine the way farmers are advised by field extension agents, the extent of advice and the degree farmers adopt the recommended practices for grain storage. The four selected grain crops are fairly predominant in the study area and are well served by extension service. The following aspects are addressed under this part: (a) extension methods used (b) extent of emphasis on storage of different types of grain crops (c) extent of use of recommended grain storage protectant practices and (d) farmers' degree of innovativeness.

(a) Extension methods used

An attempt was made to identify extension methods frequently used by field extension agents in advising farmers with regard to recommended grain storage protectant practices for selected grain crop storage. Three categories of methods (individual, group and mass) were used to solicit farmers' responses. Their views expressed in percentages of respondents are given in Table 7. The results in Table 7 show that, on average, 13 percent of the farmer respondents identified group method as a more frequently used extension method. Individual method was identified by 10 percent of the respondents while mass method was identified by only 8 percent. Generally the results revealed that group extension method was more frequently used followed by individual and mass methods as the least frequently used. These results might be a reflection of Tanzania policy which provides priority in terms of government support, including extension services to farmers

groups rather than individuals. This in turn requires group organization and group decision-making which can result only from meetings and other group activities.

Table 7: Percentage distribution of farmer respondents' (N=132) perceptions on extension methods frequently used in relation to recommended grain storage protectant practices

Recommended grain storage protectant practice	Extension method used		
	Individual (%)	Group (%)	Mass (%)
Use of traditional pesticides			
Neem	22	19	6
Ash	9	28	3
Use of synthetic pesticides			
Actellic super dust	9	9	16
Actellic 50 Ec	9	6	16
Super shumba	9	9	16
Use of mechanical processes			
Steel drums	6	9	0
Sun drying	9	13	0
Average	10	13	8

However, it appears that individual method and group methods were prominently used in relation to uses of neem and ash, respectively, which are traditional pesticides. This may be partly explained by the procedure used in preparation and use of traditional pesticides. This procedure provides farmers with [!]suitable opportunity to access and interact with field extension agents. Thus the results show that there are grain storage protectant practices in which more frequent use of individual and group methods are inevitable. Individual approach is more expensive in terms of time and finances consumption, in comparison to

group method; however they were both preferred by the farmer respondents as easy way of communication for elaboration of innovation. Finally, mass method seems to be important in relation to use of synthetic pesticides as compared to other recommended practices. This could be partly due to its characteristics of wide coverage to reach the audience and efforts made by the government to create public awareness on the use of synthetic pesticides in Tanzania

(b) Extent of emphasis on storage of different types of grain crops

The study sought to test the generally held view that extension workers tend to put emphasis, in terms of time spent, on advising farmers on synthetic pesticides grain storage protectants rather than traditional and mechanical processes. In order to test this, farmer respondents were asked to indicate whether extension workers spent more time in advising farmers on storage of grain crops in relation to some selected grain storage protectants. The results are summarized in percentages of respondents as given in Table 8.

The results in Table 8 show that, on average, greater emphasis by way of advice given to farmers by field extension workers was put on use of synthetic pesticides than use of traditional pesticides and mechanical processes. Specifically, 100% of the farmer respondents indicated that field extension agents spend more time in advising farmers on use of Actellic Super Dust as a synthetic pesticide for maize storage. However, it appears that field extension agents put relatively less emphasis in advising farmers about use of traditional pesticides when compared to other selected grain storage protectant practices. This may be due to the fact that methods employed in the use of synthetic pesticides are simple compared to traditional pesticides and mechanical processes.

Table 8: Percentage distribution of farmer respondents' (N=132) perceptions on extent of emphasis given to storage of different types of grain crops

Recommended grain storage protectant practice	Type of crop stored			
	Maize (%)	Paddy (%)	Sorghum (%)	Beans (%)
Use of traditional pesticides				
Neem	19	0	9	6
Ash	10	0	16	13
Use of synthetic pesticides				
Actellic Super Dust	100	0	9	0
Actellic 50 Ec	56	0	0	0
Super shumba	44	0	0	0
Use of mechanical processes				
Steel drum	31	28	16	16
Sun drying	56	28	16	16
Average	45	8	9	7

(c) Extent of use of recommended grain storage protectant practices

The study sought to determine the extent of use of recommended grain storage protectant practices by farmers. Data on this aspect constituted the perceptions of farmer respondents about the use of recommended grain storage protectant practices by farmers. Their views expressed in percentages of respondents are given in Table 9. The results from Table 9 indicate that the farmer respondents felt that grain storage protectant practices were generally in use for all the crops at different levels with more farmers relying on mechanical processes and traditional pesticides. This observation is rather surprising in light of the fact that synthetic pesticides have been advocated for years in Morogoro district. One possibility is that synthetic pesticides grain storage protectant recommended practices, over the years, have been reduced to mere slogans due to shortages or lack of

inputs and supplies associated with some of the recommendations. Consequently, farmers have, in some cases, had to rely on traditional ways or mere past experience in protecting their crops.

