FACTORS INFLUENCING THE ADOPTION OF "ZAI" PIT FARMING TECHNOLOGY TO ENHANCE FOOD SECURITY: THE CASE OF MAKUENI COUNTY, KENYA

BY

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DECLARATION

This project report is my original work and has not been presented for a degree in any other university.

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DEDICATION

I dedicate this research project report to my loving husband Steve Kimuyu and my daughter Rehema; my graceful treasure.

ACKNOWLEDGMENT

Special recognition goes to my supervisor Prof. Charles M. Rambo who constantly encouraged and guided me in the development of this project report. I appreciate my lecturers for the impartation of knowledge in various topics; I am a better person due to your expert instruction during the lectures which contributed to my studies and to the success of this project. I am very grateful to the University of Nairobi for giving me the opportunity to pursue MA Project Planning and Management a course that has added value to my life. I am ever grateful to all my colleagues and friends for supporting me during the study of this course. Special thanks to my brother Mulinge Kimuyu who encouraged me to give this research my best. I am forever indebted to my sister Purity Kendi who supported me greatly to accomplish this project. My parents and husband played a key role, urging me to 'keep showing up' and not give up each time I felt weak; this gesture will always be etched in my heart and mind.

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ABBREVIATIONS AND ACRONYMS

ASAL	Arid and semi-arid areas
CA	Comprehensive Assessment of Water Management in Agriculture
CSI	Coping Strategy Index
DGIC	Directorate of International Cooperation
DTCs	Drought Tolerant Crops
EPA	Environmental Protection Agency
FAO	Food and Agriculture Organization of the United Nations
GEMP	Ghana Environmental Management Project
GDP	Gross Domestic Product
IPCC	Intergovernmental Panel on Climate Change
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IMF	International Monetary Fund
IPS	Inter Press Service
ISFM	Integrated Soil Fertility Management
MCIDP	Mang'elete Community Integrated Development Programme
NDMA	National Drought Management Authority
PAI	Champions of Global Reproductive Rights
PEOU	Perceived Ease of Use
PU	Perceived Usefulness
RWH	Rainwater harvesting
RWHTs	Rain Water Harvesting Technologies
SDG	Sustainable Development Goal
TAM	Technology Adoption Model
UDO	Utooni Development Organization
UN	United Nations
WFP	World Food Programme
WFS	World Food Summit
WVI	World Vision International

ABSTRACT

The purpose of this research was to determine the factors influencing the adoption of Zai pit farming technology to enhance food security in Makueni County. Makueni, one of the ASALs in Kenya, is characterized by hot and dry weather, low and erratic rainfall, meaning that smallholder rain-fed agriculture has been severely destabilized. Food security (availability, access, stability and utilization) is continually declining. Progress towards food security and nutrition targets requires that food is available, accessible and of sufficient quantity and quality to ensure good nutritional outcomes. Livelihoods are at risk as the majority of the population in these rural arid and semi-arid lands depends on rain-fed agriculture for their sustenance. The low prevalence of Zai Pit, a micro-catchment technology to increase yields for enhanced food security in Makueni County poses a contradiction given the fact that it has succeeded in Africa's driest regions and even in Kenya, some regions of Makueni County included such as Wote, Mtito Andei and Mbooni. The objective of this study was to determine the influence of perception, social-economic factors and extension services on adoption of Zai pit farming technology in Makueni County. A theoretical framework was developed based on the technology acceptance model (TAM) and Everett Rogers' innovation diffusion model. The study used descriptive survey research design and was limited to Makueni County in Kenya. The population was 55 farmers and 10 field extension officers in Makueni County, who have applied Zai pit farming technology and the field staff of local organizations. The sample size was 48 farmers and 10 extension officers using purposive sampling. Data collection was conducted by use of semi-structured questionnaires containing questions on the influence of perception of Zai pit farming technology using a Likert scale and the influence of social-economic factors, extension services. Pilot testing was carried out in 5 households before the commencement of the study. Data analysis was done using Ms Excel, presented using frequency and percentage tables and interpreted using computed descriptive statistics such as means and percentages. The study findings indicate that perception of technology influences the adoption of Zai Pit farming technology as 97.9% perceived that Zai Pits were useful for farming meaning they were easy to use, increased food security by increasing yield and reducing the risk of crop failure. The findings indicate that social-economic factors, specifically group membership as 89.6% were found to be group members, meaning the chamas were the main channels of propagation of the technology and members receive adoption support from fellow members. The study found that 60% of the officers merely offered support to the community trainer of trainers (ToT) but did not check directly with the farmers. The study concludes that the perception of the Zai Pit farming technology as being labor-intensive and costly were prohibitive to further adoption despite farmers perceiving the technology as useful for farming and easy to use, that group membership is important to adoption, provided that a balance can be sought to ensure males are active participants of the chamas. It is recommended that extension services should be more hands-on by involving the extension officers to enable the farmers to grasp the concept and receive constant monitoring and improvement since they were always on the ground. Collaboration between NGOs and government should be better as findings indicate that the government support was there but most farmers were not able to roll out the Zai Pits to land above one acre. Further research should focus on the role of behavioral intention to adopt Zai pit farming technology for non-adopters in Makueni County where the farmers have not been exposed to the Zai pit farming technology, what viable income generating activities can be supported by Zai pit farming in Mbooni, Makueni County and how to reduce the labour used in digging Zai Pits to increase the scale of use of Zai Pit farming technology. The study provides evidence for the potential of Zai pit farming technology in agriculture in Makueni County.

