THE ROLE OF INDIGENOUS KNOWLEDGE IN SUSTAINABLE FOOD PRODUCTION: A Case of Post-Harvest Practices in Maize Preservation in Mua Hill Location, Eastern Kenya

Research Project submitted to Van Hall Larenstein University of Applied Sciences

In partial fulfilment of the requirement for the awards of masters degree in master of development specialising in rural development and communication

By

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September 2011

Van Hall Larenstein University of Applied Science

Part of Wageningen University

The Netherlands

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Acknowledgement

First and foremost I would like to thank the Royal Netherland Government through the Netherland Fellowship Program (NFP) for granting me the scholarship and therefore the opportunity to do this masters course in the Netherlands.

I thank my course specialisation; Rural Development and Communication coordinator, Loes Weeteevin for her support and great encouragement throughout the course. I express my special gratitude to Ivonne de Moor my supervisor for patiently and encouragingly guiding me through the thesis writing process.

I express my deep appreciation to all my lecturers for giving me a wealth of information and experience that will be of great value to me in my work and life. I thank my colleagues especially the Rural Development and Communication group for the quality time we spent encouraging and learning from each other.

I also express my gratitude to the MoA staff who participated. Special gratitude goes to Kioko Kithae the FEW Mua hill location, David Musyoka the elder Kyanda village and all the farmers who participated in the exercise for their great support in data collection.

Dedication

I dedicate this research work to my husband Paul Waithaka for allowing me to travel abroad in pursuit for higher education and for taking care of the children when I was away. I am also very grateful to my three children: Faith Wangari, Caroline Wanjugu and Joash Wamai, for allowing me to be away from home for the one year I was in the Netherlands. My family's support, encouragement and prayers helped me to go through the course successfully and for that I will always love you.

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Abbreviations

KARI- Kenya Agricultural Research Institute
AIRC-Agricultural Information Resource Centre
MoA-Ministry of Agriculture
LGB- Larger Grain Borer
RTDC- Rural Technology Development Centre
DivCO-Divisional Crops Officer
FEW-Frontline Extension Worker
AI- Active Ingredients
NGO- Non-Governmental Organisations
AEZ- Agro-Ecological Zones
KBC - Kenya Broadcasting Cooperation
NCPB-National Cereals and Produce Board
SMS-Subject Matter Specialist

Abstract

One of the main challenges facing Kenya today is to ensure food security for its rising population. The Ministry of Agriculture (MoA) and Kenya Agricultural Research Institute (KARI) spend a lot of resources searching for effective and sustainable methods of producing and preserving food. However, most of the strategies and technologies they develop never get implemented by farmers. Many farmers still rely on Indigenous Knowledge (IK), but its role is downplayed. Meanwhile, it is in danger of extinction because modernisation and other global changes have weakened its value and disrupted its transmission and preservation. The main motivation for doing this research was to provide MoA with information that would stimulate it to acknowledge the role of IK in ensuring food security and therefore make effort to preserve it for future generations. To achieve this, a case study was done to investigate the role of IK in preserving maize; Kenya's most important food crop, in Mua hill location of Eastern Kenya. The study explored maize preservation practices and IK circulation and preservation methods in the location. Two MoA staff and fifteen farmers were the sources of information. Qualitative and quantitative data analysing methods were used. The results of the case study reveal that both scientific and indigenous knowledge are used in maize preservation. For example a few farmers store maize in cribs, either the recommended scientific crib or the traditional crib. However, most of the maize preservation practises combine scientific knowledge and IK. For example most farmers store maize inside the house and not in the cribs which is the indigenous and the MoA recommended practise. The results also indicate that IK is in the custody of old people who have no one to pass it to and who may soon die, taking valuable information to the grave. The conclusion drawn from this study is that the role of IK in food preservation and in ensuring food security is real and significant. This will become evident in future as more IK practises are lost, if nothing is done to prevent it. The recommendation is that IK should be integrated with scientific knowledge in the MoA extension package and documented, for preservation before it is too late. This should be done urgently to prevent wastage of resources on developing technologies and disseminating information that will not ensure food security.

KEY WORDS:

Knowledge circulation, knowledge extinction, knowledge integration, extension

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CHAPTER ONE: INTRODUCTION

1:1 Background Information

Agriculture plays a dominant role in Kenya's economy as reflected by its contribution to income generation, employment creation, food security and raw materials for industrial development. The sector accounts for 26% of the country's GDP and 60% of the export earnings. 80% of Kenyans are engaged in subsistence farming and pastoral activities as a source of livelihood (MoA, 2004). Maize is the most important food crop in Kenya and a major cash crop in some parts of the country. It is also an important livestock feed both as silage and crop residue. It is grown by 1.4 million small holdings in the country and nearly 80% of the large scale farmers (Ligeyo, Mbugua and Mugo,2011).

Maize farmers in Kenya face many challenges; one of their major problems is high post-harvest losses. About 80% of all the maize harvested in Kenya is stored on farm and 20-30% of this maize is lost within six months of harvest if no preservation measures are undertaken (Kimondo,2008). Post harvest losses in maize are caused by diverse factors which include poor handling, poor storage and destruction by diseases and pests. Common weevils and LGB cause losses between 5-17% and 30-90% respectively in maize (Likhayo et al., 2004 and Songa, 2004). Maize grain loss results to food insecurity and low farm income and therefore efforts should be made to minimise post-harvest losses.

The MoA is mandated with training farmers on how to preserve maize. KARI develops scientific post-harvest strategies to prevent maize loss. These are then passed on to the MoA for dissemination through various extension methods. Farmers are expected to learn scientific maize preservation technologies and practise them in their farms. The MoA and KARI expects that by farmers replacing their indigenous practises with the recommended scientific practises; which in their view are superior, post harvest losses of maize would be greatly reduced and food security achieved. However, although Kenya has a well developed agricultural research and extension infrastructure, use of scientific strategies in preservation of maize is still limited. This is mainly attributed to inadequate research-extension-farmer linkages and limited demand driven research. Many farmers continue to rely on indigenous ways of preserving maize. As a result the agricultural sector has suffered from inadequate management of pests and diseases, lack of storage facilities all this leading to high post harvest losses, (MoA, 2004).

Between 1982 and 1989 the MoA implemented a rural structure program whose objective was to develop and disseminate low cost rural structures and to build expertise in extension on rural structure development. This was meant to increase food security by reducing post harvest losses in maize. The project package involved constructing crib structures for drying maize and trainings on post harvest management of maize. The MOA assumed that the project package was superior to the practises existing in the local community and hence it would be readily accepted and adopted by the farmers. Another assumption was that the neighbours would follow the good example of the demonstration farmers and thus the technology would diffuse fast in the community. The project recommended that first, the normal grass thatched roof of the crib should be replaced by iron sheet; this proved too expensive for the farmers. Second, all the maize was to be shelled at once to prevent spread of mould and insect pests; this task was difficult because of labour shortage and other equally important tasks that required attention. Third, the project package was to be used as it is without improvising anything; farmers could not use the local knowledge and inputs to reduce cost. Many farmers rejected the recommendations and the project failed to meet its objectives. (Tobinson 1997 cited in Lloyd-laney ,1997)

The role of IK in food production and preservation has for long been taken for granted and all the credit given to scientific knowledge. IK is not documented but orally exchanged and transmitted from generation to generation. It is therefore in danger of getting extinct as preservation becomes increasingly difficult due to changes in the world. At the same time a lot of resources are being wasted in research and dissemination of strategies and technologies that are not adaptable to farming situation at the farmer's level. This research was carried out to establish the contribution of IK in preserving maize and the methods used to circulate and preserve it at Mua hill location of Eastern Kenya. The aim was to provide MoA with information that would stimulate the acknowledgement of the role played by IK in sustainable food production and therefore integrate it with scientific knowledge in the extension packages. This integration would make the extension messages more valuable and acceptable to the farmers and save IK from extinction.

Chapter one gives the introduction, chapter two is the theoretical framework, chapter three gives the methodology, chapter four gives the findings, chapter five gives the discussion, and chapter six gives the conclusions and recommendations.

1.2 Research Problem

The demand for maize in Kenya is increasing as the population increases, but production is low and post harvest losses are high. The government through MoA and KARI is seeking for ways to reduce post-harvest losses of maize, in an effort to achieve food security. However many of the food production and preservation technologies developed by KARI and disseminated by MoA never get to the level of being implemented by farmers, the people for whom they are developed because they do not meet their requirements. Farmers especially those in the marginal areas still rely on IK despite MoA efforts to promote scientific technologies. However, the MoA and KARI have continued to take the role of IK for granted and concentrated on searching for more scientific technologies. Meanwhile, very little attention is given to IK which is in danger of getting extinct, because of modernisation and other global changes.

1.3 Justification

Despite limited use of scientific technologies, KARI and MoA have continued to spend a lot of resources researching and disseminating those technologies. Meanwhile old people who hold the IK are dying taking with them valuable information to the grave. This information which is not documented then goes beyond reach and is lost forever leading to a major loss to humanity. If its contribution to sustainable food production is significant, the production will continue to go down as more and more of indigenous practises are lost. The country requires more food than before and the demand is increasing with the increase in population. This research was carried out to establish the role of IK in food production and its current preservation methods with the aim of recommending that IK should be documented and preserved before it gets extinct, if its role is found to be significant.

1.4 Objective

The objective of this study was to contribute to making the extension messages disseminated by MoA more relevant and acceptable to farmers through integration of IK. This was achieved by exploring how IK contributes to preservation of maize and how it is circulated and preserved in Mua hill Location of Eastern Kenya and the possibilities of integrating it with scientific knowledge in the MoA extension packages to promote and preserve it.

1.5 Main Research Question

What is the contribution of IK in the preservation of maize in Mua hill location of Eastern Kenya?

1.5.1 Sub-questions

1. How can maize preservation methods currently in practice, be classified as scientific, indigenous or a combination of both?
2. What maize preservation methods are practised most?
3. What are the strengths and weaknesses of IK and scientific knowledge on maize preservation according to the farmers and MoA staff?
4. How is IK on maize production circulated and preserved in the community?
5. What indigenous maize preservation methods used in the past are no longer in use and why?

CHAPTER TWO: THEORETICAL FRAMEWORK

This chapter gives a belief review on the literature that provided the background information of this research. It gives the different characteristics that were used to distinguish between IK and scientific knowledge. It shows how various concepts have been operationalised in the research.

2.1 Literature Review

This section gives some background information on various sources from which farmers get agricultural information. It gives some already identified roles played by scientific knowledge and IK in agriculture and rural development .It highlights some views held by different authors regarding documentation and preservation of IK and its circulation within and outside communities. The section also highlights some documented possibilities and effects of using IK as an entry point to agricultural innovations as well as the effects of integrating indigenous and scientific knowledge for sustainable development

2.1.1 Sources of agricultural information

A study done by Afuoku , Emah and Itedjere (2008) on information utilization among fish farmers in Nigeria revealed that the most important source of agriculture information for farmers is other farmers. The results indicated that 86% of farmers get information from farmers groups, 70% from other farmers, 70% from NGOs, 45% from extension agents, 10% Research Institutions, 10% from Universities.

Another study on factors Influencing Soil Fertility Management (ISFM) among small holder farmers in western Kenya revealed something similar. The results showed that most (17%) of the farmers highly preferred information gained through their own experience. MoA was the information source that was not preferred by the highest percentage of farmer. Results were as shown in table 1 below (Adolwa et. al, 2010).

Table 1: Preference of ISFM information sources among the farmers (Source: Adolwa et.al, 2010)

ISFM information source	Type of information	Highly preferred (% response)	Not preferred (% response)
Experience	traditional	17	1
Farmers group	modern	14	1
Mass media	modern	12	2
MoA	modern	9	4
Neighbours and friends	traditional	9	1
Extension staff	modern	7	3

The above case studies reveal that farmers have many sources of agricultural information. However, the information sources in the two case studies can be put in two main categories;

farmers and MoA. This research focused on the two as sources of information. In the ISFM study case agricultural information is classified as either modern or traditional. In this research agriculture information is classified as indigenous, scientific or integrated

2.1.2 The Role of scientific knowledge in agriculture

The term scientific knowledge is attributed to some facts and principles that are acquired through a long process of inquiry and investigations. It is knowledge that is acquired by a systematic study and then organised in accordance with some general principles (Chema, Gilbert and Roseboom, 2003). Scientific knowledge is generated by researchers in the research centres and Universities and then disseminated to the farmers through extension workers. Scientific knowledge plays an important role in food production and preservation although it has strengths as well as weaknesses as described in the next paragraphs.