Table 9: Percentage distribution of farmer respondents' (N=132) opinions on the extent use of recommended grain crop storage protectant practices

Recommended grain storage protectant practice	Type of crop			
	Maize (%)	Paddy (%)	Sorghum (%)	Beans (%)
Use of traditional pesticides				
Neem	41	0	9	3
Ash	56	0	16	13
Use of synthetic pesticides				
Actellic Super Dust	59	0	9	6
Actellic 50 Ec	19	0	0	0
Super shumba	9	0	0	0
Use of mechanical processes				
Steel drum	25	28	16	13
Sun drying	100	28	16	13
Average	44	8	9	7

(d) Farmers degree of innovativeness

It was felt that a measure of farmers' degree of innovativeness would provide some indications of the extent to which the farmers utilized recommended grain storage protectant practices for decreased grain loss in the study villages. Three elements of the adoption process namely: knowledge, trial and adoption were chosen in this case. By use of questions posed to farmers it was possible to determine their degree of innovativeness

in terms of extent they had performed in respect to the three elements. The results are given in Fig. 5:

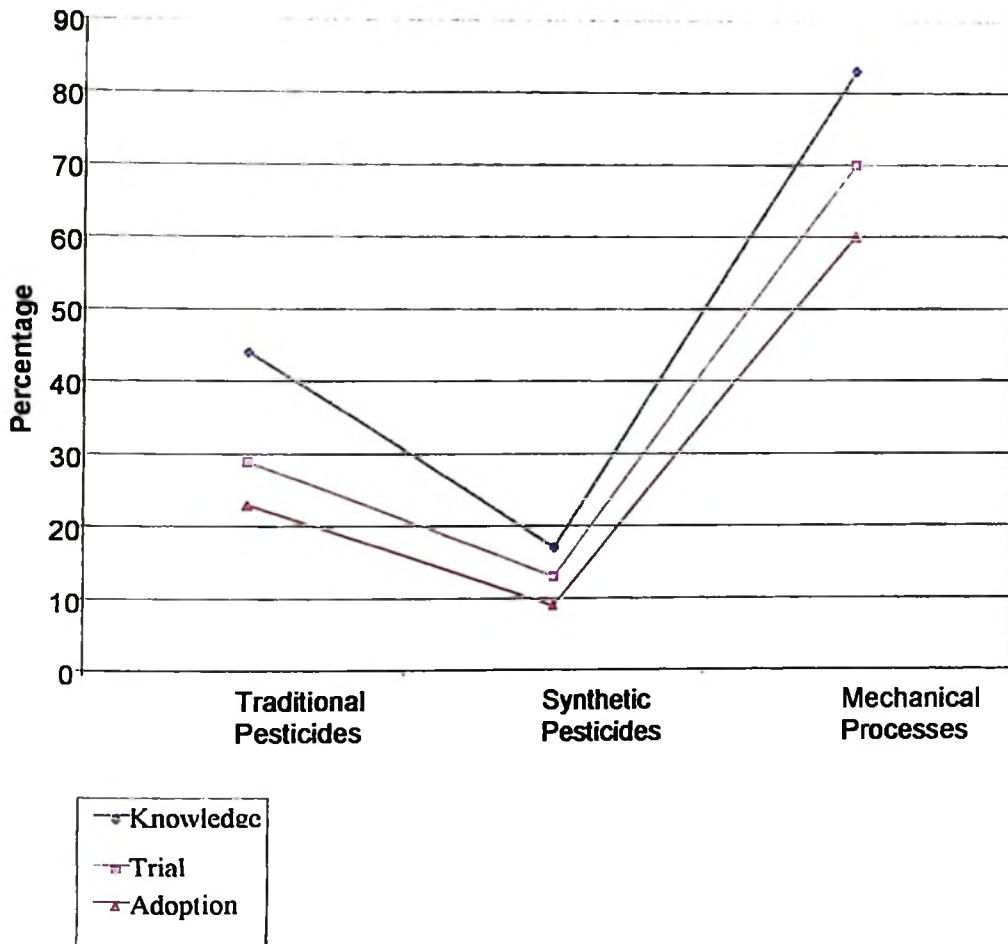


Figure 5: Distribution of three measures of innovativeness

According to (Fig.5), a number of observations can be made. Firstly, the level of knowledge acquired by farmers was generally higher than the extent to which trial and adoption were reached. This observation is in line with the principles of adoption process which portray human beings as progressing from initial stage of awareness through interest, evaluation and trial before adopting an innovation. In this case therefore one is likely to expect progressively more farmers in the knowledge category than in the trial and adoption categories.

These results indicate that the data bear a relationship with what is already known about the adoption process. The implication that may be drawn from these results is that the successful motivation of farmers is a culmination of series of distinct phases. These involve awareness of a new opportunity, generation of interest in it, consideration of its suitability, its trial examination and finally its adoption in grain storage protection practices. Each group of farmers and each phase of adoption tends to require a particular behavior and rejection can occur at any time. Good field extension workers will therefore adjust their approach to farmers in light of this sequence. That is, field extension workers always need to first learn what stage of adoption process farmers are in. Based on this, they can then operate in accordance with the stage reached. In this way the field extension workers may communicate to farmers at different levels.