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Subsistence agriculture is the main economic activity in Makueni County along with other activities such as beekeeping, small-scale trade, dairy farming and limited coffee growing, ecotourism and commercial businesses (Kari McGill, 2015). Despite these activities, 34% of people in urban areas and 67% of those in rural areas in Makueni County live below the poverty line. Ouko and Gioko's (2015, p.3) findings indicate that "the major factor affecting food security in the county was poor temporal and uneven spatial distribution of the short rains coupled with a late onset and early cessation in most areas. Other factors affecting food security are poor soil fertility across all the livelihood zones, human-wildlife conflict, limited forage and water retention, limited household stocks, and overreliance of maize as staple food".

To counter this high risk of food security, various water harvesting techniques have been applied in some parts of Makueni County such as macro-catchment technologies, micro-catchment technologies and rooftop harvesting technologies. Micro-catchment methods collect runoff near the growing plant and replenish the soil moisture and are generally used to grow intermediate water requiring plants for example maize, sorghum, groundnuts and millet. Micro-catchment methods such as Zai pits, strip catchment tillage, contour bunds, semi-circular bunds and meskat-type methods are used (Kimani, Gitau and Ndunge, 2015).

Zai pits are excavated on damaged land in the dry season and the unearthed soil is then placed round the pit to boost the soil's ability to retain water. Decomposed material is put in the pit, mixed with water and covered in a thin sheet of soil. Seeds are added to

the pits on the wet ground. Zai pits preserve water, limit soil erosion, and trap rainfall and surface run-off water as well as prevent seeds and organic matter from getting eroded away thus conserve nutrients. Despite being labor intensive, experts assert that they improve harvests by even 500% if well implemented ("Bright future for farmers in Mtito Andei," 2013). Rainfall is held in the pit and concentrated to the center. Zai pits are also used to reclaim crusted and degraded lands. Growing Maize in Zai pits in Kenya requires one to dig circular or square pits 30cm (1ft) deep. A square pit measuring 75 x 75 x 30 (cm) holds nine maize plants. The top soil is mixed with farm yard compost at a ratio of 4:1 and added back to the pit. The method causes improvement to the state of soil water (Cofie et al. 2004; Kandji et al. 2006).

However, the adoption rate of Zai Pit, a micro-catchment technology to increase yields for enhanced food security is low despite evidence that the Zai pit farming technology has successfully worked in much drier areas such as the West African Sahel in countries such as Mali, Burkina Faso and Niger. The technology has been successful in some parts of Makueni County such as Wote, Mtito Andei and Mbooni (Mati, 2007). This contradiction points to the need to assess factors influencing the adoption of Zai pits to a wider scale.

Despite the low small-scale irrigation in Kenya, its contribution to the national income, employment, sustainable irrigation of small scale dry-land farming and nutrition is recognized worldwide. The increasing demand for staple food and income generated from small scale irrigation agriculture in Africa is currently at Ksh. 12,000 billion annually (Jamah, 2011). 80% of farmed land relies on rainfall, and the rain backs 58% of worldwide harvests (Bruinsma, 2009), becoming the key channel of global farming output. The scope of water using in farming has expanded to both irrigation and rainfall farming (Wani, Rockström and Oweis, 2008). The idea of blue water (water found in

rivers, lakes and aquifers) and green water (rainwater deposited to the ground and used straight by crops via evapotranspiration) highlights the usefulness of rainfed farming to irrigation and vice versa. Indeed, freshwater used up in irrigation symbolizes only 20 percent of water spent by plants during evapotranspiration (CA, 2007).

1.1.1 Global Food Security Situation

Two major commitments were made by United Nations member states to address hunger in the world. Firstly, the World Food Summit (WFS), 1996, was convened in Rome and 182 governments purposed "to get rid of food shortage in every country, using a current outlook to decreasing the people who are underfed by half the existing levels by 2015". Secondly, the Sustainable Development Goal number 2, was agreed upon in 2015 by the members of the United Nations, focusing on "zero hunger", with a target of "by 2030, guarantee reliable diet creation methods and develop robust farming techniques to grow output and creation, which aid sustain environments, which build up capability to adapt to climatic changes, famine, floods as well as that increasingly the quality of soil and land" (UN, 2016). Its pointer is "the quantity of farms utilized in productive and sustainable agriculture" to make sure availability, accessibility, sufficiency of food nutrition targets are met for decent nutritive results (FAO, IFAD and WFP, 2015).