Agricultural research systems reflect many years of evolution, during which they adapted as best as possible to changing circumstances and demands (Chema, Gilbert and Roseboom, 2003). Scientific Knowledge can be relocated from the specific place in which it is created to other places with similar environmental conditions. It is transferable across time, space and social setting (Dewalt, 1994). Scientific pesticides are also more effective than indigenous pesticides as Padaria et al. (2009) found out in a study done to validate IK, by using an extract of neem, tobacco and garlic to control gundhi bug in rice. When the effectiveness of chemical pesticide and plant extract was compared it was discovered that though the plant extract efficiently managed the pest and saved the yield loss yet, the chemical pesticides were more effective. Moreover farmers stated unavailability of the required material, cost and labour intensiveness, cumbersome process of extract preparation as limiting factors in IK. Dewalt (1994) states that scientific knowledge systems have the advantage that they can broaden the base of understanding and provides a great array of option for farmers. But, in order to be effective, the results of scientific knowledge systems must ultimately be incorporated into indigenous knowledge systems.

Scientific technologies are expensive and not affordable by many small scale farmers. Tillman (1995) cited in Röth (2001) notes that majority of small scale farmers in developing countries do not have resources to embrace expensive technologies promoted by the government ministries. This view is supported by Hiemstra , Reijintjes and Werf (1992), the authors argue that the very low income of the rural farmers reduces the incentive to use high input technologies. Galjart (1976) cited in Saidou (2006) points out three reasons why farmers do not embrace certain scientific innovations. First, ignorance: farmers may not get the information so have no other knowledge except their own. Second, incapacity: they may know what is recommended but not do it because of various constrains. Third, reticence: they may know what is recommended and have means to do so but remain reluctant because of certain values. Scientific technologies are not sustainable because as Dewalt (1994) observes, they highly depend on inputs from external resources which farmers cannot afford. They are also potentially dangerous in causing degradation of ecological systems.

According to Agrawal (2008) scientific knowledge is divorced from the daily lives of people and builds general explanations that are one step removed from concrete realities. In addition Dewalt (1994) argues that in developing scientific technologies and strategies, scientist usually ignore the wider context. They advocate for one change of the system without paying attention to the results for the overall system. Scientists focus on the short term without looking at what the potential long term implication of advocated change might be. Leach and Scones (2006) argues that in scientific knowledge problems and solutions are often framed to universalised terms. The nature of agricultural problems and solutions are often assumed to be broadly similar across fast areas so that solutions can be transferred without problems. However, the authors point out that such universality runs into several problems. First, ecologies and practices that people have developed to sustain their livelihoods are highly diverse. Interactions between social and ecological change vary across regions producing multiple needs. Second, new technologies may obscure important opportunities to spread already tried and tested “old” technologies adapted to these particular local circumstances. Third, poverty and hunger are not the result of technical matters only; the social, economical and political aspects are intimately intertwined.

Literature indicates that scientific knowledge plays an important role in agriculture, but it has both strengths and weaknesses. This research explored the strengths and weaknesses of maize preservation methods recommended by the MoA for Mua hill location, with the aim of identifying how acceptance and impact of MoA technologies can be improved.

2.1.3 The role of Indigenous Knowledge in agriculture

IK is knowledge that is anchored in actions, experiences and values of a particular social group. IK is not just a compilation of facts drawn from local and remote environment, but a complex and sophisticated system of knowledge drawn from centuries of experience, testing and wisdom of local people (World Bank, 1998). IK systems combine culture and religion therefore making it compatible with indigenous environment and culture. IK includes accumulated knowledge as well as skills and technologies of the local people that are developed locally and handed down through centuries (Khodamoradi and Abedi, 2011). Dewalt (1994) states that even farmers who are part of the modern agriculture have an IK system. African communities have a vast array of IK in food technology that is favourable to the supply, quality and safety of food and hence it has a direct contribution to food security (Aniang’o, Allotey , Maraba, 2003).

According to Khodamoradi and Abedi (2011) IK is accessible, useful and cheap. This makes it important in supporting the poor farmers in the marginal areas who have no physical and economical access to scientific technologies. Gadziravi, Mutandwa and Chikuvire (2008) observe that the farmers’ dilemma is how to ensure food security from one season to the next at low crop preservation cost. In the absence of the required chemicals, small scale farmers can trade off efficiency of the preserving method for convenience and affordability. The authors give the example of the effectiveness of cob powder in preserving maize. It is only achieved at high levels of ash concentration but, farmers are willing to strike a balance between low cost and the labour time invested to remove ash when preparing food for consumption

Tillman (1995) cited in Röth (2001) argues that passive resistance of farmers to new technologies is seen as traditionalism, ignorance and lack of flexibility. This view is further supported by Michael and Herweg (2000) cited in Röth (2001), the authors’ state that many researchers and experts have for a long time considered IK as primitive, backward, and subordinate to scientific knowledge. As a result the local peoples’ self confidence has declined making them strongly dependent on external solutions. But, small scale farmers are permanently confronted with scarcity of many resources and have therefore developed flexible and multifunctional strategies to address various problems simultaneously. According to Leeuwis (2004) farmers reject certain scientific innovations because of their perception of the consequences and since farming is a complex and carefully co-ordinated activity even relatively minor changes in agriculture practise may have a number of consequences which farmers have to consider. Farmers do not only consider possible technical consequences but also socio-economic effects. IK forms the basis for local level decision making in food preservation.

According to Gadziravi, Mutandwa and Chikuvire (2008) IK is an important ingredient for development but it is grossly under-utilized. Local prescription emanating from IK base, are grossly under-researched thus, there is scarcity of information which illustrates the value of IK in preservation of agricultural products. Many indigenous practises and technologies are not validated therefore people hesitate to share them. Conventional approaches concentrate on transferring technologies from research institutions to the rural community. But, the authors point out that conventional approaches are not always sustainable. They cite a case of southern Africa where although weevils account for severe losses in stored maize grain, sustainability of chemicals used in preserving grains is questionable given the high level of poverty present in the rural communities. After comparing the effectiveness of traditional sun-baked mud bins with simple gunny bags in an experiment to validate IK, Gurung (2002) concluded that indigenous methods do not have to be fully effective to be perpetuated because, however small and simple farmers' practices are, they have a profound impact on grain storability and thus rural farmers food security.

Obe et al (2011) states that, although farmers have many practises and technologies of value, yet they do not know everything required. Pests, diseases and climatic conditions are constantly changing and farmers may not know of new threats or opportunities. In addition IK can negatively affect the environment through overuse of natural resources as inputs.

In the above discussion various authors have argued that IK plays an important role in food production and preservation but this role is currently ignored.The main motivation for doing this research is to get information that would stimulate the MOA, to acknowledge the role of IK in ensuring food security and therefore, makes efforts to document and preserve it for future generations. This research was done to determine the role of IK in preserving maize at Mua hill location.

2.1.4 Documentation and preservation of Indigenous Knowledge

World Bank (1998) points out that indigenous practise can adapt in response to gradual changes in the social and natural environment since they are interwoven with peoples' cultural values, however they cannot adapt to rapid changes. Therefore, many IK systems are at the risk of extinction because of rapidly changing natural environment, economic, political and cultural changes on a global scale. Indigenous practises are vanishing as they become inappropriate for new challenges or because they adapt too slowly. Local practises can also disappear because of the intrusion of foreign technologies however; it is possible to preserve IK alongside modern technologies.

Warren (1993) argues that IK is a valuable national resource but if nothing is done to preserve it; it will be buried with its custodians leaving no trace behind. IK is orally transmitted and skills are acquired through observation and practise. World Bank (1998) reports that in some countries, local crops varieties are preserved in a gene bank. The gene bank preserves the genetic information of indigenous varieties in hope that genetic traits of these species may prove instrumental in future breeding programs against pest and disease. However, the report points out that preserving genetic trait without preserving the knowledge of their husbandry may prove futile as the seeds and clones in the seed banks do not carry the instruction on how to grow them. Hence in addition to preserving seeds in the gene bank the essential production knowledge and skill should be preserved.

Agrawal (2008), points out that modernisation is a threat to the lifestyles, practises and culture of small scale farmers and indigenous people. The indigenous method of preserving IK through oral transmission from parents to children is almost gone because of modernisation. Moreover, IK and indigenous people are disappearing all over the world as a direct result of the pressure for communities and countries to become modernised and culturally homogenous under the auspices of the modern nation and the international trade systems. Their disappearance in turn constitutes an enormous loss to humanity since they possess the potential remedy to many of the problems that have emasculated development strategies for several decades. The author argues that although the indigenous people may be fated to disappear yet their knowledge can be acquired and documented before they disappear. Therefore, great efforts must be made to document and apply indigenous strategies for preservation and just as scientific knowledge is gathered, documented and disseminated in a coherent and systematic fashion so too should IK be handled. Myer (2000) notes that as the pressures on traditional and indigenous community's mount, the search for effective forms of documentation to support the preservation and transmission of IK is becoming increasingly urgent.

From their argument Agrawal (2008), Warren (1993), Myer (2000) and the World Bank (1998) strongly point out that IK is in danger of getting extinct and its disappearance will be a great loss to humanity. They recommend that measures should be taken to preserve IK before it is too late. In this research the possibility of documenting and also integrating IK into conventional extension packages for promotion and preservation were explored.

2.1.5 Circulation of Indigenous Knowledge within and outside a community

Warren et al. (1993) cited in Agrawal (2008) argues that documentation of IK is not enough; rather the collection and storage of IK should be supplemented with adequate dissemination and exchange among interested parties. According to Boven and Morohashi (2002) IK is a community's information base which facilitates communication and decision making, but it is also a valuable source of knowledge that should not only benefit the local people but shared with other communities; success stories held out as examples can be a source of inspiration for other communities. Therefore, there should be a forum where communities can meet to share and exchange their knowledge, experience and expertise.

World Bank (1998) states that IK is shared readily among the members of a community since it is part of the daily life of the community, but it is shared less across communities because they are not linked. Development practitioners can learn a lot about communities by facilitating sharing of IK within and across communities. Ulluwishewa (1993) quoted in Agrawal (2008) points out that IK can be transmitted from one area to another because indigenous technology useful in one area may be used to solve problems faced by another community in similar agro-ecosystems. According to Gadziravi, Mutandwa and Chikuvire (2008) IK is grossly under-utilized and indigenous practises and technologies are given very little attention so they remains localised. Meanwhile, conventional approaches to development focus on transfer of technology from research centres to farmers obliterating the importance of local knowledge and experiences in solving local problems peculiar to rural communities.

Dixon (2005) says that in the rural areas of developing countries, IK tends to be communicated through events such as storytelling, village meetings and folk drama. Boven and Morohashi (2002) observes that the pot moulding knowledge and skills in western Kenya are held by the potters who do not record or document their knowledge but orally transmit it from generation to generation. Traditionally, girls developed interest early in life as they spent time beside their mothers. The girls watched their mothers moulding pots and imitated them as they played with clay. They gradually learnt the skill themselves. In addition, every village had at least one specialist who transmitted the pottery skills to every newly married woman in the area who was interested in becoming a potter. In this way pottery skills were transmitted from generation to generation. Dewalt (1994) states that IK is unevenly distributed among people in the community, there are exceptionally knowledgeable individuals and there are often specialists who have a great deal of knowledge in certain realms. Identifying these gifted informants is an important first step in learning about IK. World Bank (1998) gives six steps through which IK should be exchanged. First: identification of knowledge. Second: validation in terms of its significance, relevance, reliability, functionality, effectiveness and transferability. Third: recording and documentation. Fourth: storage in text documents, tapes, films and database. Fifth: transfer into new environment. Six: dissemination and exchange

The authors in the preceding discussions point out that, sharing and exchanging IK inside and across rural communities is a key component to rural development of which food security is a key component. In this research, communication channels used for share and exchange agricultural information in Mua hill Location were explored with the aim of finding possible ways of strengthening them.

2.1.6 Local knowledge as the entry point of agricultural innovations

According to Leeuwis (2004) many technologies and strategies developed by the researchers never reach the stage of being applied in everyday practise. This has lead to a lot of debate on the usefulness, quality and validity of scientific verses IK in farming. The author argues that research products can only be considered innovations if they actually work in everyday practise. Dixon (2005) states that whilst adaptive capacity is intrinsically linked to acquisition of new knowledge new knowledge may be inappropriate on account of its being developed under a completely different set of environmental and socio-cultural condition to the place it is disseminated.

World Bank (1998) points out that a successful development strategy must incorporate IK into development planning. Before introducing new practises, investigations on what the local communities know and have in terms of indigenous practises should be done and then new practises can be used to improve them. Similarly Aniang'o, Allotey and Maraba (2003) state that for food security to be realised indigenous food technologies that have proved capable of ensuring food security should be implemented first before considering the introduction of external ones.