4.3.4 Reasons for farmers' rejection of recommended grain storage protectant practices

It was felt that an understanding of farmers' reasons for rejecting recommended grain storage protectant innovations would provide some clues on the extent of acceptance or rejection of recommended grain storage protectant innovations. Five intrinsic characteristics of innovations to farmers were used. Farmers' responses to structured questions involving these characteristics were analyzed. The results are summarized in percentage of respondents of the recommended grain storage protectant practices for stored grains as shown in Table 10.

Table 10: Percentage distribution of farmer respondents' (N=132) reasons for rejecting recommended grain storage protectant practices

Recommended grain storage protectant practice	Reasons of rejection				
	Practices previously used are better (%)	Inconsistence with past experience (%)	Difficulty in technology (%)	Not easily triable (%)	Not easily observable (%)
Use of traditional pesticide					
Neem	0	0	30	0	60
Ash	0	0	60	0	30
Use of synthetic pesticides					
Actellic Super Dust	60	60	90	0	0
Actellic 50 Ec	90	60	30	0	0
Super shumba	60	60	30	0	0
Use of mechanical processes					
Steel drum	0	0	0	0	30
Sun drying	0	0	0	0	0
Average	30	26	34	0	17

The results in Table 10 show that on average there are only a small proportion of farmers rejecting recommended grain storage practices with regard to each of the intrinsic characteristics of innovations. The results further reveal that the previously used practices

for grain storage were better than recommendations regarding use of the synthetic pesticides. This means that the recommended practices are not perceived to have obvious advantages over the old and therefore have less relevance to needs of farmers in their prevailing situations.

The study results also reveal that farmers failure to use synthetic pesticides for grain storage is due to such recommendations being inconsistency with past experience and technologically complex. This means that the use of synthetic pesticides is not compatible with values and norms of farmers' social system. This may be the reason for some farmers not having bothered to incorporate the use of synthetic pesticides in their grain storage system. On the other hand, farmers feeling that the use of pesticides for grain protection practices was technologically complex in grain storage would mean that recommended use of synthetic pesticides requires them to develop new skills and understanding. Considering the low level of knowledge on farmers' part, it appears that use of synthetic pesticides is not readily understood by some farmers and therefore it is most likely to be accepted more gradually.

These results may generally imply that various characteristics of innovations such as: relative advantage, compatibility and observability appear in this study to contribute to different rates of acceptance or rejection of grain storage protectant innovations.

4.4 Extension Agent Characteristics and Their Opinions on Availability, Transfer and Adoption of Selected Grain Storage Protectant Innovations

Features related to village extension agents and their job performance was examined in order to ascertain their extension strategy in farmers' grain storage protectants practices. These features are now presented under: extension agent personal characteristics;

extension methods used to disseminate selected grain storage protectant innovations; importance and use of information sources; and factors contributing to success or failure of transfer and adoption of grain storage protectant innovations.

4.4.1 Extension agents' personal characteristics

Personal characteristics were expected to influence village extension agents' performance in extension activities at village level. Among the more important personal characteristics dealt with in this part are gender, age, marital status, education level, personal experience of working in villages. Of the four village extension agent respondents, three were males and one was a female. Their age distributions were between 48 and 58 years. Their field experience ranged from 20 to 35 years and all of them were married. It was also noted that of the four extension agent respondents, 3 who formerly belonged to the Ministry of Water and Livestock Development, and one the Ministry of Agriculture, Food Security and Cooperative had been shifted to Ministry of Regional Administration and Local Government. All the respondents had attained a secondary education, one had a certificate in Agro-vet, and each of the other three had diploma; one in animal health, the other in animal production and the remaining in crop production.

In addition, all the extension agent respondents stated that they attended in-service training courses organised by DALDO's office and various organizations, such as: FAO, JICA and NGOs. One of the in service training courses was training of trainers (ToT) on Farmer Field schools (FFS) which basically deals with pest management. This implies that they had knowledge on grain protection since one of the components of FFS generally deals with plant protection. However, in-service training is more highly needed for all of the extension agents to orient them on grain storage protectant practices, build more of their capacity and increase their competency in this discipline. In view of the fact that grain

storage protectant innovations have been changing with changing technology, there is a need for every extension worker to undergo continuous process of renewal, by attending on regular basis, refresher courses and other professional programs.

4.4.2 Extension methods used to disseminate recommended grain storage protectant practices

An attempt was made to identify the extent to which the selected extension methods were used by village extension agent respondents with regard to dissemination of the specific recommended grain storage protectant practices for the main grain crops. These practices were: (i) use of traditional pesticides; (ii) use of synthetic pesticides; and (iii) use of mechanical processes. Two categories of methods (individual and group) were examined. Individual extension methods were further considered under farm/home and office visits; while group extension methods included farmer field schools, demonstrations and group meetings. The responses of village extension agent respondents' ratings who indicated that they used particular extension methods for each grain storage protectant practice are given in Table 11.