More than 800 million of 5.8 billion people in the world, are food insecure, 1.3 billion have a daily income of less than $1 per day. The context for majority of these poor people includes living in rural areas of developing countries characterized by marginal land and fragile ecosystems. Women in the Sub-Saharan Africa area have 5.1 children which despite being a decline from 6.7 children in 1970 is above double 2.5 children, the world average (UN Population Division in the World Population Prospects (as cited in Bremner 2012). Sub-Saharan Africa is home to nearly 240 million chronically food

insecure population, which makes 25% of the total population living in the developing countries (Jamah, 2011). On the contrary, agricultural production is declining significantly in Africa (Gabre-Madhin, 2009). In 1995, more than one third total grain intake in Africa was imported (Aileen, 2003). Moreover, yearly about 30 million individuals are in need of crisis food assistance. Food aid of 2.8 million tonnes was issued in the year 2000 (Slater, *et al*., 2007).

Today, 80 percent of the global population lives in the developing world contrasted by an annual increase in population at1.9 percent (James, 1998). The demand for food is driven up by the increase in numbers of people, resulting in more use of arable land and water, given the lack of advanced food production technology and integrated programs that tackle the need for food and reproductive health in the community. There will be a doubled demand for food globally by 2050 as projected by FAO, as a result of population and economic growth (PAI, 2011). About one in seven persons worldwide face chronic hunger, as they lack sufficient food to live healthy actively notwithstanding there is adequate food to cater for everyone in the world (*State of Food Insecurity in the World* report by FAO, 2008). Rural poverty plus food insecurity persist with the decrease of food aid and donor funding from the World Food Programme (WFP), World Bank and the International Monetary Fund (IMF) respectively (Christian and Mbuthia, 2008).

Despite women being the chief conduits of food in families and young ones, the effort put in farming may not paid, as well as being faced by limiting laws and customs on land ownership rights and or access to credit (ICRW, 2016). Increase in intake of meat and to a smaller degree, dairy products increases burden on water, given the large quantities of water used in their preparation (CA, 2007). Town dwellers may possess more food variety, but short of farmland, their food security is reliant on the earnings

and capacity to buy food products (FAO, 2010). Underprivileged people in towns and cities often end up spending up to 60 percent of the income on food, driven by hiked transport costs or monopolistic practices by powerful traders, meaning that low earnings and high food prices multiply the chances of starvation and undernourishment (FAO, 2010).

In Kenya, the agricultural sector supports 25% of the Gross Domestic Product (GDP), being the second largest sector after the service sector. The agricultural sector supports livelihoods of about 80% of the 41 million people Government of Kenya, [GOK]: Population Census, 2009). Over 75% of the total agricultural output and about 50% of the agricultural produce marketed is produced by small scale farmers (GoK, 2009). Agriculture uses up about 70% of the total global freshwater supply and thus the agricultural sector is adversely affected by the global climatic changes (Karl, Melillo and Peterson, 2009). The global climate change influences the small-scale irrigation dryland farming worldwide due to the increased variability in precipitation and competing demands for fresh water supply which challenge the capacity to maintain output (Slater, Peskett, Ludi and Brown, 2007).

There is a significant increase of natural risks such as temperature and rainfall trends, higher frequency and extremity floods and droughts (Intergovernmental Panel on Climate Change, IPCC, 2014). The Fifth Assessment Report of the IPCC, Climate change has a negative effect on agriculture, resulting in negative change in key crops, livestock farming and fishing. Availability of food is determined by land to farm in addition to water sources that have been strained given increases in population (PAI, 2011). The effects of environmental changes on temperature, snow, and agricultural output may weaken food security in particular regions. Modern research submits that climatic changes will bring severe effects to principal foods— mainly in continents with

prevalent hunger such as Africa and Asia (Lobell, Burke, Tebaldi, Mastrandrea, Falcon and Naylor). Where the weather is appropriate for rainfed farming, there is high possibility to increase output where harvests are low, such as in many parts in sub-Saharan Africa (CA, 2007). The Heinrich Böll Foundation carried out research in 2010 "*Climate Change Vulnerability and Adaptation Preparedness in Kenya*", indicating that Kenyans possess low cognizance on climatic changes. A 2007/08 Gallup opinion poll established that only 56% Kenyans recounted awareness on global warming with most of the poor living in the countryside being most ignorant.