Brokensha, Warren and Werner (1980) cited in Agrawal (2008) explain that incorporating IK in development is an essential first step because, development from below is a more productive approach than development from above. Incorporating IK ensures that human needs and resources are emphasised rather than materials alone. It also makes the adaption of the technology to local need possible and preserves valuable local knowledge. Agrawal (2008) suggests that studies on the manner in which farmers experiment and innovate by combining their existing knowledge with new information can fill a very significant gap in approaching IK. Unfortunately though IK possess much significance and value and can be a pivotal resource for development worldwide it has been undervalued and is fast disappearing

After a study of the role of IK in storage pest management in Nepal, Gurung (2002) concluded that it is important to assess local assets before launching new programs on improvement of agricultural efficiency. Farmer's assets which include perception, knowledge and practises influence their actions and decisions. The author discovered that an enormous gap separates what is practised by farmers from what is known by policy makers and researchers. The prevailing belief among researchers and policy makers is that traditional agricultural systems and technologies are not capable of producing sufficient food and therefore should be replaced. This and the widespread attitude that professionals should determine what works best for farmers have led to failure of well-intended efforts of the past and the present agricultural policies. Consequently a partnership between farmers and outsiders is indispensable to achieve good results.

Gurung (2002) points out that IK forms the basis for understanding agricultural systems and traditional practises and it is the departure point that leads to the development of appropriate and acceptable technologies. In a study on the post harvest management of grains in Bangladesh Tonti (1989) cited in Gurung (2002) discovered that project workers took more than one year to identify insecticidal plants and to train men so that they can pass the newly attained knowledge to the villagers. But the women, who had always been responsible for storing the grains, used exactly those same plants every day , they had learnt from their mothers where to find them. In an arduous, scientific and detailed work, the project was in the process of discovering, by men what was already known to women. The author concluded that because of not taking time to assess what is already in practise; extension workers sometimes teach what is already known and obvious to farmers.

According to Michael and Herweg (2000) cited in Roth (2001) the concept of participatory technology development integrates at least two main points, first: local knowledge and experience have to be the starting point. In this way due respect is paid to the innovative capacity of the end user. Second: the local people do not only play the active part in the development of improved technologies but eventually they decide what to be done. One of the most successful rural innovations in Kenya is the modification of clay water pots, Boven and Morohashi (2002) attributed the success to three things. First, because the pots were produced locally they were widely accepted by the population. Second, the modification did not affect the long tradition that had been passed from generation to generation of using clay pots as storage vessels for drinking water. Third, the pots maintained their original form and function; they still kept the water cool and improved the taste just like before. This success story reveals that taking local knowledge into account can serve as an important entry point for rural innovations.

Brokensha et al (1980) cited in Agrawal (2008) warns that to ignore peoples knowledge is to ensure failure. But, building on local development efforts enhances capacity building of the local people and ensures sustainability. Hence, IK should be a principal component when developing extension programs. According to Boven and Morohashi (2002) IK is a valuable source of knowledge; success stories provide alternative solutions that can improve development planning by providing policy makers and development practitioners with deeper insight into the many different aspects of sustainable development and the interrelated role of local people and their cultures.

The authors in the above discussion have highlighted the importance of using IK as an entry point for rural development and food security. In this research possibilities of identifying success stories in the community and using them as entry point for food production initiatives were identified.

2.1.7 Integrating indigenous and scientific knowledge for sustainable development

World Bank (1998) report states that IK should be seen as complementing rather than competing with scientific knowledge in the food production. Khodamoradi and Abedi (2011) state that experience has shown that IK has no contradiction with formal knowledge but instead, different IK features are complementary for scientific knowledge. Their view is supported by

Leeuwis (2004) who suggests that scientists and farmers knowledge can in principle enrich each other and deliver important ingredients for innovation in agriculture. However, the author notes that this process of enriching has been hampered by the fact that many scientists tend to look at their scientific knowledge as universal, generally applicable and superior to farmers knowledge.

Leach and Scones (2006) point out that the very low income of the rural farmers reduces the incentive to use high input technologies; as a result approaches go though several modifications over the years, increasingly incorporating practices that are less input demanding. The authors argue that in the farmers view a technology may not necessarily be a bad one but it may not be the only solution. Therefore, the real question should be, “what is the range of options available? They point out that existing native practices could suggest useful hypothesis for maize practice that can be tested under an experiment station condition. Indigenous systems could be used as spring board for integrating the best of both systems. World Bank (1998) report states that impact and sustainability of scientific technologies could be enhanced if they are adapted to the local condition and indigenous practice. Development practitioners need to understand and integrate systematically the most effective and promising indigenous practices in their development strategies. Building on local experience, judgement and practice can increase the impact of development and create a sense of ownership that may have a long lasting impact on relations between the local people and development agencies.

Nederlof and Odonkor (2006) argue that an integrated approach which differs from the conventional practices of transferring technology would give better results in increasing food production because farmers, who are the ultimate users of technologies are directly involved in the technology generation process .Their view is supported by Warren and Rajasekaran (1993) who point out that integrating IK with scientific knowledge would ensure that the end users are involved in developing technologies appropriate to their needs. Khodamoradi and Abedi (2011) argue that IK does not only have economic aspects but social and spiritual aspects as well. This view is supported by Thrump (1989) cited in Agrawal (2008) observation, that IK encompasses non-technical insights, wisdom, ideas, perceptions and innovative capabilities. The author points out that as more case studies explain the utility of IK, its relevance to development planning will become self evident and as more development strategies done without taking into account the role of IK continues to fail, only the most obtuse will refuse it a place in planned development.

Nkosinomusa, Hughes and Modi (2010) in a study of the use of scientific and indigenous knowledge in agricultural land development and soil fertility found out that, farmers approach is more holistic than the approach of the scientists but, despite the many differences in the approaches comparison of the two approaches showed that there are many links between the two systems. Farmer’s evaluation systems correlated with scientific evaluations. The authors pointed out that the significant agreements between the approaches imply that there are fundamental similarities between them. Therefore, the inclusion of IK into scientific approaches would lead to the development of technologies that are more relevant to the farmers.

The authors in the preceding discussion point out that integrating IK into development strategies for rural areas can enhance impact and sustainability. This research looked at the possibilities of integrating IK with scientific knowledge in the development of food preservation strategies in an effort to make them sustainable.

2.2 Characteristics of IK and Scientific Knowledge

The characteristics of IK and scientific knowledge given by different authors in the literature reviewed can now be summarised as shown in table 2 below

Table 2: Contrasting characteristics of IK and scientific knowledge

IK	Scientific Knowledge
Locally generated by farmers on their farms	Generated by researcher in research institutions
Based on farmers' years of experience, practise and testing	Based on years of scientific experimentation and adaptation trials
Context specific; different rural communities have their own knowledge	Context specific; different AEZ have their own recommendations
Based on principles that may be community specific since they are influenced by local materials and culture	Based on general principles formulated for AEZ which may cuts across different communities
Emphasises survival and settles for low production in return for sustainability in the long-term	Emphasises risk taking for maximum production and profit in the short-term
Requires high labour, depends on local inputs and emphasises diversity	Requires low labour, is highly dependent on external inputs and emphasises monoculture
It is implicit knowledge expressed through values and actions and is orally transmitted	Explicit knowledge easily expressed in words and is often documented

2.3 Operationalisation of concepts

In this section concepts from the literature review that are applied in this research are made operational. Definitions of various terms as they apply in the context of this research and distinctive characteristics of IK and Scientific Knowledge and indicators used to differentiate them in the research are also given. Research framework and means used to verify information during the research are given.

2.3.1 Definitions

The terms and concepts highlighted below are used in this research. The authors mentioned in the literature review give diverse definitions of the terms and concepts. However, the following definitions have been adopted in this research.

Indigenous Knowledge

IK is farmers knowledge based on experience, tested over centuries of use, developed over time and continues to be developed by people in a given community (Boven and Morohashi, 2002)

Scientific knowledge
Scientific Knowledge is knowledge that gives general principles derived from years of scientific experimentation and adaptation trials (Chema, Gilbert and Roseboom, 2003)

Innovation
An Innovation is a “new ways of doing things “or “doing new things “that works in everyday practice (Leewis, 2004).

Sustainable technologies
Sustainable technologies are technologies that ensure an impact beyond ‘transferring technologies that work’ to farmers (Warren and Rajasekara, 1993)

Extension worker
An Extension worker is a person who disseminate scientific information directly to the farmers on behalf of MOA, KARI, NGOs or Universities (Author)

Knowledge
Knowledge is a body of mental inferences and conclusions that people build from different elements of information and which allow them to take action in a given context (Leewis, 2004).

Local innovation
Local innovation is the dynamic IK that is completely internalized within the local ways of doing things and grows by incorporating learning from own experience and knowledge that is gained from other sources (Leewis, 2004).

2.3.2 Research framework

This research explored various sources of maize preservation practises at Mua hill location and classified them as either scientific, indigenous or a combination of both depending on their source of knowledge. The research also identified the contribution of scientific knowledge and IK and compared the contribution of each to maize preservation. Various methods used to circulate and preserve IK in the location were identified. Strengths and limitations of scientific and indigenous knowledge were explored.

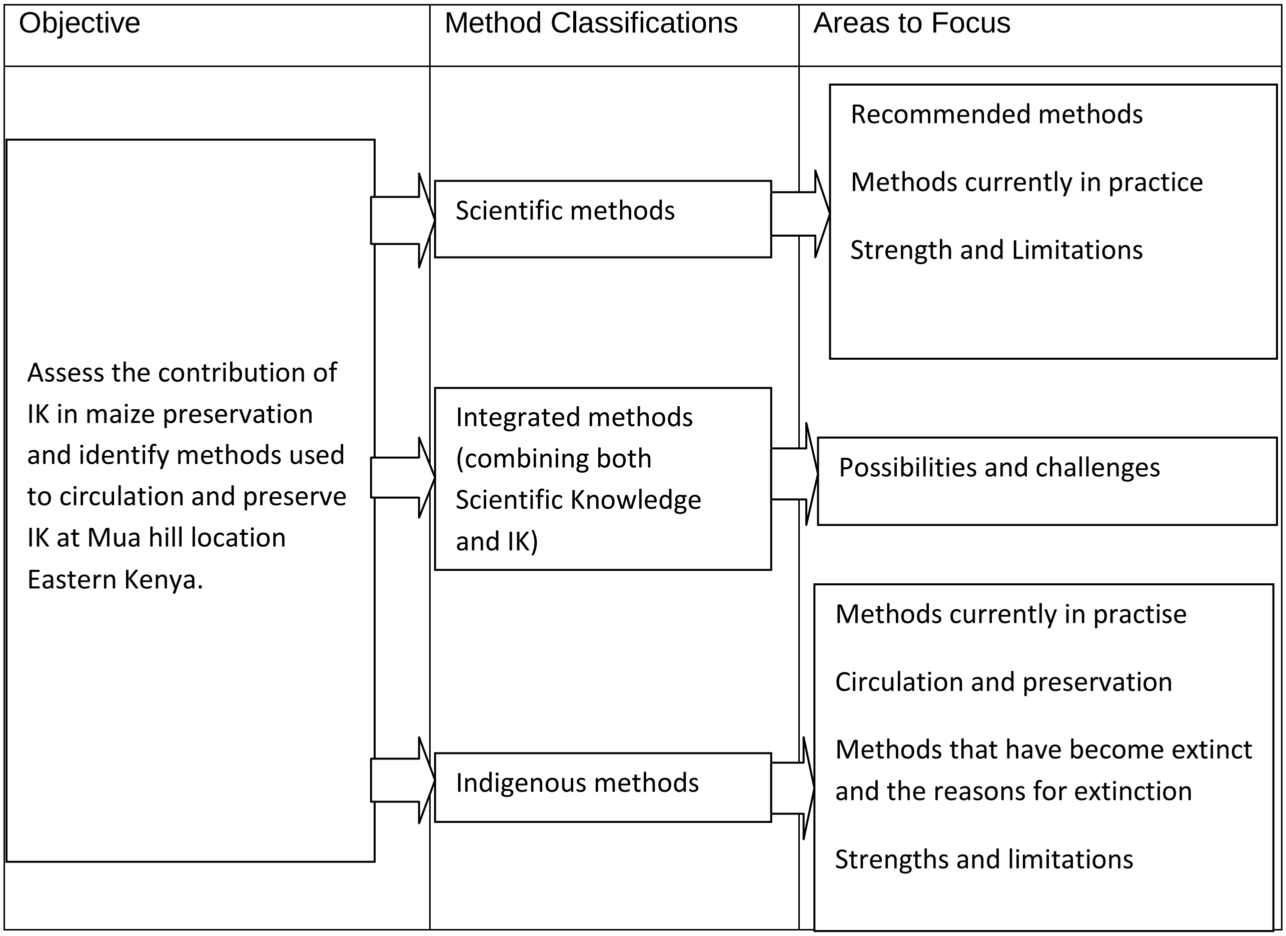

Figure 1: Research Framework

2.3.3 Distinctive characteristics of Indigenous Knowledge and scientific knowledge

Figure 2 and 3 below show the distinctive characteristics of indigenous and scientific knowledge respectively that were used to distinguish and categorise post harvest methods in Mua hill location. The characteristics are based on the information and descriptions given by different author in the literature review. The inner circle shows the characteristic while the outer circle shows the indicators.