The data in Table 11 indicate that the most frequently used individual extension method was farm and home visits. On the other hand, the most frequently used group extension method was group meetings. Generally, the results reveal that group method was most frequently used. Specifically, it appears that group method was rated by three out of four extension agent respondents in relation to use of ash, Actellic super dust and sun drying. In addition, the results indicate that three out of four extension agent respondents made use of individual extension method in promoting practices such as use of ash and sun drying.

Table 11: Distribution of village extension agent respondents (N=4) using particular extension methods for communicating recommended grain storage protectant practices to farmers

Recommended grain storage practice	Type of extension method				
	Individual		Group		
	Farm/home visit	Office visit	FFS	Demonstrations	Meetings
Use of traditional pesticides					
Neem	XX*		X	X	XX
Ash	XXX	X	X	XX	XXX
Use of synthetic pesticides					
Actellic super dust	XX	X	X	XX	XXX
Actellic 50 Ec	X		X	XX	X
Super shumba	X		XX		XX
Use of mechanical processes					
Steel drum	X		X		X
Sun drying	XXX	XXX	XXX		XXX

X* Frequency of extension agent respondents' responses

Overall, the data in Table 11 show that in general village extension agents used a combination of extension methods in promoting particular grain storage protectant practices. The focus on extension intervention was on farmer groups and individual farmer. This suggests that they supplemented group extension methods with individual extension methods which enabled them to respond to individual farmers concerns and problems.

4.4.3 Importance and use of information sources

It was felt that understanding the village extension agents' efforts in contacting farmers and other individuals or groups for information, within and outside the villages in which they worked, would provide some indication of how they updated their knowledge related to the job of extension agent. The village extension worker respondents were, therefore, requested to give their opinions on the types of selected personal information sources they considered important for their work. They were also asked to rank these information sources according to their level of importance. The extent of use of these information sources was measured by the level of village extension workers contact with different groups/persons that were in position to provide information related to extension. The results on the level of importance of the information sources are shown in Table 12.

Table 12: Village extension agent respondents' (N=4) ratings of the importance of particular types of information sources

Type of information source	Extension agent respondents rating		
	Important	No opinion	Not Important
Farmers	XXXX*		
SUA staff	XXXX		
Fellow extension agents	XXXX		
DALDOs SMS	XXXX		
Other village professionals	X		XXX
Research staff	XXXX		

X* Frequency of extension agent respondents' responses

The data in Table 12 show that all the four extension agent respondents perceived farmers who are rich in indigenous knowledge as being important information sources. In addition, all the other information sources were also perceived by all the respondents as being

important except other village professionals (extension agents from other sectors) who were perceived by only one extension agent respondent. This is expected, for example, the other three extension agent respondents might have had no opinion on other village professionals as important information sources due to their lack of information exchange on the use of grain storage protectant practices.

Furthermore, research as generated from the Ministry's research institutions and Sokoine University of Agriculture is supportive to work of extension agent since it seeks solutions to the problems of inputs and techniques required by farmers. Extension service becomes all important bridge between producers and adaptive research. Two things follow: first, without effective extension service, research loses momentum and its sense of purpose with strong probability of being irrelevant to production needs. Secondly, an active extension services will continuously remind researchers that their clients are farming communities; this suggests that village extension agents should pay particular attention to upward communication of farmers' problems in their research system. In addition, village extension agents importance rating of their fellow extension agents imply that they were willing to collaborate with other fellow workers since discussions over mutual problems can be very useful.

The above results suggest that particular attention should be given by district councils to ensure that village extension agents are ready to cooperate and exchange information with farmers, their colleagues, and research personnel from different institutions and workers from other relevant agencies in the villages. This exchange of information and assistance can be useful to improving effectiveness of extension, thus leading to greater extension efficiency.

The above reflections from data given in Table 12 suggest that because extension is essentially an activity involving the exchange of information, it follows that the effectiveness of extension services must depend highly on the quality, reliability and efficiency of information sources from which the village extension agents themselves draw.

4.4.4 Factors contributing to success or failure of transfer and adoption of available selected grain storage protectant innovations

4.4.4.1 Problems that constrain the transfer of selected grain storage protectant innovations

An analysis of the problems that constrain field extension agents in transferring the grain storage protectant innovations for grain storage was carried out. The results are given in Table 13.

Table 13: Extension agent respondents' (N=4) perceptions on constraints to transfer of selected grain storage protectant innovations

Type of constraint	Extension agent respondents ratings		
	Important	Not Important	No Opinion
Poor transport facilities	XXXX*		
Involvement in many other activities	X	XXX	
Lack of incentives	XXXX		

X* Frequency of extension agent respondents' responses

Data in Table 13 revealed that the major constraint for field extension agents for transferring grain storage protectant innovations was poor transport facilities. This was rated by all the respondents. Involvement in many other activities in addition to extension

role was also rated by all respondents and lack of incentives to provide good service was by one respondent. In Morogoro district, as is the case in Tanzania as a whole, transport facilities are persistent constraint in the extension system. Considering the large areas covered by extension agents (normally 5 to 6 villages) it is high time for district councils to take action in provision of appropriate transport facilities to extension staff in order to increase effectiveness of extension service.