1.1.2 Use of Zai Pit Farming Technology in Makueni County to Enhance Food Security

The World Agroforestry Centre coordinates the climate smart water management programme implementation in Kenya, Mali, Burkina Faso, Niger and Ethiopia in association with various national and regional allies. In Kenya, Utooni Development Organization in Wote has implemented Zai pit farming technology alongside sand dams, water harvesting ponds and drip irrigation systems to scale up water for the farmers in the county, partnering with DGIS. The farmers use Zai pits and rainwater ponds and drip-irrigation systems to water mangoes, tree nurseries and tomatoes. The areas targeted have rainfall ranges of 400-800mm. One Zai Pit is averagely $0.22m^3$ in volume and takes roughly 15 minutes to dig, the major costs being the labor needed.

World Vision International empowered 720 farmers within Mtito Andei on present agricultural methods and farming of Drought Tolerant Crops (DTCs) through a food safety project in Matengulu and Miangeni villages in Mtito Andei, an area that is dry with high temperatures, and is vulnerable to drought. Residents receive relief food from supporters, non-governmental organizations and even government. The DTCs include

green grams sorghum, millet, cowpeas and cassava. Farmers' harvests increased up to 17 bags of green grams, which sell at Ksh 70 a kilo (about USD 0.82), giving the farmer Ksh 94,500 (roughly USD 1111.8) after selling 15 sacks, and keeping two for the family. Zai pits enable intercropping maize and water melons or cowpeas. Prior to this method, the farmers used traditional methods of farming, cutting the grass prior to ploughing. They mostly planted a single crop, something researchers assert contributes to soil exhaustion and diminishing harvests. World Vision not only supported the community with cost-effective agricultural methods and supplied farming tools such as hoes, wheelbarrows, rakes, spades, fertilizers, watering cans, and seeds, complemented Zai pit farming technology with greenhouses and irrigation pumps. The food security project benefitted about 4,320 people and was projected to grow to 14,200 at the closure of the project by 2014, as reported by World Vision staff in charge, Jackson Muraguri.

The Embassy of Sweden and Department for International Development/ Ukaid (2011 – 2015), through Zinduka Afrika, a local NGO, in a program called *Act! Changieni Rasili Mali Facility* funded by supported 2,000 small scale farmers in Matalani village, Mbooni sub county, Makueni County in use of Zai pit method to produce food in high levels of due to climate change. A farmer Marietta Kisayi, who used Zai Pits in a period where rains flopped failed throughout Makueni County in 2014, and reaped three sacks of maize in below an eighth of an acre, in the least fertile area of her farm Non-government bodies have a huge duty to expedite knowledge transmission in methods which were formerly examined yet abandoned in publications rather than being adopted in communities.

1.2 Statement of the Problem

Zai Pit, a micro-catchment technology has successfully been used to increase yields for enhanced food security in Africa's driest regions. The dryland farming technology was introduced in Kenya, including some regions of Makueni County such as Wote, Mtito Andei and Mbooni and Tharaka Nithi County. The low prevalence of Zai pit farming technology in Makueni County despite its known benefits and demonstrated success in much drier areas of Africa poses a contradiction that raises serious questions on what the underlying factors are.

Only one in ten rain periods in Makueni as well as the larger Eastern Kenya, gains sufficient rain for farming (Reij and Thiombiano, 2003). Michael Arunga, WVI Emergency Communications Advisor – Africa, postulates that "emergent trend which did not exist three decades before where rainfall failed once in two years". A national disaster was declared in 2011 and in 2017 after harvests failed; meaning that reliance on crisis foodstuff aid has increased. The UN WFP underscored that about two million people received crisis foodstuff at the close of 2011 in Kenya. The short rains food security assessment report, 2014 indicated that the major factor affecting food security in Makueni County has been poor temporal and uneven spatial distribution of the short rains coupled with a late onset and early cessation in most areas. The household food security mean coping strategy index (CSI) for the county in December 2014 was 23, compared to 17 in December 2013 for non-beneficiaries of food aid initiatives implying the situation is deteriorating and households are becoming more vulnerable (Ouko and Gioko, 2015).

Therefore, this study seeks to determine the factors influencing the adoption of Zai pit farming technology in Makueni County.

1.3 Purpose of the Study

The purpose of the study is to determine the factors influencing the adoption of Zai Pit farming technology to enhance food security in Makueni County, Kenya.

1.4 Objectives of the Study

The specific objectives of the study were:

i. To determine how perception of technology influences the adoption of Zai pit farming technology to enhance food security in Makueni County.
ii. To examine the extent to which social-economic factors influence the adoption of Zai pit farming technology to enhance food security in Makueni County.
iii. To assess how extension services offered to farmers influence the adoption of Zai pit farming technology to enhance food security in Makueni County.

1.5 Research Questions

i. How does perception of technology influence adoption of Zai pit farming technology to enhance food security in Makueni County?
ii. To what extent do social-economic factors influence the adoption of Zai pit farming technology to enhance food security in Makueni County?
iii. How do extension services offered to farmers influence the adoption of Zai pit farming technology to enhance food security in Makueni County?