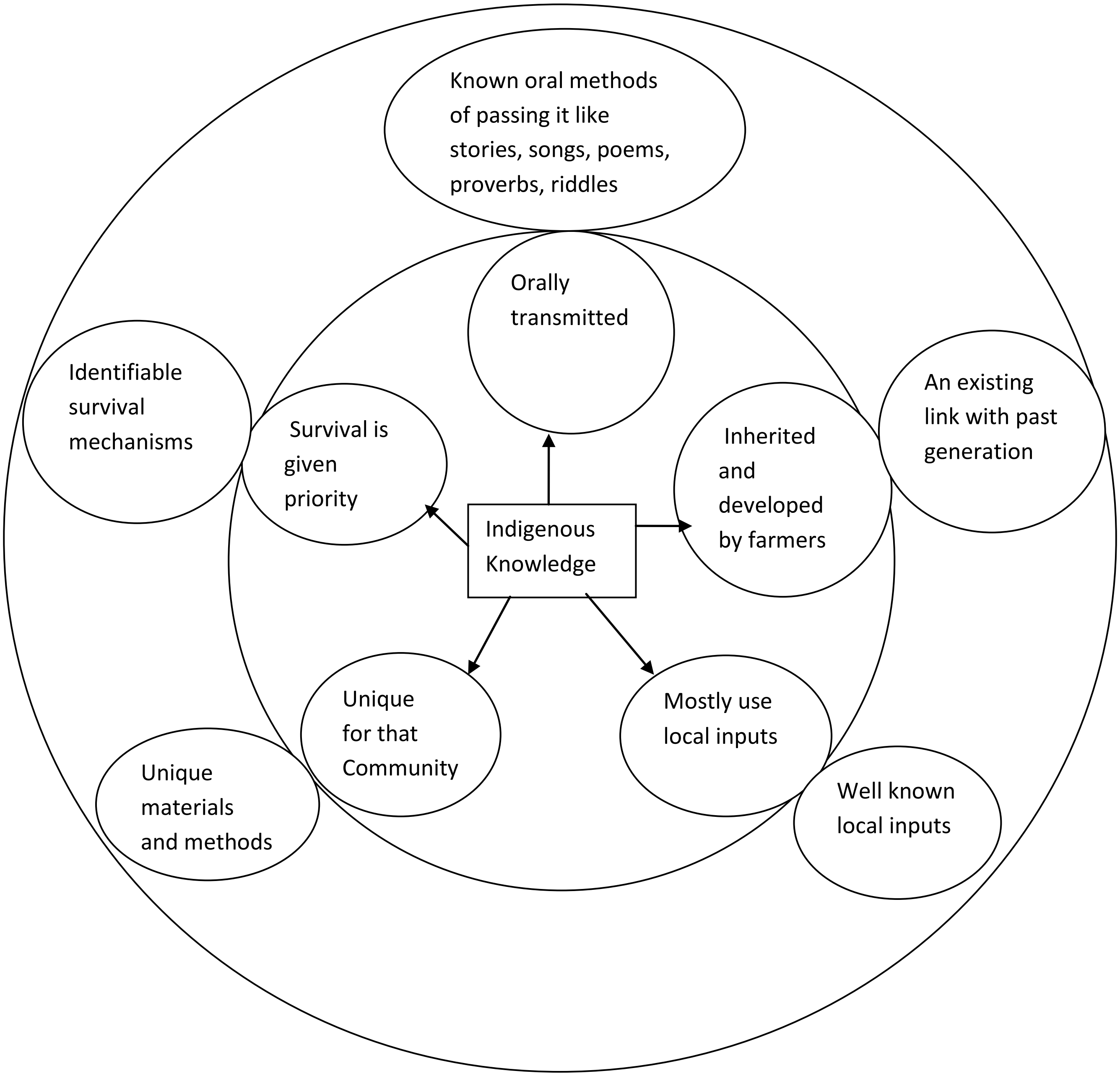

Figure 2: Distinctive characteristics and indicators of IK.

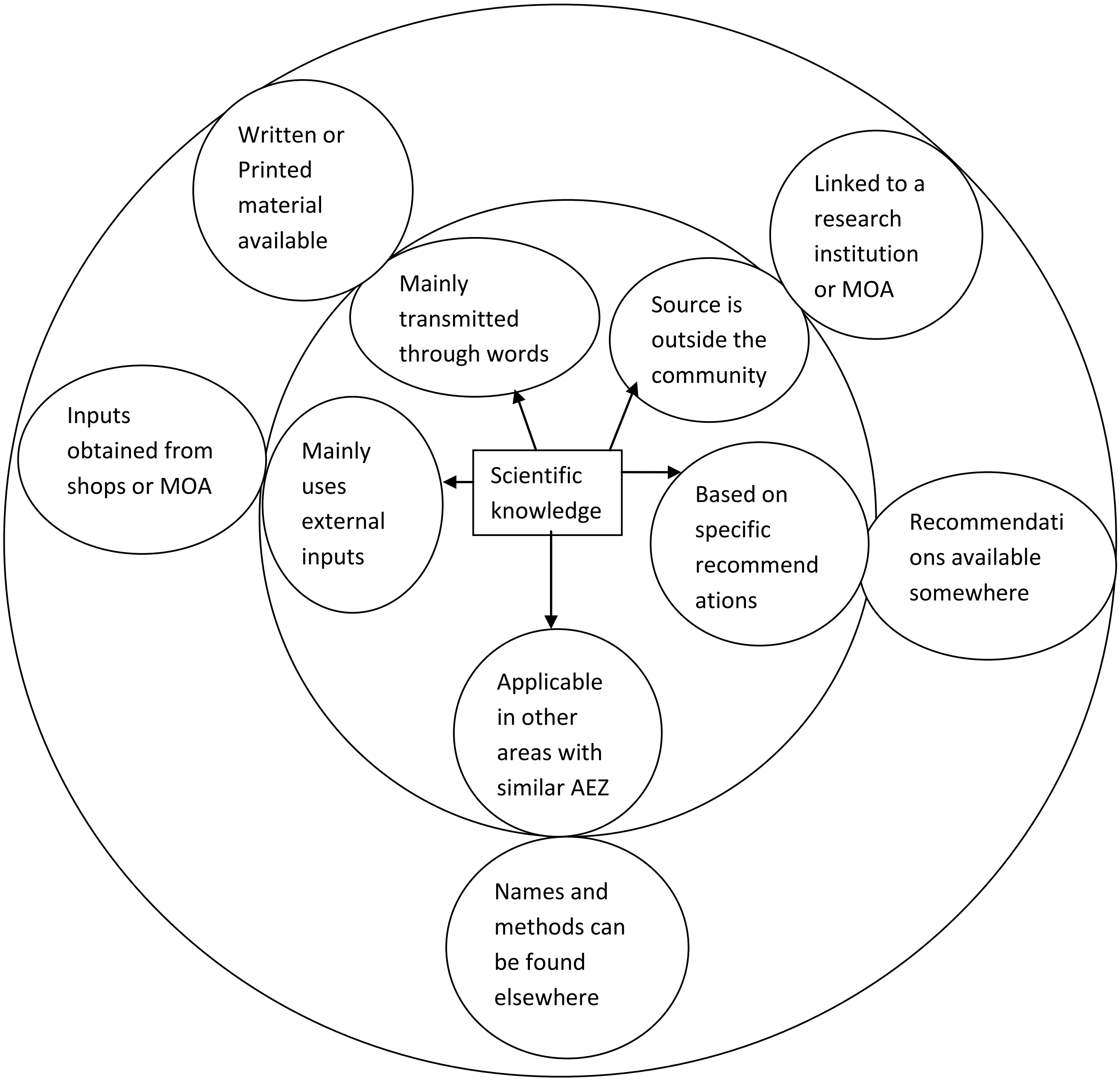

Figure 3: Distinctive characteristics and indicators of scientific knowledge

2.3.4 Information classification and verification

Information obtained was classified and verified using the parameters given in table 3 below.

Table 3: Parameter used to source or to classify information

Information Required	Knowledge category	Means of Verification
Classification of current maize preservation practises	Indigenous	If it has 4 out of the 5 indicators shown in figure 2.
	Scientific	If it has 4 out of the 5 indicators shown in figure 3
	Integrated	If it shows both scientific and indigenous indicators
Strengths and weaknesses of maize preservation methods	IK and Scientific Knowledge	Ease of application Efficacy of the method Affordability by farmers Availability of the information Availability of the inputs Sustainability of the inputs Health implications Environmental implications
Knowledge circulation in the community	Indigenous	Different channels of passing it from farmer to farmer Various methods of passing it from generation to generation
Extinct methods	Indigenous	A list of methods no longer in use Reasons why they are not in use
Possibilities available for IK and Scientific Knowledge	Integrated	Existence of maize preservation methods that have integrated scientific and indigenous knowledge

CHAPTER THREE: RESEARCH METHODOLOGY

This chapter presents the research context, study design, data collection strategy and data analysis.

3.1 Research Context

This section gives some background information of the organisation for which this research was done and why it was done. It also gives some background information on the area where data was collected.

3.1.1 Organisational context

Agricultural Information Resource Centre (AIRC) is a branch of the Ministry of Agriculture (MoA) mandated with sourcing, repackaging and disseminating agricultural information to farmers and other stakeholders in the agricultural sector. The information sourced is put in a library or stored in an electronic database. Some of the information is re-packaged into simple publications for farmers and staff. The centre has radio and video studios; it produces radio programs in Kiswahili language and some vernaculars .It produces video documentaries in English and Kiswahili languages for training farmers. It also has a publishing press. The centres' vision is "to be a choice source of agricultural information nationally and beyond "(MOA 2008, p 11) by fulfilling its mission which is "to provide quality agriculture information to the farming community and other stakeholders using integrated platforms" (MOA 2008, p 11). Hence, this research was done to find out how the information sourced and disseminated by the centre, can be made more valuable and acceptable to the farmers and the other stakeholders thus making AIRC a choice information source.

3.1.2 Study area

This research was done in Mua hill Location of Eastern Kenya. The location lies in the AEZ lower midland 4 which has an average annual rainfall of about 600mm in two rainfall seasons; the long rains (march-may) and short rains (October-November). The major food crops grown in the area are maize, beans, cowpeas, pigeon peas and sorghum. Among these maize is the most important food crop and it is grown by every household twice a year during the two rainfall seasons. The average production of maize is10 bags per hectare and because of the low rainfall the farmers occasionally fail to have any harvest for even two consecutive seasons (MOA, 2010). When the rains fail, the government provides the families in this region with relief food. This area was chosen because first, maize meal is a staple food in the area, maize is therefore an important food crop (MOA, 2010) so it would be easy to find a lot of information on maize preservation. Second, it is a marginal area so it would be possible to find average and poor farmers who may not have access to agricultural information and external inputs and therefore are likely to use IK for maize preservation.

3.2 Study design and strategy

A case study was chosen in order to get in-depth information. A qualitative approach which involved primary and secondary data collection was used in this research. A Desk study was carried out to explore literature on the existing information that would provide a baseline for this research. Information was obtained from books, journals, internet and Ministry of Agriculture(MoA) reports. Two MoA staff were interviewed; a Divisional Crops Officer (Div.CO) and a Frontline Extension Worker (FEW) to get the ministry's maize preservation recommendations and the MoA's methods of communicating recommended maize preservation information in Mua hill location. The Div.CO was chosen because she is the ministry's SMS (Subject Matter Specialist) who deals with maize production at the level closest to the farmers, while the FEW is the ministry's staff who disseminates information directly to the farmers. Information on maize preservation recommendations was also obtained from KARI Katumani. Fifteen farmers participated in this research. Ten of them were women because in the research area maize is a woman's crop and so women would have more information than men. The farmers provided information on the past and current maize preservation methods. They also provided information on how maize preservation knowledge is exchanged in the community and transmitted from generation to generation. Some of the information was obtained through observation and where necessary clarification was sought from farmers and the two staff. The different types of information sourced and their sources is summarised in table 5 attached as annex 2.

3.3 Data analysis

Qualitative and quantitative methods were used to analyse data. The indicators in figure 2 and 3 were used to classify knowledge into indigenous, integrated and scientific. The type of knowledge used in a practise was used to classify them into indigenous, integrated and scientific, using the criteria given in table 3. The parameters given in the same table were used to categorise knowledge quality from the descriptions given by farmers as an advantage or disadvantage. The numbers of people using a method was used to judge the significance of the method. Results were summarised in tables and illustrated as figures.