Involvement in many other duties additional to normal extension activities of field extension workers appears to affect the quality of work of field extension workers. Contrary to the job description of field extension workers that appear on paper, for too little time is actually spent on advising farmers on grain storage protectant practices. With many additional tasks there may be dilution of efforts, poor competence and unwarranted interruptions.

Field extension workers are likely not to have incentives to provide good service if they lack transport, suitable accommodation, proper working tools, supportive technical services and training facilities. Also lack of necessary extension inputs such as credit and marketing facilities may make extension program unsuccessful. In this case farmers inevitably blame field extension workers for not being able to make available to them such inputs. This situation could reduce the effectiveness of field extension workers.

4.4.4.2 Problems that constrain the adoption of selected grain storage protectant innovations

An analysis of the perceptions of field extension agents on the problems that constrain farmers in adopting recommended grain storage protectant innovations put forward to them was carried out. The results are indicated in Table 14.

Table 14: Extension agent respondents' (N=4) perceptions on constraints to farmers adoption of selected grain storage protectant innovations

Type of constraint	Extension agent respondents ratings		
	Important	Not Important	No Opinion
Low level of farmers training	XXXX*		
Lack of grain storage protectants		XXXX	
Lack of agricultural credit	X	XXX	

X* Frequency of extension agent respondents' responses

Data in Table 14 show that low level of farmers training was identified by all extension agent respondents as a major constraint for adoption of selected grain storage protectant innovations. However, there were signs that the Universal Primary Education (UPE) launched more than three decades ago in Tanzania has influenced educational levels of farmers. Thus in future the extent of illiteracy will be greatly reduced considering that the number of youth recently benefiting from secondary education will be farming in the country side.

Lack of agricultural credit was identified by only one out of four extension agent respondents as being important constraint. Considering that the use of some grain storage protectant innovations such as synthetic pesticides demands the use of inputs (grain storage protectants) which must be purchased, these findings indicate that farmers have funds to pay for grain storage protectants, despite the fact that in some cases financial institutions such as National Bank of Commerce (NBC) have been blamed for their lengthy bureaucratic and commercial procedures which work in disfavour of small farmers. Lack of grain storage protectants was not identified as being important constraint for adoption of grain storage protectant innovations by all the field extension agent respondents. This is surprising, considering that in many cases, despite the farmers willing

to adopt new technology, adoption has been impaired by sheer unavailability of certain essential inputs on the market. For example, the researcher noted that synthetic pesticides which are not available to farmers had been recommended for use on grain storage in all the villages surveyed. Thus, while it is not the direct role of field extension workers to make inputs available to farmers, their work is greatly affected by unavailability of such inputs.

4.5 Summary of the Discussion

The overall objective of this study was to assess the extent of availability, transfer and utilization of grain storage protectant innovations. The results show that grain storage protectant innovations are generally available in forms that vary in terms of degree to which they can be helpful to the field extension agent. There were those that appeared in simplified packages that could be easily utilized by extension agents and farmers, on the other hand, and those that were complex and therefore not easily understood. The extent of transfer and utilization of grain storage protectant innovations was found to vary from type of grain crop to crop. Some of the constraints to the transfer of such innovations are of extension nature while others are clearly beyond the responsibilities of extension service. The following Chapter gives conclusions and recommendations based on the major results of the study.

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

1. The extension service appears to have an inventory of extension innovations to disseminate for grain protection. Synthetic grain storage protectant innovations are more simplified while traditional and mechanical processes are complex for extension workers to transfer and farmers to use. In general, it would seem that grain storage protectant innovations are available but in forms that are not easily understandable to the farmers.
2. The transfer of grain storage protectant innovations from district agricultural officers takes the form of advice. Field extension agents tend to advise farmers mainly through group and individual extension methods. The results clearly reveal that the farmers have been able to go through important stages of adoption process (knowledge, trial and adoption). However, the transfer of grain storage protectant innovations is clearly hampered by lack of incentives, such as in-service training and transport facilities.
3. The study has shown that farmers prefer to utilize innovations which are perceived to be better than those which were previously used, consistent with the past experience, simple to apply, triable and observable. Successful continued utilization of grain storage protectant innovations appears to be constrained by low level of farmers training. However, the study results indicate that the majority (72 percent) of the study respondents had attained a level of primary (69 percent) and

secondary (3 percent) education which reflected the level of education of most farmers in Tanzania.

5.2 Recommendations

1. Since generally grain storage protectant innovations are available but in forms that are not easily understandable and complex to the farmers use, much effort should be made to refine grain storage protectant innovations into simplified packages that can easily be understood and disseminated to farmers. This calls for closer links among research, training and extension organizations for such further refinement.
2. In view of the fact that grain storage protectant innovations have been changing with the changing technology, there is a need for every extension worker to undergo a continuous process of renewal, by attending on regular basis, refresher courses and other similar professional programs. In addition, the district councils should take action in provision of transport facilities to extension staff in order to increase effectiveness of extension service.
3. Considering that the number of youth currently benefiting from secondary education in Tanzania will be future farmers in the country side, there is a need for the government to improve secondary education quality, access and equity.