1.6 Significance of the Study

This study determined the factors influencing the adoption of Zai pit farming technology in Makueni County which need to be looked at in a practical manner, given that Zai pit farming technology has been successfully used in arid and semi-arid areas in Mali, Burkina Faso and Niger, which are comparatively drier areas. The findings of

this study are hoped to provide useful information that can influence for food security policies in the county by both the County and national governments.

The findings of the study are hoped to create awareness regarding the practical aspects of Zai Pits that can be integrated in development interventions in arid and semi-arid areas in Kenya like Makueni County. This is desired to act as a means of documenting the Zai pit farming technology process for further adoption in arid and semi-arid areas.

1.7 Limitations of the Study

The major challenge anticipated in the study when collecting data, was the language barrier amongst the participants to be interviewed and the interviewer due to lack of fluency in the "Kamba", the local language. This was heightened by the fact that only few potential respondents are conversant with "Swahili", the national language. An interpreter was used as an intermediary.

As the study area was Makueni County which is a large area meant data collection would be time-consuming and high costs would be incurred. To counter this, purposive sampling was done in the areas that have currently adopted Zai pit farming technology, specifically Mbooni sub-county.

1.8 Delimitation of the Study

This study was conducted in Makueni County to determine the factors influencing the adoption of Zai pit farming technology to enhance food security in the County. The rationale was that these were the people who have firsthand information on usage of Zai pit farming technology, as Makueni County among others, was where the technology was first introduced in Kenya.

1.9 Basic Assumptions of the Study

It was assumed that perception of technology, social-economic factors and extension services offered to farmers influence the adoption of Zai pit farming technology to enhance food security in Makueni County. It was assumed that the records and data collected during the study reflect the true status of activities as at the time of the study. It was also assumed that the sample population that was selected for data analysis was representative of the people practicing farming using Zai pit technology in Makueni County. The study also assumed that the respondents provided correct and truthful answers to the questions, they provided reliable data free from bias and prejudice and finally that the respondents were easily accessible.

1.10 Definition of Significant Terms Used in the Study

Adoption of Zai pit farming technology to enhance food security **means the use of "Zai" planting pits in farming, majorly applied in arid and semi-arid areas to ensure that households have physical and economic reach to adequate, harmless and nourishing food that fulfills their nutritional requirements. Adoption was measured by the size of land under Zai pits and the number of trainings attended. Perception of technology** means the attitude that farmers develop concerning a new technology that was introduced including its inherent features, perceived ease of use and perceived usefulness, aspects which influence how they adopt the Zai pit farming technology. This entails perceived food security, perceived yield increase, perceived labor demand, perceived capital needed and the perceived risk of crop failure.

Social-economic factors are the aspects of the social and economic position of a household that influence whether or not farmers adopt Zai pit farming technology. These factors include education, gender, age, group membership and its composition,

the source of labor, farm size, access to credit, water availability and the household income.

Extension services offered to farmers means providing leadership, technical staff capacity building, facilitating and managing uptake and adoption of appropriate agricultural technologies for improved agricultural productivity, food security and incomes. The indicators of extension services offered to farmers are the accessibility of information, accessibility of inputs, the communication channels, post implementation support and the duration of extension.

Dry land farming is a system of agriculture in semi-arid places minus the use of irrigation by use of drought-resistant plants and moisture conservation.

1.11 Organization of the Study

This study is organized in chapters, with chapter one containing the background to the study, statement of the problem, the purpose of the study, objectives, research questions, significance of the study, limitation and delimitations, assumptions of the study and definition of significant terms. Chapter two highlights relevant literature from other scholars on the adoption of Zai pit farming technology to enhance food security, perception of technology and adoption of Zai pit farming technology to enhance food security in Makueni County, social-economic factors and adoption of Zai pit farming technology to enhance food security in Makueni County and extension services offered to farmers and adoption of Zai pit farming technology to enhance food security in Makueni County. It also outlines the theoretical and conceptual frame work and knowledge gap. Chapter three focuses on research design, target population, sample size and sampling procedure, research instruments, data collection procedure, data analysis techniques, ethical considerations of the study and the operational definition

of variables. Chapter four contains the analysis, presentation, interpretation of data on adoption of Zai pit farming technology, findings on influence of perception of technology and adoption of Zai pit farming technology to enhance food security in Makueni County, social-economic factors and adoption of Zai pit farming technology to enhance food security in Makueni County and extension services offered to farmers and adoption of Zai pit farming technology to enhance food security in Makueni County. Chapter five presents the summary of findings on the influence of perception of technology and adoption of Zai pit farming technology to enhance food security in Makueni County, social-economic factors and adoption of Zai pit farming technology to enhance food security in Makueni County and extension services offered to farmers and adoption of Zai pit farming technology to enhance food security in Makueni County, discussions, conclusions, recommendations and suggestions for further research.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter discusses a selection of current and foundational literature on Zai pit farming technology, empirical studies, the factors influencing its adoption in Makueni County and its potential for ensuring food security in the County, the theoretical framework and the conceptual framework. The chapter concludes by discussing the gaps to be filled by the study.