CHAPTER FOUR: RESEARCH FINDINGS

4.1 The Main Agents of Post Harvest Loss in Maize

The DivCO and KARI Katumani scientists gave the following information regarding the post harvest losses of maize in the research area.

The main agents of post harvest loss in maize are insect pests which include common weevils (*Sitophilus zeamays*), LGB (*Prostephanus truncatus*) and red flour beetle (*Tribolium castaneum*).The insect pests eat maize grains reducing quantity and their faeces contaminate the grains and flour reducing quality. Insect pests thrive best in warm temperatures and in warm conditions they multiply greatly. LGB is the most destructive pest but it's not common. LGB eats grains, sacks and crib timber if no preventive measures are taken and it is so very difficult to control. The weevils are the most common storage pest but they cause less damage and are easier to control than LGB because they respond better to pesticides. Infestation of storage insect pests starts in the field; however the greatest infestation occurs in the store from pests hiding in debris and any remnant maize from the previous harvest. Rodents eat grains and especially the embryo part destroying quantity and seed viability. Rodents are found hiding inside the store and in the bushes around. The most feared loss agent is aflatoxin, a fungal growth that causes poisoning in both human and livestock. Finally a different type of post harvest loss is human. Thieves steal maize causing loss to the owners.

4.2Maize preservation Methods Currently in Practice

Maize preservation methods found in Mua hill location include growing suitable varieties, proper drying before storage, proper storage and effective pest control. The status of each method, as presented by the interviewee and confirmed by observation is given in this section.

4.2.1 Growing suitable maize varieties

According to the FEW, two varieties are recommended by MoA; H512 and katumani composite. These varieties are recommended because they have a high yield potential and mature early, therefore have time to dry well before the next rains. All the fifteen farmers interviewed grow recommended varieties but the local variety has better storage qualities. Five of them grow small amounts of local variety as well. The five said they grow the local variety mainly because of its good taste and because they inherited seeds from their parents. The farmers said that they have gradually moved away from the local variety to recommended varieties mostly because the recommended varieties have a higher yield potential than the local variety. They said that the farm size has become small and drought is frequent so they grow the varieties that promises higher yield.

4.2.2 Proper drying before storage

Eight of the fifteen farmers interviewed dry maize by hanging cobs inside and/or around buildings as shown in figure 4 and 5, until they completely dry. These farmers said they choose this method because it is not labour intensive and it discourages thieves. Three farmers spread cobs on mats or sacks outside under direct sunlight during the day as shown in figure 6 and take them inside a house at night. They said they choose this method because cobs dry faster under direct sunlight and taking maize inside the house saves it from thieves. They said that the method is labour intensive; however they harvest low quantities so shifting it is manageable. Four cut and stalk maize near the home as shown in figure 7.

Figure 4: Drying cobs by hanging around a crib

Figure 5: Drying cobs by hanging indoors

Figure 6: Drying cobs by spreading them outside

Figure 7: Drying maize by cutting and stacking

4.2.3 Proper maize storage

Ten farmers store maize inside a house; seven store it as cobs either hanged or spread over sacks on the floor while three store it as grain in sacks. Two farmers store it in traditional cribs shown in figure 8 and 9. Two farmers store it in modified cribs shown in figure 12 and 13. One farmer stores it in a modern crib shown in figure 11. Observation revealed that the traditional cribs have sides made of woven twigs and the roof is thatched with grass. They are well ventilated; so air can flow through cooling and drying maize. According to the oldest interviewee who owns one of them, these are the oldest type of cribs existing in the village. The farmers who own traditional cribs said that their cribs preserve maize better than their neighbours because they remain cool throughout and storage pests do not like cool environments. Only one other grass thatched crib was seen in the research area.

Figure 8: A round shaped traditional maize crib

Figure 9: A square shaped traditional maize crib

The FEW said that, the greatest challenge for making traditional cribs today would be getting enough grass to thatch. According to him traditional thatching grass was a special variety and it is no longer grown on farms. In the past it was grown among the crops in rows to serve as a windbreak and along borders to demarcate land. It has now been replaced by more valuable crops. He said that the little thatch grass now available which is a different variety from the traditional one is mainly mixed with maize stalks to make livestock feed as shown in figure 10

Figure 10: Mixing grass and maize stalk to make livestock feed

One of the farmers, a man in the mid-fiftieth described the changes he has seen the roof of a maize crib go through since his childhood. The oldest crib he ever saw was thatched with grass. The grass was later replaced by banana pseudo stems. The banana pseudo stems were in turn replaced by tin material made from rejected tins when a canning factory was opened nearby. By then the demand for pseudo stems as cattle feed had gone up as more farmers bought exotic animals which are heavy feeders. Finally the tin roof was replaced by iron sheets as people became modern and got income to buy them. From observation replacement of the roofing material was not done by all farmers at the same time; all types of cribs except the pseudo stem roofed were found in the area in different shapes and sizes. Figures 12 and 13 show some of the modified cribs.

Figure 11: A Modern maize crib
.

Figure 12: An iron sheet roofed modified maize crib

Figure 13: A Tin roofed modified maize crib

One farmer who has an iron sheet roofed crib in the same compound where his aged mother has a grass thatched crib said that the weevils prefer maize in his own crib to that in his mothers crib. He attributed this to the temperature differences in the two cribs. During hot weather the iron sheets roof makes his crib warm providing a favourable environment for weevil's infestation and multiplication while the grass thatched roof on his mothers crib keeps the temperature cool throughout. When asked why he did not change his roof to grass thatch after he discovered it is more effective, he quickly responded that his wife would be stigmatised by her age mates because of moving back to primitive life.

4.2.4 Effective pest and disease control

Disease control

All the 15 farmers try to control fungal growth by drying maize well before storage. However the farmers complained that this is become increasing difficult because of the changes in weather patterns and the need to store maize in the house to protect it from thieves. They said that in the past it was almost possible to predict the very day the rains would set in but today it is almost impossible. The rains at times set in unexpectedly before the crop is ready for harvest forcing them to hurriedly harvest it to protect it from rotting and to prepare land for the next crop. This maize is harvested at high moisture content and there is no sun to dry it because the rainy season has set in. Maize dried under direct sunlight and stored in well ventilated cribs has less chances of fungal growth but thieves make this difficult forcing farmer to store it inside a house which may not be well ventilated The FEW said that cases of aflatoxin poisoning have increased in the last ten years.

Use of insecticidal plants to control pests

Three farmers apply chemical pesticides to the grains and cobs to protect them from pests. Three farmers use insecticidal plants to control pest in maize that is meant for consumption. Before placing maize in the crib, they put dry leaves or branches of Mexican marigold (*Tagetes erecta*) or neem (*Azadirachta indica*) or lantana camara (C*amara vulgaris*) plants on the crib floor. After placing maize other similar leaves are placed on top. The leaves have a repellent odour that keeps the insects away. Some said that they also crash dried hot chillies to powder and use it to dust cobs and grains to control insects and rats. Since pepper is not poisonous, the grains are safe for consumption.

Three farmers preserve seed by hanging cobs over fire. Two farmers said they use insecticidal plants to preserve grains meant for seeds. They crash a mixture of Lantana camara (C*amara vulgaris*) and Tithonia (*Tithonia rotundifolia*) leaves into powder and then mix it with seeds to control pests and rats. They also use a concoction made by soaking a mixture of Mexican marigold (*Tagetes erecta*), Sodom apple (*Solanum linnaeanum*) and hot chillies (*Capsicum annuum*) in water for some time, seeds are put into the resulting liquid concoction and then dried. The farmers said that because Mexican marigold (*Tagetes erecta*) and Sodom apple are poisonous, the concoction ensures that the seeds are not eaten no matter what and this ensures there is always seed for the next season. The older farmers said that this was the community's strategy of preserving own seed. The seed was stored in a communal place and the elders made sure that every person saved some.

Observation showed that the insecticidal plants used for maize preservation are not planted or tended by farmers; they grow naturally, the FEW confirmed this observation. He said that Lantana camara (C*amara vulgaris*) shown in figure 14 and Sodom apple (*Solanum linnaeanum*) which he is pointing at in figure 16 grows wildly in the pastures while Mexican marigold(*Tagetes erecta*) shown in figure 15 is a weed and grows voluntarily among crops.

Figure 14: Lantana camara . (C*amara vulgaris*)

Figure 15: Mexican marigold (*Tagetes erecta)*

Figure 16: Sodom apple . (*Solanum linnaeanum*)

In figures 17 and 18 , one of the farmers show simple local grinders used for crashing dried insecticidal plants to powder.

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Smoking maize and using ash to control insects

One farmer said he sometimes mixes maize with ashes from her hearth like the one shown in figure 19 to control pest. She said that ash controls pest if maize is stored for a short period and since she does not harvest much maize to last long, ash manages the pest. However, if she sees any sign of LGB she sells the maize immediately because she knows she will lose it all to the pest. She said that no chemical can control LGB and it is very destructive so farmers call it "osama" a name reflecting the magnitude of the damage it causes. Three farmers select choice cobs and preserve them for seed by hanging them on logs or wires placed above the fireplace as shown in figure 20. The hot smoke from the fire dries and covers the cobs with soot making them unpalatable to pests. A black layer of soot can be seen covering the walls and roof of one of the interviewee's kitchen shown in figure 19.

Figure 19: A Soot covered kitchen
.

Figure 20: Maize being smoked by hanging over fire

Controlling thieves

All the 15 farmers interviewed mentioned thieves as a threat to their maize; the farmers attributed stealing of maize to food scarcity resulting from low crop yields in the area. All the homes visited had dogs like the one shown in figure 21, the farmers said dogs alert them of any foreigner entering the compound both day and night. Moreover, some dogs are fierce and attack intruders; this discourages thieves from entering their compounds. Ten farmers protect maize by storing it inside the house like the one shown in figure 22. Observation revealed that some cribs like the one shown in figure 23 and all the houses have locks. The owners said they keep them locked whenever there is no one in the compound to avoid theft. Observation also revealed that all the cribs were built next to the main house as shown in figure 24. The owners said that building cribs next to the main house makes monitoring of thieves' activities at night easy.

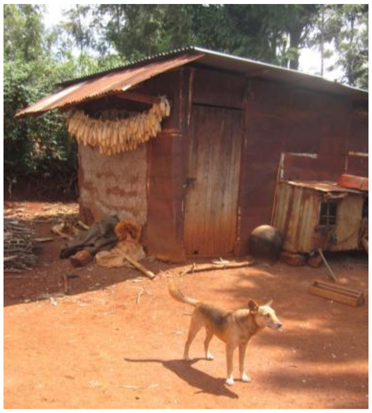


Figure 21: A Dog guarding a compound

Figure 22: Maize stored indoors

Figure 23: A locked crib

Figure 24: A Crib built next to the main house

Controlling rodents

Figure 25: A Cat

Ten farmers had cats to control rats. Cats like the one in figure 25 kill and eat any rat that they come across. Five farmers said they use hygiene methods like clearing the stores of all debris and clearing the bush around the house and cribs to control rats. According to the farmers the rats population has greatly reduced today because of the modern lifestyle; the modern type of houses and the relatively high hygiene standards makes it difficult for rats to survive. Farmers said that the grass thatch roof was an ideal hiding place for the rats.

4.4 Maize Preservation Methods Recommended by the MoA

KARI Katumani scientists and the FEW said that the methods recommended for maize preservation in the Mua hill location are as follows:

Recommended varieties H512 or katumani composites should be planted because; they mature early giving maize time to dry before the next rains. Maize should be timely harvested at physiological maturity stage to saves losses due to storage insect pests like LGB and weevils whose infestation begins in the field and from thieves. Maize should be harvested and transported carefully to avoid mechanical damage which lowers quality and makes it susceptible to attack by storage insect pests. The stalks should be cut down and cobs de-husked immediately. The stalks and husks should be either burnt or fed to livestock immediately to ensure elimination of possible hiding and breeding places for post harvest insect pests. Maize should be dried as soon as possible by spreading it outside under direct sunlight. Maize should be shelled immediately it dries and treated with storage pesticides. All maize should preferably be shelled because the pesticide is more effective on shelled grains than cobs. Storage pesticides have a shelf life of six months so should be reapplied after every six months.

The maize crib should be raised one meter above the ground and rat guards placed across the stands to prevent rodents from entering. The sides should be well ventilated to permit air circulation and so reduce mould damage. The roof should be corrugated iron sheet to keep maize dry. The crib should not be more than one meter in width so that wind may blow through easily and make drying efficient. Debris from previous harvest which may harbour weevils, LGB and rats should be cleared. The store should be cleaned and disinfected with super actellic dust or other storage fumigants. The storage bags should be disinfected with permenthrin 25% powder to eliminate all storage insect pests. Rodenticides should be placed at strategic places in the store to kill rats.