5.3 Suggestions for Further Research

This study has not exhausted all aspects concerning availability, transfer and utilization of grain storage protectant innovations. It is clear that a lot more needs to be done. Two suggestions are therefore made concerning specific areas that should further be studied.

1. To undertake case studies on the process of acquisition of information by extension workers from the district agricultural offices. The major purpose of this study would be to find out if the extension workers are offered opportunity to retrieve information on grain storage protectant innovations from research stations and to process it adequately for use by farmers.
2. To undertake case studies on interaction between field extension workers and farmers. The major purpose of this study would be to elicit more reliable clues about communication behaviors of field extension workers and farmers during the process of innovations transfer. The Participant-As-Observers technique could be useful in seeking data for such a study.

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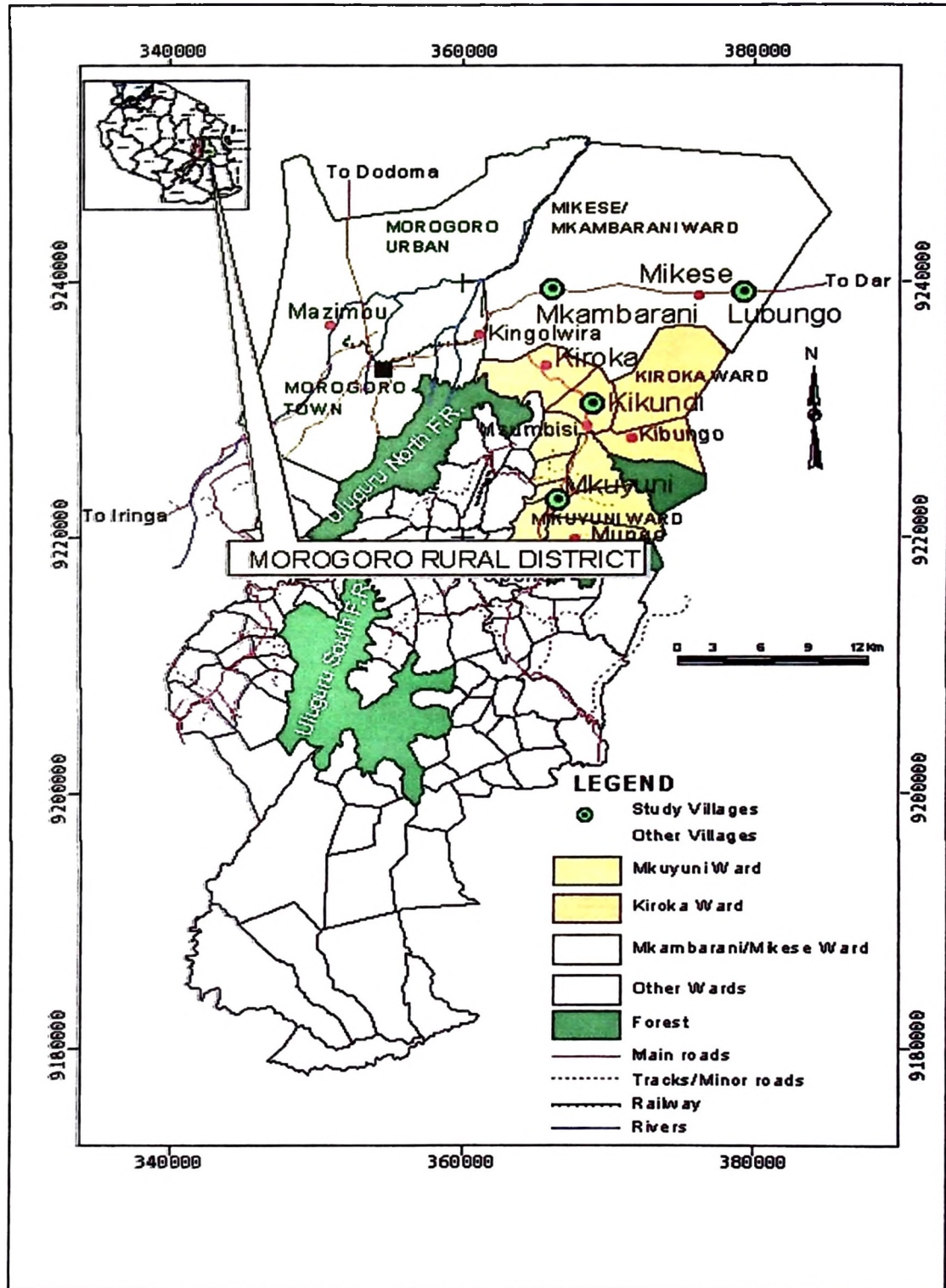
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Appendix 2: Map of Morogoro district showing the study villages