2.2 Adoption of Zai Pit Farming Technology in Drylands to Enhance Food Security

Drylands occupy approximately 41% of land on the earth and are inhabited by over 2 billion people (Safriel, Adeel, Niemeijer, Puigdefabregas, White, Lal, and McNab, 2006). For dry-land farming to be realistic for farmers, financial incentives are necessary for example preservation easements, such as the transfer of development and/or land use rights to a government body or a non-profit organization giving tax benefits or direct payments for retirement of the land (Kromm and White, 1990). Even a 2˚C increase in Africa is forecast to have worse effects than formerly expected given the continent's huge sensitivity to frequent risky events (Turral, Burke and Faure, 2011). La Niña in Kenya and El Niño impacts in southern Africa are worsened by greater occurrences of drought, estimated at 15 percent of GDP in Africa (Barclays and Met Office, 2009).

The future accessibility of water equivalent to crop water needs is unlikely in areas with low rainfall – especially the arid or semi-arid regions (Turral H *et al*., 2008). Water gathering and moisture preservation are critical for fruitful agriculture in the Sahel,

combined with Integrated Soil Fertility Management (ISFM) for improved plant performance in fluctuating climate.

Micro-catchment methods of harvesting rainwater in the Sahel are Zai planting pits, half-moon bunds, tied ridges and rock lines. Zai pit entail ancient dryland farming method that originated from Burkina Faso through use of superficial basins of 20-30cm diameter (about 80 cm) and 10-15cm deep are dug (Olufunke et al. 2004). Reij and Thiombiano (2003) recognized how the Central Plateau of Burkina Faso, following long durations of key land dilapidation and relocation, experienced major improvement. Millet and sorghum harvests increased from around 400 kg ha-1 in 1984-1988 to 650 kg ha-1 in 1996-2000. The rise was primarily due to improved soil and water preservation as well as additional aspects of ISFM.

Table 2.1: Impact of Zai pits and ISFM measures on sorghum yields in West Africa

Water and fertilizer management	Sorghum grain km/ha
Zai planting pits	200
Zai + Cattle Manure (CM)	700
Zai + Mineral Fertilizers (MF)	1400
Zai + CM + MF	1700

Adapted from (Reij et al., 1996)

Landlocked Sahel nations that have with rising town populaces, for example Burkina Faso, Mali and Niger, highly rely on fewer basic food such as rice, oils and milk (Thanh, et al., 2008). The Djenné Agricultural Systems implemented a project in 1989-1990 and found that agricultural harvests rose to more than 1000 kg ha-1 paralleled to conventionally cultivated control plots. In Niger, (Hassane et al., 2000) and Hassane (1996) noted typical grain harvests at 125 kg ha-1 in control fields and 513 kg ha-1 in land with Zai Pits and lowest figures at 297 kg ha-1 in1992 and a highest at 969 kg ha-

1 in1994. also recounted Sorghum harvests increased where the Zai Pits got modified by addition of organic and inorganic nutrients, demonstrating the significance of nutrient control to supplement the efficiency of Zai pit method. (Reij and Thiombiano, 2003). With a typical annual rainfall of 885mm, farmers plant twice or thrice before the August rains. The low rainfall combined with poor soil fertility result in poor harvests in the region. However, farmers remain food insecure tediously and laboriously tilling land for cropping every year. The Upper East Region is in the Sudan Savanna zone, characterized by a uni-modal rain pattern for five to six months and a long dry duration, six to seven months (EPA, 2014).

The Regional Director of the Environmental Protection Agency (EPA) highlights that farmers in the Ghana Environmental Management Project (GEMP) functional areas, adopted the technology to increase food production and food security with their support. Most families in the region could barely afford three meals per day, but with the introduction of the Zai concept together with composting, *mucuna* intercropping with maize, the natural regeneration and stone lining, families' food security has been enhanced. Moreover, the Dutch Ministry of Foreign Affairs through the General Directorate of International Cooperation (DGIS) funded the *Enhancing Food and Water Security for Rural Economic Development in Drylands'* - a regional project running 5 years, aimed at enhancing the food and water security for farmers and populations in the Sahel and Horn of Africa

Techniques of gathering water which intensify water penetration up to 50% could increase grain yields up to 60 to 90% subject to rainfall and soil fertility (Sanginga and Woomer, 2009).

When growing maize, the manure ratio can be lessened depending on soil quality, and the need for use of artificial fertilizers. One acre accommodates 1778 plant pits each measuring 75 x 75 x cm which gives plant population of 16000. One pit yields a minimum of 1.5 kg giving 30 bags of maize from one acre. The right maize variety must be planted early enough to benefit from the rainfall available and where possible plant using phosphorus fertilizers for early crop root establishment.