4.5 Farmer's Perception on Recommended Scientific Technologies

Farmers said that the local variety has a good cob sheaths that make weevil infestation in the field difficult. When they cook grains from the local variety, the food stays fresh longer than food from recommended varieties. They select local variety seeds from previous harvest unlike recommended H512 that must be bought. When they use fertilizers and manure the recommended varieties produce more than their local variety, but if they don't put any inputs the local variety produces more. Farmers said they appreciate and grow recommended varieties despite the poor preservation qualities because quantity is a priority, given that the land size is small and productivity low.

Farmers said that the timely harvesting of maize recommended by the MoA is something that has been practised for generations in the community. They had learnt from their parents and confirmed through experience, that drying maize well before storage increases the shelf- life. They had also observed that when they take too long to harvest, weevil's infestation is high so concluded it starts in the field. However, even though they know that timely harvesting and drying maize well before storage is crucial for preservation, yet the change in weather pattern and unpredictable setting of rains has given them a real challenge. They said that sometimes rains set in unexpectedly before maize is ready for harvest and they have to clear it from the field. When this happen drying under the sun as recommended does not work, they have to dry by hanging cobs in and around the buildings. The crop takes too long to dry and chances of mould growth are high.

Farmers agreed that maize should be handled carefully to avoid mechanical damage as recommended by MoA. They said that one way to achieve this is to use hands to thresh. They reflected on easily this was achieved in the past when the family and community labour was readily available; because threshing is labour intensive. They would shell maize in groups, singing, telling each other folktales, riddles and proverbs; this made work interesting and easy. However, today labour is unavailable, in most homes only women spend the day at home, men are away working to get income and children are in school. Labour shortage makes it too expensive for the poor farmers. Farmers said that to make shelling easy they put maize in a sack, tie it and beat it with wooden sticks to detach grains from the cobs. The beating detaches most of the grains and those that remain are loose and easy to thresh. But, beating the cobs may cause mechanical injury to the grains. They said that the simple shelling equipment designed by RTDC a branch of MoA, are not found in local shops.

Eleven of the interviewed farmers store maize in cobs and shell only what is required at a given time, contrary to the MoA‘s recommendation. The interviewed women said that shelling all the maize at once makes it very hard to control daily consumption. When all maize is shelled it’s likely for the family to consume too much and exhaust all the maize before the next harvest. It also makes it easy for men to sell it for income; something very common, since there is no cash crop in the area. They sell it when everybody has just harvested and the price is low, but within months the family food reserve is exhausted and maize is by then too expensive. The farmers said that there are traders who buy maize cheaply soon after harvest and store it only to sell it later in the season at a higher price, to the same people who sold it. The women are particularly affected by this because they are responsible for feeding the family while men earn and control income. Therefore the women said they prefer to keep maize in cobs because it’s rarely sold as cobs.

Farmers acknowledged that burning or feeding maize stalk and husks immediately to the animals as MoA recommends is a very effective method of controlling storage insect pests but unrealistic. They keep livestock in addition to food production and maize stalk is an important fodder for the animals as shown in figure 26 and 27, so burning it is illogical. They cannot feed all the maize stalks and husks at once to the animals because fodder is scarce, so they have to make it last as long as possible. Moreover animals like it so it is mixed with other types of fodder like dry grass to improve palatability. The women said that after shelling, cobs become an important source of cooking fuel, giving them a break from daily firewood fetching.

Figure 26: Maize stalks reserved as fodder

Figure 27: Maize stalk fodder provided to cattle

Farmers reported that the traditional crib is able to achieve all what the recommended crib does and it is even better in controlling pests because the grass thatched roof keeps the temperature in the crib low all the time while that in the recommended cribs fluctuate depending on the weather. They said that materials for making the recommended crib are expensive while indigenous cribs use local materials. The farmers said that in the past maize cribs were constructed by women because traditional cribs are easy to construct. The women could also maintain them because materials were locally available. On the contrary the recommended cribs are difficult to construct and material are purchased from shops. This makes the women dependent on men because constructing and maintaining is now a man's job. However, the farmers said that today the society associates grass thatched buildings with poverty and backwardness. One farmer said that since he did not want to be labelled primitive and he could not afford iron sheets he used tins which are cheaper and almost look like iron sheet to roof his cribs.

Three farmers said that recommended chemical pesticides are effective in controlling storage pests except LGB, but one said they are ineffective even in controlling weevils. All the 15 farmers expressed fear that consuming maize treated with chemical pesticide can cause health problem. They mentioned some side effects like allergies which in their view result from consuming maize treated with chemicals pesticides. Two farmers said that rodents learn after sometimes that a substance is poisonous and avoid it frustrating their efforts, so they have to keep changing the bait. They also fear that the rodenticide can kill non-targeted animals.

4.6 Extinct Maize Preservation Indigenous Practises

The interviewed farmers mentioned the maize preservation practises presented in this section as practises they remember seeing in the past but which are no longer practised. They also gave the reasons why they are not practised anymore.

4.6.1 Storing maize in the loft over the fire place

In the past farmers made a storage place in the loft over the fireplace and maize cobs would be stored there. Hot smoke from the fire would dry and cover them with soot making them unpalatable to storage pests. The soot would be removed by cleaning the maize before eating. No loft was found in any of the homes visited during the research and farmers said that this method is not used anymore. Farmers said they no longer smoke maize for consumption because it considered unhygienic today.

4.6.2 Storing maize in earthen pots

Large earthen pots were used to store maize in the past. An earthen pot when well closed and sealed with cow dung could store maize for up to one year without any pesticides. Earthen pots that were very common in the past for cooking have gradually been replaced by metallic pots. Modern pots have thrown traditional earthen pot moulders out of business and pots especially the big size specially designed for grain storage is no longer available.

4.6.3 Storing maize in gourds

The olden day's farmers in the area used big gourds to store maize for as long as one year without any treatment. The gourd would be closed with a cork and sealed with cow dung to make it airtight suffocating any insect pest already present. Cow dung was a repellent and it would keep pests off. The gourds were grown among the food crops. The big gourds are no longer grown in the area or in the surroundings so they are not available for maize storage.

4.6.4 Storing maize in woven baskets

In the past maize was stored in woven baskets. The basket was lined with grass and smeared with cow dung to seal it so that no air got in, so no insect could survive. This basket known locally known as *iinga* would hold up to 12 bags of threshed grains and preserve them for as long as 5 years without any pesticides. Farmers used *iinga* to preserve maize that would provide food in seasons when the crop would fail and there would be no harvest. Farmers said the baskets have not been in use for a long time and only five interviewees; the oldest in the group could remember them. Only the oldest interviewee could describe in details how the basket was made; the other farmers referred to her as the only person who had the information.

4.6.5 Use of sisal gunny bags to store maize

Sisal bags were the main bags used to store maize in the 1970s and early 1980s. The farmers who had used them reported that they were biodegradable and did not warm up in hot weather. The bags were slowly replaced by imported synthetic bags. The main sisal bag factory called East African bags was closed down in the late 1980s.

4.7 Strength and Limitations of Maize Preservation Methods

Farmers said that recommended chemical pesticides are more effective in controlling pests than their own plant extracts and ash. They are also easy to apply because they buy them readymade and all they need to do is mix them with grains. On the other hand, preparing indigenous pesticides is a long cumbersome process; they have to search and harvest the plants which are not easily available, dry and crash them to powder before they can be ready for use. Similarly accumulating enough salt in today's kitchen is difficult because fire is made only when it is needed because of firewood scarcity. The indigenous pesticides require large volumes of raw materials to make Moreover, people today are conscious of food hygiene so do not like grains mixed with ash. The farmers said that generally raw materials required for making pesticides locally are very scarce and they are getting less every day, so indigenous pesticides can only be used to store low quantities of maize.

Farmers said that the scientific crib is easy to construct and the materials are available in the shops but, making a traditional cribs requires searching for thatching grass which is scarce. Some said that the materials for making the recommended crib are expensive and unaffordable, but making an indigenous crib is cheaper because it uses local materials. Three women said they prefer the indigenous crib because they can construct and maintain it without relying on men. The older women said that in the past women were responsible for making cribs. Weaving the twigs for the sides, cutting and preparing grass for thatching is manageable to them and they would do it as a group, however the recommended crib is mainly the work of men. They rely on men who at times are not available especially to do repairs which are common. They also depend on men to buy materials to make and maintain the crib which may not be a priority to the men. The farmers said that the traditional crib is more effective in controlling weevils and LGB because the temperature inside remains constant unlike in the recommended crib which at times warms up creating a favourable environment for pests.

Farmers said that recommended maize varieties have a high yield potential but they require a lot of inputs like fertilizer and pesticides to achieve the high yield and, in the absence of inputs the yield is very low. The local variety has a low yield potential so, even if input are used production is still low, however it is adapted to the local condition and in the absence of inputs it gives higher yield than the recommended varieties. Grains from local variety have a good taste and the cooked grains have a longer shelf-life than those from recommended varieties.

Farmers said that cobs of the local variety resist weevils better than those of the recommended varieties. Farmers said food is a priority, so they prefer the recommended varieties as long as they can afford some inputs. Moreover those who grow local varieties are labelled backward by the society because of the high and long promotion done for the recommended varieties by the MoA in the area.

The FEW said that indigenous practises like ash and plant concoctions have not been researched on so the Active ingredient (AI) and exact dosage are not known. This makes it hard for extension workers to promote them because they don't want to be held responsible for any food poisoning or takes responsibilities of method failure. Moreover even if the leaves used to repel pests in the crib are not eaten they make the food to have a bad smell.

4.8 Methods used to Communicate Agricultural Information

The DivCO said that the ministry disseminates maize preservation information through various methods. The extension worker trains farmers both at an individual and a group level. Information and skills are given through demonstrations, agricultural shows, exhibitions, field days and educational tours to research centres or other communities. The ministry also makes publications like brochures and simple book for farmers, AIRC makes video documentaries on various agricultural aspects and these are used by the staff to train farmers but farmers can buy them as well. AIRC makes radio programs in Kiswahili the national language and in vernaculars. However the DivCO said that the radio programs and video documentaries scope in terms of farmers who watch DVDS or listen to the programs is low are aware of their existence and therefore.

The farmers narrated how IK was circulated in the communities in the past and how it was preserved from generation to generation. According to the farmers who were interviewed, in the past girls would spend time with their mothers while boys spent time with the fathers as they carried out their daily chores. The children learnt different skills from their parents through listening, observation and practise. In this way indigenous practises were passed on from parents to children and from one generation to the next. New information obtained from sources outside the community, from neighbours and from personal experience was passed to the children and it became part of the IK to the next generation.

They narrated how in the olden days farmers would unite and carry out tasks communally. The women would form groups called *ngwatio* (join hands) and they would move from farm to farm working on each other's farm. This was especially so in seasons when there was a lot of work to be done like during threshing. Women made and repaired cribs in groups. In the process of working together and visiting each other's they would learn from each other through observation and exchanging ideas. As they worked they sang folksongs and told each other folktales, riddles and proverbs; all these were capsules filled with rich messages. Farmers said that there were strong social bond in this community and many social functions like; childbirth celebrations, dowry payment gatherings, circumcision ceremonies, village dances, weddings ceremonies and burials. The social functions were well attended then and some like burials took many days. These social gatherings provided forums where information could be exchanged and spread easily in the community.

The older farmers in comparing how information was passes in their youth and today made the following description of their current community. Unlike in the past, today the social networks are weak because people have now become more individualistic and independent. Today men are less involved in agricultural but in other forms of income generating activities so they hardly have much agricultural discussions in their social gatherings. Moreover social gatherings are few and not well attended like in the past. Weddings are good examples of how different social gatherings are today; in the past a wedding was a community affair, it was celebrated by the relatives , friends and neighbours in the village, it was open for all but today the couple invites only a few people by cards and its mostly in town limiting the number of uninvited villagers attending.

The children today spend most of their time in school away from the parents and they rarely see the parents practice the maize preservation skills. After completing school children want to move away from the farm to seek formal employment in town. Those who remain in the rural areas embrace modern maize preservation technologies because they are educated. Farmers said that IK is now in the custody of the old people especially women since maize is a women's crop. Those who hold it are ashamed of sharing it because it is associated with poverty and backwardness; moreover almost nobody is interested in it. When the oldest interviewee now in her eightieth was asked why she has not passed the woven basket knowledge to anyone she said that nobody is interested. When one of the farmers was asked why nobody has started to mould storage pots again now that LGB is a threat and chemical pesticides are either not working or are too expensive, he said that pots belong to the past so nobody would be interested in them today.

Farmers said that, there are still forums where they can meet and exchange information. Social functions though few and not well attended are still held today. Travelling is much easier today so many of them said they get opportunities to travel outside the community learn. One farmer mentioned an education trip he participated in, they went to Kitale the main maize growing district in the country. They interacted with the Luhya tribe who live there and learnt new maize preservation practices. There are documents on maize preservation practices now available which the children and the modern young farmers who are now educated can read.