Appendix 3: Definitions of the key variables

Key Variables	Operational definition
Age	Number of years from birth
Sex	State of being male/female
Marital status	State of being married/not married (Single)
Education	Category and level of education attained
Land ownership	Possession of farm land for cultivation
Crop yield level	Total crop productivity per unit area of land
Grain storage protectants	Contact insecticides/rodenticides added to the stored grain in form of traditional, synthetic pesticides and/or mechanical processes
Grain storage structures	Infrastructures used for keeping grains during post-harvest
Farmer	An adult male/female who has the right to produce from a farm
Research	Investigation by experts to come up with new findings
Extension worker	Expert extending new innovation to farmers
Extension services	Agricultural technical services to farmers by extension agents as a bridge liaising research and farmers
Innovation	Successful exploitation of new information
Availability of innovations	Prevailing information on the specific recommendation for the utilization of traditional pesticides, synthetic pesticides and mechanical processes found in different publications as pamphlets, leaflets, brochures, magazines,
Transfer of innovations	Mode of transfer of innovations from researchers to farmer through extension agents by use of simplified tools; leaflets, pamphlets, brochures, booklets, magazines,
Adoption of innovation	The degree of continued use of a new technology in a long run equilibrium by the clientele
Utilization of innovation	Used interchangeably with the term adoption of innovation
Rejection of innovation	Rejecting the implementation of the new idea and confirmation or decision not to adopt an innovation
Factors affecting innovation	Source of information, intrinsic characteristics of information itself and its appeal to clients, characteristics of the unit concerned, preparation of innovation client
Food security	Accessibility, availability and utilization of enough food at any time
Poverty alleviation	Any process which seeks to reduce the level of poverty in a community; Coping strategy against food insufficiency
Improved livelihood	Indicator of alleviated poverty

Appendix 4: Farmer respondents' questionnaires

Confidential

Questionnaire: Personal Interviews

Respondents: Farmers

Study Topic: Availability, transfer and utilization of selected grain storage protectant innovations in Tanzania: The Case of Morogoro District.

Region.....District.....Ward.....Village.....

Respondent's number Dates.....

1.0 Characteristics

1.1 Personal characteristics

1.1.1 Age (Years)

1.1.2 Sex; Male/Female

1.1.3 Marital status (Married / single / divorced / widowed).

1.1.4 Educational level

i) None.....

ii) Adult literacy.....

iii) Primary.....

iv) Secondary.....

v) Others (specify).....

1.2 Situational characteristics

1.2.1. Do you own a farm? (Yes/No

1.2.2 If yes in question.1.2.1 above what types of grain crops do you grow on your farm?

(i)..... (ii)..... (iii)..... (iv)..... (v).....

1.2.3 In relation to the following Table record type of grain crop, average yield, amount sold/stored, and type of structure used for crops grown in 2006 / 2007 season

Types of grain	Area (Acres)	Average yield/acre (Kg)	Amount sold (Kg)	Amount stored (Kg)	Storage structure
Maize					
Paddy					
Sorghum					
Beans					
Others (specify)					

1.2.4 Indicate whether you use the following grain storage protectants for grain storage

Type of grain storage protectant	Yes	No
Traditional pesticides		
i) Neem		
ii) Vogel tephrosia		
ii) Ash		
iii) Others (specify)		
Synthetic pesticides		
i) Actellic super dust		
ii) Super shumba		
iii) Actellic 50 Ec		
iv) Others (specify)		
Mechanical processes		
i) Steel drum		
ii) Plastic drum		
iii) Clay pot		
iv) Others (specify)		

1.2.7 Give your opinion on the extent use of recommended grain crop storage protectant practices to the stored grain crops

Recommended grain storage protectant practice	Type of grain crop stored				
	Maize	Paddy	Sorghum	Beans	Others (specify)
Traditional pesticides					
i) Neem					
ii) Vogel tephrosia					
iii) Ash					
iv) Others (specify)					
Synthetic pesticides					
i) Actellic super dust					
ii) Actellic 50 Ec (liquid)					
iii) Super shumba					
iv) Others (specify)					
Mechanical processes					
i) Steel drum					
ii) Plastic drum					
iii) Clay pot					
iv) Others (specify)					

2.0 Extension contact

2.1 Have you ever received advice from extension agent or any other source on the use of the following grain storage protectant practices?

Type of grain storage protectant innovation	YES		NO	CANNOT REMEMBER
	Extension agent	Others (specify)		
Traditional pesticides				
i) Neem				
ii) Vogel tephrosia				
iii) Ash				
iv) Others (specify)				
Synthetic pesticides				
i) Actellic super dust				
ii) Actellic 50 Ec (liquid)				
iii) Super shumba				
iv) Others (specify)				
Mechanical processes				
i) Steel drum				
ii) Plastic drum				
iii) Clay pot				
iv) Others (specify)				

2.2 What extension methods did extension agents use to reach you?

Recommended grain storage protectant practice	Extension method used		
	Individual	Group	Mass
Use of traditional pesticides			
Neem			
Ash			
Others (specify)			
Use of synthetic pesticides			
Actelic super dust			
Actelic liquid 50 Ec			
Super shumba			
Others (specify)			
Use of mechanical processes			
Steel drums			
Plastic drums			
Clay pot			
Others (specify)			

3.0 Reasons for farmers rejection of recommended grain storage protectant innovations

3.1 Which of the following statements accurately describe major reasons for your continued rejection of innovations for the following grain storage protectant practices on stored grain?