This table shows sample data income from growing maize in Zai Pits in Kenya

Table 2.2: Income from growing maize in Zai Pits in Kenya

Yield per acre is 30 bags @ KES 2000 = Gross income of KES 60,000		
Cost of 10 kg seed	@140	1,400
Cost of 1778 Zai pits distributed into 6 seasons	@50	14816
3 x 50 kg fertilizers	@2500	7,500
593 debes of FYM (each debe serves 3 pits)	@10	5,930
8 m/days of weeding	@200	1,600
Insecticides	Assorted	2,000
8 m/days of harvesting	@200	1,600
2 m/days dusting and spraying	@200	400
30 gunny bags	@50	1,500
10 m/days threshing and winnowing	@200	2,000
Total variable costs	**32,820**	**60,000-38,648**
Gross margin for growing maize in Zai pits in Kenya	**21,354**	

Adapted from (WVI, 2013)

Tesfay (2008), examined rainwater harvesting in Ethiopia and found that poor capital and human endowment, lack of access to credit, involvement in off-farm activities, negative perception, gender issues, inaccessibility of inputs, lack of technical know-

how, poor water extraction and application methodologies. The suggested remedies included creating awareness for the people, providing technical and institutional support, merely supporting methods with greater financial returns, well-timed delivery of inputs, investing in female led families and design introducing alternate strategies that are relevant to the farmers. The implementation of farming methods such as soil and water preservation methods are influenced by factors such as socio-economic, demographic, institutional and technical, farmers' perception about the technology and attitude (Foti *et al* 2008:317).

Studies conducted by Binod (2010), on adoption of improved maize varieties in developing countries, particularly Africa and South Asia, have pointed out a number of socio-economic characteristics, agro-ecological variables, and farmers' perception as important determinants of improved maize varieties in different countries. Different scientists (Binod., 2010; Prokopy *et al.* 2008; Steven, 2010; Foti, 2008) have identified education level, age, capital, income, farm size, security of land tenure, soil characteristics, access to information, agricultural credit availability, yield and profitability, market access, positive environmental attitudes, environmental awareness, and utilization of social networks as factors that influences a new technology.

Farmers' decisions to adopt rainwater harvesting methods are determined by gender, education and age (socioeconomic variables) as well as wealth status, access to credit, social status and family members' perception (economic variables) (Mbogo, 2014).

2.3 Perception of Technology and Adoption of Zai Pit Farming Technology to Enhance Food Security

Perception is the manner in which individuals obtain information or stimuli from the surroundings and convert it into mental cognizance, meaning an individual's perception varies markedly from someone else in the same condition due to their past encounters (Ndiema, 2010). The users' perception of the characteristics of a technology has been found to be an important determinant to its adoption (Adesina and Zinnah, 1996).

Studies on farmers' perceptions confirm that delayed response to adoption of soil conservation practices could be attributed to the demand and complex nature of such innovations, with some requiring more labor for instance digging Zai Pits, planting, manure application, transporting, and integration (William *et al.* 2012). The attitude towards the behavior, the subjective norms and the perception of behavioral control lead to the formation of a behavioral intention, which in turn leads to the performance of the behavior (Ajzen 1991). Attributes of a technology such as how it improves nutrient availability, water availability, yield increase, amount of labour needed, ability to secure land tenure, capital required, level of perceived risk and accessibility to information (Drechsel, P., et al, 2005)

2.4 Social-economic Factors and Adoption of Zai Pit Farming Technology to Enhance Food Security

Nyikahadzoi et al. (2012), found that low uptake of improved technologies and inappropriate soil fertility management practices compromise environmental sustainability and food security among smallholder farmers. The driver of agricultural growth for any country is higher returns to farm productio1n; to increase the returns, producers in large numbers must adopt agricultural practices that increase productivity

and use resources such as land and water more efficiently, effectively, and in an environmentally sustainable manner (World Bank Group, FAO and IFAD, 2015).

Bett (2006) noted different variables such as age and education affect adoption of agricultural technologies either positively or negatively. He found that higher education influences adoption decision positively because it is associated with ability to synthesis more information on technologies that are on offer and this leads to improvement of the general management of the farm. On the other hand, more education can lead to a household head having more available occupation options thereby sparing less time to attend to this farm activities affecting adoption of agricultural related technologies negatively (Bett, 2006).

Barro et al. (2005) stated it takes about 300 hours/ha to dig the Zai Pits. Kaboré and Reij (2004) asserted that it takes 450 hours/ha to dig the holes, plus another 250 hours/ha to fertilize them hence the Zai system is more realistic when undertaken by groups of farmers instead of individuals. This means that wealthier farmers may benefit more from the technology. Farmers plant crops in planting pits and built stone contour bunds, which are stones piled up in long narrow rows that follow the contours of the land in order to capture rainwater runoff and soil; a combination that has recovered between 200,000 and 300,000 hectares of land and yielded an additional 80,000 tons of food per year.