CHAPTER FIVE: DISCUSSION

This chapter discusses the results given in chapter four. In the discussions the information from the results is also compared with the findings of the literature review.

5.1 Maize Preservation Methods Currently in Practice

This section discusses the findings on the maize preservation methods in practice

5.1.1 Growing recommended varieties

Results show that all the farmers who were interviewed grow recommended varieties, but a few also grow local varieties in small quantities. This indicates that the local variety which has undergone indigenous breeding for years, to fit the local conditions and needs has almost been replaced by the recommended varieties. The main reason given by the farmers for replacing local varieties with recommended varieties is yield. Scientist's seem to have had yield as a priority in their breeding program because, according to farmers the local variety has various advantages over recommended variety; it has a better taste, and better storage qualities As the need for population increases the need for food increases and the land size decreased. Scientist bred a high yielding variety in response to those changes but farmers did not. The local variety may be valuable but farmers are faced with new threats that make it unsuitable. The scientific knowledge was able to adapt to challenges' of increasing population but the indigenous knowledge was not.

The recommended H512 seeds have to be bought every season because it is a hybrid. Moreover, to get high yield both H512 and katumani composite require a lot of inputs to grow and preserve. Local inputs cannot sustain production so scientific knowledge provides a solution by providing fertilizers; the grains are susceptible to storage pest so scientist provides chemical pesticide which if used as recommended, effectively controls the storage pests. This confirms Dewalt (1994) observation that scientific methods are highly dependent on inputs from external resources. The external inputs are too expensive for many small scale farmers as pointed out by Tillman (1995) cited in Röth (2001), Hiemstra, Reijintjes and Werf (1992) and Dewalt (1994). Moreover, while these inputs are important in ensuring high production and food security for the present, the long term implication like environmental and health impact is not taken into consideration. They are also potentially dangerous in causing degradation of ecological systems as pointed out by Dewalt (1994).

Growing hybrid varieties means that the farmers do not need to preserve seeds using the indigenous methods since the recommended varieties both H512 and katumani composites are already treated with chemical pesticides at the time of purchase. Seeds for katumani composites can be replanted, but many farmers did not know this, they thought that seeds for all recommended varieties must be bought. Moreover, own seed selection and preservation is not promoted alongside the variety by MoA. The reason for this could be the scientists' belief that the indigenous methods of seed preservation are primitive and so should be replaced as stated by Michael and Herweg (2000) cited in Röth (2001). It also reflects Gurung (2002)'s view that policy makers and researchers believe that professionals and not farmers should determine what works best. The results show that the number of people preserving own seed using IK is very low an observation that confirms Michael and Herweg (2000) cited in Röth (2001) statement that the low attitude of scientist towards IK has contributed to a lot of decline in local peoples self confidence and has brought about their strong dependence on external solutions.

5.1.2 Drying maize well before storage

The results indicate that farmers use various drying methods among them spreading maize outside. This method is recommended by MoA and farmers said it is also a traditional practice. However, the global climate change has affected weather pattern and the onset of rainfall seasons is no longer predictable. The unpredictable weather patterns and the high cases of maize theft make this method unsuitable to most farmers. This is because it involves taking maize in and out of the house every day until it dries completely, to protect it from rain and thieves and this requires a lot of labour. The results indicate that family labour is scarce since children attend school and many men spend the day away from home seeking income. Women are left at home to do the daily chores which are involving, so moving maize in and out of the house daily is difficult for them. Hiring labour is expensive because there are few people available for hire, so the price is high. As result farmers prefer to hang maize in and around buildings, where they can leave it until it dries and in some cases until it is all consumed. The results show that farmer's methods of drying are not contradictory to the recommended method but complementary as Khodamoradi and Abedi (2011) states. They also confirm Leeuwis (2004) statement that scientific knowledge and IK can enrich each other and deliver important ingredients for innovation in agriculture.

5.1.3 Proper maize storage

The results indicate that only one farmer out of the fifteen interviewed stores maize in the recommended crib, this is a very low number considering the resources the MoA and researcher have put in place to design and disseminate the technology even through past the rural structure program. The reasons given by the farmers for not adopting the crib are that the crib is expensive to construct and it is not very effective in controlling insect pests. The number of people using indigenous cribs to store maize is also low and the reason given for this was that modernisation has put pressure on farmers to move away from the traditional grass thatched buildings including maize cribs, which it has labelled primitive, to modern buildings which have iron sheet roofs. This supports Agrawal (2008)'s observation that modernisation is a threat to the lifestyles, practices and culture of small scale farmers and indigenous people. Moreover, the high quality indigenous thatching grass which was once grown is no longer grown because it has been replaced by crops considered more valuable in the modern world.

Because of modernisation pressure and MoA recommendation, farmers who have no money to make the recommended crib in the exact design have been modifying the traditional crib. This confirms World Bank (1998) report that indigenous practise can adapt in response to gradual changes in the social and natural environment since they are interwoven with peoples' cultural values. It also confirms the statement by Leach and Scones (2006), that the very low income of the rural farmers reduces the incentive to use high input technologies, as a result approaches go though several modifications over the years, increasingly incorporating practises that are less input demanding. This supports Agrawal (2008)'s observation that farmers experiment and innovate by combining their existing knowledge with new information. The results show the crib has gone through several modifications as one farmer described and several shapes and designs of cribs were found in the research area. The results indicate that the traditional crib is the most effective of all the cribs, in controlling storage insect pests. The women, who are the people responsible for preserving maize, can easily construct and maintain a traditional crib. However, it has given way to modified cribs as farmers strive to achieve the recommended crib due to modernisation. And as Leach and Scones (2006) put it, new technologies have obscured an important opportunity to spread an already tried and tested' old" technology adapted to these particular local circumstances.

Results indicate that in the past farmers had five maize storage devices and these were cribs, earthen pots, woven baskets, large gourds and the loft. Maize for immediate use was stored in cribs; maize to be used within one year was stored in well sealed earthen pots or gourd and maize that could be used even five years after the harvest was stored in woven baskets. People in this community had their own strategic food reserves at the individual and community level, unlike today when they mostly depend on the national food reserve, NCPB silos controlled by the government. Results indicate that in their indigenous practises, farmers had a lot of knowledge that served to meet their needs. They knew that low temperature is very unfavourable for storage pests; they also knew that the temperature inside earthen pots, gourds and grass lined basket is low and effective in controlling the pests. They knew that without air insects cannot survive, so they sealed the storage vessels completely to make them airproof. They knew that cow dung repels insects' pest, so they smeared a layer of cow dung on all openings. Farmers knew what storage device can preserve maize for only a short time and what can preserve it for long. All this shows that farmers are not ignorant and their knowledge is not primitive rather, IK is a complex and sophisticated system of knowledge drawn from centuries of experience, testing and wisdom of local people (World Bank, 1998). These results also agrees with what Agrawal (2008) remark about indigenous population; they possess highly detailed and richly complex information about agriculture and as Thrump (1989) cited in Agrawal (2008) puts it, IK encompasses non-technical insights, wisdom, ideas, perceptions and innovative capabilities.

5.1.4 Effective Pest control

Results indicate that farmers in Mua hill use several methods to control pests among them chemical pesticides, field and storage hygiene, timely harvesting, smoking, ash, powders and concoctions from insecticidal plants and cats. A majority use timely harvesting of maize and hygiene methods only to control pests, because the harvested maize does not last long. The poor harvest explains why there is a lot of maize stealing in the area which has forced farmers to put special effort to protect it. Use of chemical pesticide was said to be the most effective way of controlling pest similar to what Padaria et al. (2009) found out in the IK validation study. But results indicate that very few farmers use chemical pesticide even though many know that they are more effective than indigenous pest control methods. They would prefer to eat grains mildly infested by pests rather than treat it with chemical pesticides whose effect on the body they were not sure. This is a confirmation of what was pointed out by Galjart (1976) cited in Saidou (2006) that apart from ignorance, incapacity and reticence can also hinder farmers from adopting some scientific innovations. The results also show that there are few farmers who still use less effective methods like ash to control pests because as Gadziravi, Mutandwa and Chikuvire (2008) observe the farmers' dilemma is how to ensure food security from one season to the next at low crop preservation cost. Apparently they are willing to trade off efficiency of the preserving method for convenience and affordability. In the past a concoction made by mixing Mexican marigold, Sodom apple and chillies was commonly used to dress seeds. This poisonous concoction ensured that seeds were not eaten even in time of drought no matter how severe the drought turned out to be. This was the community's strategy of ensuring there was always seed for the next season.

The results indicate that LGB is the most destructive maize storage pest and the most difficult to control. Apart from chemical control, burning of maize stalks and husks immediately after removing and de-husking cobs as recommended by MoA maybe another effective control for the pest. But it is unrealistic because as the results indicate in this community maize is not grown for grains only, every by-product is important for the community's survival. They use the grains as food, the upper part of stem and leaves as livestock fodder, the lower part of stem and cobs as fuel. This confirms Michael and Herweg (2000) cited in Roth (2001) argument that small scale farmers are permanently confronted with scarcity of many resources and therefore have developed flexible and multifunctional strategies to address various problems simultaneously. This pest control method may work for other areas but not for this community something the researchers and MoA may have overlooked in their recommendation. This echoes Leach and Scones (2006)'s argument that in scientific initiatives the nature of agricultural problems and solutions are assumed to be broadly similar across fast areas, by so doing they ignore that communities have diverse livelihood, multiple patterns and different needs.

5.2 Classification and Ranking of Maize Preservation Methods

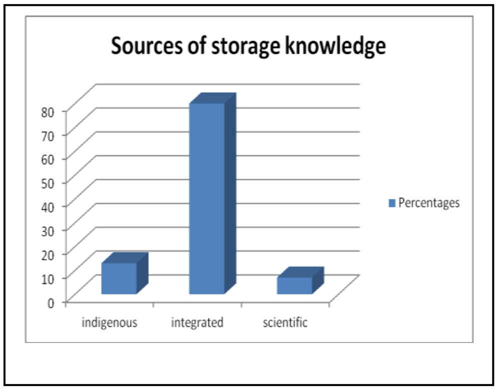
From the results, maize preservation methods currently practised in Mua hill can be classified into scientific, indigenous and integrated depending on their source of knowledge. Scientific methods use scientific knowledge, indigenous methods use IK and integrated method combines both scientific knowledge and IK. Table 4 below shows the classification and the percentage of people using them.

Table 4: Maize preservation methods ranked in order of preference by farmers

Activity	Method	Knowledge source	Percentage of people using it
Drying	Hanging cobs inside or around buildings	Integrated	53 %
	Cutting and stalking	Integrated	27 %
	Spreading cobs in the sun	Integrated	20 %
Storage	House	Integrated	67 %
	Modified cribs	Integrated	13 %
	Traditional cribs	Indigenous	13 %
	Modern cribs	Scientific	7 %
Insect pest control in maize for food	Timely harvest and proper hygiene only	Integrated	53%
	Insecticidal plants	Indigenous	20%
	Chemical pesticides	Scientific	20%
	Ash	Indigenous	7%
Preservation of own seed	Smoking	Indigenous	60%
	Plant concoctions	Indigenous	40%
Rodents control	Cats	Integrated	67 %
	Hygiene alone	Integrated	33 %

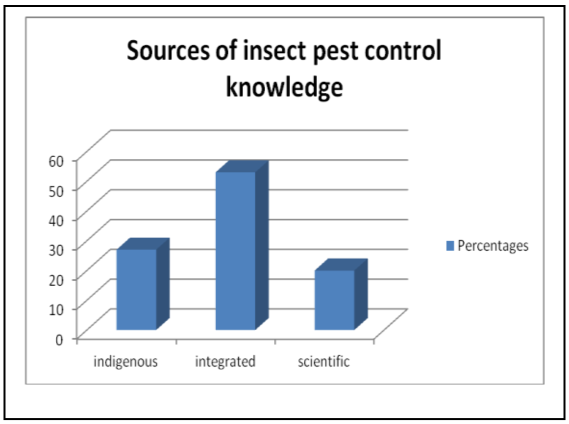
5.3 Ranking of the Different Knowledge Sources for Maize Preservation

From the percentages of people using each knowledge for maize preservation shown in table 5,the results indicate that all the people combine scientific and indigenous knowledge in the maize drying and rodents control practises but, all who grow local varieties preserve own seeds using indigenous knowledge only.



Most of the farmers in the research area combine both of scientific and indigenous knowledge in their maize storage practises as figure 28 indicates.

Figure 28: Ranking of maize storage knowledge sources



Most of the farmers in the research area combine both of scientific and indigenous knowledge in their storage pest control practises as figure 29 indicates.