Type of grain storage protectant innovation	Reasons for rejection (tick accordingly)									
	Practices previously used are better		Inconsistence with past experience		Difficulty in technology		Not easily triable		Not easily observable	
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Traditional pesticides										
i) Neem										
ii) Vogel tephrosia										
iii) Ash										
iv) Others (specify)										
Synthetic pesticides										
i) Actellic super dust										
ii) Actellic 50 Ec										
iii) Super Shumba										
iv) Others (specify)										
Mechanical processes										
i) Steel drum										
ii) Plastic drum										
iii) Clay pot										
iv) Others (specify)										

THANK YOU FOR YOUR CORDIAL COOPERATION

Appendix 5: Extension workers' questionnaire**Confidential****Respondents: Extension workers**

Study Topic: Availability, transfer and utilization of selected grain storage protectant innovations in Tanzania: The Case of Morogoro District.

Region.....District.....Ward.....Village.....

Respondent's number..... Date.....

1.0 Personal characteristics

1.1 Age (Years)

1.2 Sex; Male/Female

1.3 Marital status (Married / single / divorced / widowed).

1.4 Educational level

1.4.1 Formal education

Formal education	Final qualification (tick)	Year
Std VII/VIII		
Form IV		
Form VI		

1.4.2 Professional training

Level of training	Final qualification	Specialization	Graduation (year)
Certificate			
Diploma			
Others (specify)			

1.4.3 In-service training/re-training program

Specialization	Facilitator(s)	Duration	Place

2.0 Extension activities

2.1 Below is a list of grain storage protectant practices. Place a (tick) against extension methods you frequently use for advising farmers for each practice.

Type of grain storage practice	Extension method				
	Individual		Group		
	Farm/home visit	Office visit	FFS	Meetings	Demonstration
Traditional pesticides					
i) Neem					
ii) Vogel tephrosia					
iii) Ash					
iv) Others (specify)					
Synthetic pesticides					
i) Actellic super dust					
ii) Actellic 50 Ec					
iii) Super Shumba					
iv) Others (specify)					
Mechanical processes					
i) Steel drum					
ii) Plastic drum					
iii) Clay pot					
iv) Others (specify)					

2.2 What are your opinions on the following information sources? Rank the information as being important (I), not important (NI) and no opinion (NO) on grain storage protectant innovations

Type of information source	Extension Agent Respondents Rating		
	Important (I)	Not Important (NI)	No Opinion (NO)
Farmers			
SUA staff			
fellow extension agent(s)			
DALDOs SMS			
Other village professionals			
Research staff			
Others (specify)			

2.3 Below is a list of statements on constraints to extension agents' transfer of innovations. Rank the constraints as being important, not important or no opinion based on your transfer of grain storage protectant innovations activities

Type of constraint	Extension Agent Respondents Rating		
	Important (I)	Not important (NI)	No opinion (NO)
Poor transport facilities			
Involvement in many other duties			
Lack of incentives			
Others (specify)			

2.4. Below is a list of statements on constraints to farmers' adoption of innovations. Rank the constraints as being important, not important and no opinion based on grain storage protectant innovations.

Type of constraint	Extension Agent Respondents Rating		
	Important (I)	Not Important (NI)	No Opinion (NO)
Low level of farmers training			
Lack of grain storage protectants			
Lack of agricultural credit			
Others (specify)			

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Appendix 6: Researchers' checklist**Confidential***** Checklist: Directed discussions**

Study Topic: Availability, transfer and utilization of selected grain storage protectant innovations in Tanzania: The Case of Morogoro District.

Respondents: Researchers/Extension Officers

Region.....**District** **station**.....

Respondent's number. **date**.....

1.0 Are there any grain storage protectant innovations for extension service in your station? Yes/No. If yes, what are the specific recommendations by type of grain stored?

Type of Innovation	Specific recommendations
Use of traditional pesticides	
i) Neem	
ii) Tephrosia vogelii	
iii) Ash	
iv) Others (specify)	
Use of synthetic pesticides	
i) Actellic super dust	
ii) Actellic 50 Ec	

iii) Super shumba	
iv) Others (specify)	
Use of mechanical processes	
i) Steel drum	
ii) Plastic drums	
iii) Clay pot	
iv) Others (specify)	

2.0 List problems that make it difficult for extension agents to adequately transfer grain storage protectant innovations

- i).....
- ii).....
- iii).....
- iv).....
- v).....
- vi).....
- vii).....
- viii).....
- ix).....
- x).....

3.0 List problems that make it difficult for farmers to adopt recommended grain storage protectant innovations put forward to them

- i).....
- ii).....
- iii).....
- iv).....
- v).....
- vi).....
- vii).....
- viii).....
- ix).....
- x).....

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