Figure 29: Ranking of maize storage pest
. control knowledge sources

5.4 Strength and Limitations of Scientific and Indigenous Methods of Maize Preservation

The chemical pesticides recommended by MOA are more effective in controlling storage pest than the indigenous methods like ash and plant extracts. However, chemical pesticides are too expensive for most rural farmers so very few use them. Some of the scientific inputs like chemical pesticides, iron sheets, nails, plastic containers and polythene papers are not easily degraded hence they accumulate and can cause environmental pollution. Consumption of maize preserved with chemical pesticides may cause health problems in the long run as some farmers said. These results confirms that some modern agricultural systems have masked significant negative externalities, with environment and health hazards having recently been documented in many countries as Obe et al (2011) pointed out.

Chemical pesticides are supplied from outside the community so do not use and deplete the community's natural resources. On the other hand, indigenous inputs like thatching grass and insecticidal plants are biodegradable and so do not pollute the environment. But, the plants are part of the community's natural resources, the plants grow wildly and nobody plants more after harvesting. Continuous harvesting of the plants, without replanting depletes the community's natural resources and can cause extinction of some plants thereby destroying biodiversity. This confirms Obe et al (2011)'s remark that agriculture can negatively affect the environment through overuse of natural resources as inputs.

The chemical pesticides are easy to apply because they are purchased ready for use, all that the farmers need to do is to mix them with grains, but searching, and harvesting and preparing indigenous pesticides is a cumbersome and tiring process. Materials for constructing a modern crib like the nails and iron sheets are bought ready for use but construction of a modern crib is a man's job in this community and it is perceived to be too hard for women, the persons who are responsible for maize storage. Women are dependent on men for construction and maintenance of the crib .On the other hand constructing a traditional crib requires searching and harvesting grass which is not easily available. Arranging it well to thatch the crib takes times and requires more than one person. But women can easily construct the crib and traditionally this was their responsibility. This is the same thing observed by Padaria et al (2009) in the study to validate IK, some of the factors found to limit IK use were unavailability of the required material, labour intensiveness and cumbersome processes.

According to the FEW, the Active Ingredient (AI) in the chemical pesticides and the exact dosage required are known and well stipulated on the packages, since much research has been done to establish them. If anything goes wrong the manufacturers and stockist takes responsibility so, the extension workers can confidently promote their use. On the other hand ash and plant extracts used to control pests in the indigenous methods have not been researched on so, the AI and exact dosage required to control pests is unknown. This support Gadziravi, Mutandwa, Chikuvire (2008) observations that local prescription emanating from IK base, are grossly under-researched thus, there is scarcity of information which illustrates the value of IK in preservation of agricultural products. The extension workers hesitate to promote such pesticides because if anything goes wrong the ministry cannot protect them. Moreover even though some insecticidal plants like Mexican marigold (*Tagetes erecta)* placed in the maize cribs to repel insect are not consumed their smell permeates through the grains creating an unpleasant smell and taste. However, the results show that some farmers use the plants an indication that they are willing to endure the smell and as some put it, eat what in their view are safer grains than to eat grains treated with chemical pesticides and have health problems later in life.

5.5 Circulation and Preservation of Maize Preservation Knowledge in the Community

The results show that in the past there were well defined and effective ways of circulating information in the community. The very strong social networks, working in groups and frequent visits made information circulation through observation and exchange of ideas very effective. The women in particular were identified as the main people who circulated the agricultural information within the community through social gathering. Maize preservation IK was transmitted from generation to generation mainly through families as parents deliberately and carefully passed it to their children who would in turn pass it to their own children. This was possible then because children spent most of the time at home with parents. The knowledge was highly valued then because scientific knowledge was limited in the rural areas and farming was the community's main livelihood. It was a treasured inheritance that parents left to their children.

The results show that modernisation has disrupted indigenous informal methods of circulating and preserving maize preservation IK. Children now go to school and rarely spend time with the parents to learn through observation and practise indigenous ways of preserving maize. Most of them aspire to go to town to seek formal employment after completing school so they have no interest in their parents farming methods. This hinders IK oral transmission from parents to children and eventually from generation to generation. Those who do not get formal employment but become farmers embrace modern technologies easily because they are educated. These are the farmers who buy the pamphlets and books provided by MoA and watch the DVDs because they can read and understand the content easily. The content of those documents and electronic devices is scientific knowledge which the MoA promotes. The social networks are now weak since people have become more independent and individualistic, limiting information exchange and circulation. This supports Agrawal (2008) observing that modernisation is a threat to the lifestyles, practises and culture of small scale farmers and indigenous people. However there are still forums where information exchange can take place and theses include weddings, funerals, study tours and visits to neighbours among others.

From the results the oral method of transmitting agricultural information is slowly coming to an end. The old people said they have nobody to pass the knowledge to because nobody is interested. Those who hold IK are ashamed of sharing it freely, since it is considered primitive even by their children and other villagers. One example is the man who could not construct a crib similar to his aged mother's even though experience had shown that his mothers' crib is more effective than his own, because his wife feared that she would be a laughing stock among her friends. The extension workers hesitate to promote IK because it is not validated and they may be held responsibility if anything goes wrong. The people who hold IK are now the old generation that will soon be gone and as Warren (1993) points out they will take rich and valuable knowledge to the grave beyond reach. Agrawal (2008) points out that the disappearance constitutes an enormous loss to humanity since they possess the potential remedy to many of the problems that have emasculated development strategies for several decades.

CHAPTER SIX: CONCLUSIONS AND RECOMMENDATION

6.1 Conclusion

This research was carried out to establish whether IK plays a significant role in agriculture that would justify its integration into the Ministry of Agriculture's extension package for promotion and preservation. Due recognition is made here of the following limitations of the study. First, the study covered only one location and assumed that it would represent all other farming areas in the country some with very different Agro-Ecological Zones. Second, only fifteen farmers participated and it was assumed they would represent the whole farming population despite their number and the diverse cultures and development levels of the farming population. Third, the study investigated only one crop out of the many food crops grown in the country and moreover it investigated only one aspect of food production which is maize preservation. Therefore, within the limits of the assumptions made, reliability of the findings and the following conclusions is reasonable.

Farmers use both scientific knowledge and IK in food production, however most of the food production methods combine both types of knowledge. In this study the scientific maize preservation methods found in the research area are planting recommended variety, use of chemical pesticides and storing maize in the recommended cribs. The indigenous maize preservation methods in use are storing maize in the traditional crib and the use of ash, smoking and insecticidal plants to control storage pests. The study has revealed that both scientific and indigenous maize preservation methods are used by only a few farmers. The main reasons given for these are that scientific methods are too expensive for most farmers and farmers fear that the chemical pesticides because of health implications. On the other hand, the indigenous methods are unpopular because they are labelled by the society as primitive practises that must be abandoned. Moreover the inputs, which are mostly required in large volumes, are not easily available and the preparation methods are long and cumbersome. Most farmers' dry maize by hanging cobs inside or around buildings and store it inside a house. Most of them control pests by timely harvesting and observing proper storage hygiene only. These methods are neither the scientific recommendations nor traditional practices in the area but an integration of both.

IK does not contradict scientific knowledge in food production; instead it complements and enriches it. Both scientific knowledge and IK have strengths as well as weaknesses. Farmers use the strength of one type of knowledge to make up for the weakness of the other. For example, in this study the traditional crib is cheap because the constructing materials are locally sourced, but thatching grass has become scarce and modernisation has made it unpopular. On the other hand the recommended crib is popular because it is designed in a modern way, but construction materials are too expensive for many farmers. Therefore, some farmers have modified the traditional crib by changing only the roof. They have used tin; a type of roofing material that is more popular than grass but cheaper than iron sheet. Those who can afford have replaced the grass roof with iron sheet. As a result there are diverse types of modified maize cribs in the area.

IK is valid knowledge because it is based on sound principles that are drawn from centuries of experience, testing and wisdom of local people. It is significantly effective in solving problems in one community and therefore it can help people with similar circumstances in another community to solve their problems. This study has revealed that farmers have a wealth of knowledge that is highly detailed and richly complex. For example the study revealed that, in the past farmers were able to develop effective maize preservation devices of different types like cribs, woven baskets, gourds and earthen pots that would store maize for a long time without any pesticides. They knew what materials to use and how exactly to use them. Their storage devices used principals similar to those used in the scientific knowledge. For example they knew that insect pests cannot survive in cold environments so used materials that made their storage devices cold. They knew insect pests cannot survive without air, so they made their storage devices airproof. They also knew some materials repel insect pests so they smeared the openings with cow dung which repels insects.

IK provides a variety of problem solving strategies which are also multi-functional in purpose unlike scientific knowledge which has limited or no options. This study has revealed that farmers have different methods of drying and storing maize and they also have diverse pest control methods. These diverse methods provide options from which farmers can choose depending on personal needs and ability. On the other hand, the recommended maize preservation methods show a very narrow range of options and in some cases no options at all. In the past farmers had strategic food reserves that would reserve maize for as long as five years at the community level. They also knew how to select and preserve seeds in methods that would guaranteed that there would always be seed. The poisonous local concoction used to protect maize seeds from pests also ensured that the seeds were not consumed even in times of severe drought.

IK is at the verge of disappearing partly because indigenous practises cannot adapt to the rapidly changing natural environment, economic, and cultural changes in the country and globally. This study has shown that two changes have lead to extinction of many indigenous maize preservation practises and these are population increase and modernisation. Indigenous practises have been vanishing as they become inappropriate for new challenges or because they adapt too slowly. For example, the study has revealed that many indigenous devices that were once used to store maize like woven basket, gourds, lofts, earthen pots and gunny bags are now extinct. Some pest control methods like smoking, using ash and insecticidal plant are being used by very few farmers and so are at the verge of getting extinct. They are getting extinct because the society is now sensitive to food hygiene and the plants used are getting extinct.

IK is also disappearing because traditional methods used to preserve and circulate it have been disrupted by modernisation. The deliberate and comprehensive passage of IK from parent to children and from generation to generation has been hampered because children are either unavailable to learn IK from their parents or they have no interested in it. Therefore, it is now in the custody of the old generation, who have nobody to pass it to. The strong social networks and many functions that provided forum for exchanging and circulating IK in the past have been weakened by the fast life and individualistic nature of today's society. Maize preservation knowledge is now mainly circulated through MoA trainings and mass media but there are still some social functions and parent children ties available for circulating and preserving IK, although they are fewer and less effective.

In conclusion this case study has revealed that IK plays a significant role in food production to justify its promotion and preservation by MoA.

6.2 Recommendation

The study has established that IK plays a significant role in maize preservation and therefore in ensuring food security. It is recommended that the Ministry of Agriculture (MoA) and Kenya Agricultural Research Institutions (KARI) supports more investigations on this topic by funding further research that would use other crops and different aspects of production in order to get better insight on this topic.

The study has established that IK complements and enriches scientific knowledge. MoA and KARI should look for the successful indigenous practises and use them as entry points when developing scientific food production strategies to make extension messages more realistic and acceptable to farmers.

It is recommended that practises that are already found to work in one community be promoted by the MoA through organising or supporting forums that bring farmers together to share and exchange success stories on IK in order to boost food production.

Research should be done on the indigenous practices that are working so that the extension workers can have the confidence to promote them.

The study has established that IK is valid and can give deeper insight to what can make agricultural innovative more sustainable. It is recommended that researcher-extension-farmer's linkage be strengthened to ensure that farmers participate in identifying their problems and possible solutions to those problems.

The study has established that IK is at the verge of disappearing because its custodians the old people have almost nobody to hand it over to. It is recommended that these old experts be looked for and asked to narrate and demonstrate IK that is in their custody. AIRC to use the six steps of documenting and exchanging IK recommended by the World Bank to document and preserve it in the existing data base for future reference

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ANNEXES

Annex 1:1 Checklists

Ministry of agriculture checklist

1. Maize preservation methods recommended by the MOA in Ngoliba
2. Methods currently in practise and Farmer's reasons for the choosing them and not others
3. Existing forums that can be used to bring farmers, MOA and researcher together to exchange knowledge
4. Accessibility of indigenous knowledge to outsiders
5. Strength and Limitations of indigenous knowledge and scientific knowledge

Farmer's checklist

1. Methods being used by farmers to preserve maize and the sources
2. The reason why farmers adopt some technologies and not others
3. Channels and forums used to communicate agricultural information in the community
4. Community's 'means of preserving and transmitting indigenous knowledge from generation to generation
5. Strength and Limitations of indigenous knowledge and scientific knowledge

Annex 2: Information Sources

Table 5: different types of information sourced and their sources

Type of Information	Source of Information			
	MoA staff	farmers	documents	observations
Maize preservation methods in practise	*	*		*
Recommended maize preservation methods	*		*	
Strengths and weaknesses of both IK and scientific knowledge	*	*		
Agricultural knowledge circulation in the community	*	*		*
Maize preservation practises that have become extinct and the reason for extinction.		*		
Possibilities available for integrating IK and Scientific Knowledge	*		*	