Murgor (2013) postulated that one limitation for farmers in adopting modern technologies and inputs is financial issues such as cost of hired labour is too high, transportation cost is high for agricultural products, cost of construction material is high and lack of credit access or shortage of capital. It is difficult to increase agricultural

sector productivity without efficient credit facility, given the fact that the majority of farmers are resource poor.

Higher investment in livestock and better management leads to increased readiness of dung. Better-quality livestock keeping brings revival of indigenous foliage and greater accessibility of fodder (Reij and Thiombiano, 2003). Efficient water plus nutrient usage have been seen after combining water collecting and addition of nutrients hence creating a balance. Variable rain affects the efficiency of fertilizer and determines how risk-averse farmers in arid and semi-arid areas become (Morris et al. 2007). Research findings indicate that rainwater in Africa is at 127 mm yr-1 contrary to North America's 258, South America's 648 and global mean of 249 mm yr-1 (Brady 1990). Water efficiency could be multiplied if proper control of soil, rainwater and nutrients. Gathering water devoid of better soil productivity won't intensify harvests, particularly in dry areas (Table 2.1). Application of fertilizer is may be seen to increase the risk in dryland farming, however, it reduces risk; for example, application of Phosphorus in fast growing millet in Niger, made plants tougher, matured sooner, decreasing destruction by drought (ICRISAT 1985-88; Shapiro and Sanders 1998). Table 2.1 shows how better soil fertility results to efficient water usage.

2.5 Extension Services Offered to Farmers and Adoption of Zai Farming Technology to Enhance Food Security

Zai planting pit system (also tassa in Tahoua) is an old farming technique rediscovered after the great drought of 1973/74 and later perfected by development partners working with farmers (Abdo, 2014). According to Ministry of Agriculture, Livestock and Fisheries (2003), extension in Kenya has evolved from supply driven (necessary for awareness creation) to demand driven. Extension has become more complex with many

informed players in the sector. It involves providing leadership, technical staff capacity building, facilitating and managing uptake and adoption of appropriate agricultural technologies for improved agricultural productivity, food security and incomes. According to Agriculture Research Centre (2008), the challenge is that farmers and communities do not have the knowledge or the means to implement suitable techniques in the appropriate way.

The level of information search in terms of global, national, and local information sources depends on the aspirations of the searchers. Further, farmer's ability to search for information depends on the sources that are accessible to them. For example, local information needs could be met by a well-organized extension system that uses traditional and modern methods of communication such as television, radio, and mobile phones, while the need for global information has to be met through internet connection or through contact with private firms (Zarmai, Okwu, Dawang and Nankat, 2014). Several authors have stressed the importance of information in the adoption process (Saha et al., 1994; Dimara and Skuras, 2004).

The roles of non-governmental organizations (NGOs) and farmer-based organizations (FBOs) are increasingly being recognized as key for information sharing on specific crops and cropping systems (Swanson and Rajalahti, 2010). The private sector, which includes the high- value agriculture chains developed through contact farmers and input dealers who promote their agrochemicals, also plays a critical role in filling the information gaps that may exist in rural areas (NSSO, 2005). Dandedjrohoun et al., n.d.) reveals other participatory approaches such as the Farmer Field Schools (FFS), which is a participatory training approach targeted to smallholder farmers has been used widely in Africa (Braun et al., 2000). In 1984, in Burkina Faso, a farmer named Yacouba Sawadogo began organizing semi-annual market days to promote planting

pits. Initially small, by 2000, Yacouba's market days involved farmers from more than 100 villages in Burkina Faso. In 1992, a farmer named Ousseni Zoromé began a "zaï school," training local farmers on a gravel site next to the road. When the crop grew, the effort attracted the attention of the minister of agriculture. By 2001, Zoromé's network consisted of more than 20 schools and 1,000 members, with each group charged with rehabilitating it sown piece of degraded land. Another farmer, Ali Ouedraogo, trained individual farmers in villages around Gourcy and visited regularly to work with them in their fields and exchange ideas (Reij, Tappan, and Smale, 2009).

Yahaya (2002) reported that radio is the most potent source of information for farmers and farmers' companions. Not only do farmers seek and find information from radio useful, but such information seeking behavior has been associated with an increase in farmers' knowledge of improved agricultural practices, thereby enhancing their productivity. According to Yahaya (2002), constant listening to a radio programme contributes to the easy adoption of new practices by non – literate farmers and can lead to enhanced productivity. Several farmers' characteristics have been found to be significantly related to radio – listening habits, knowledge of improved agricultural practices and, consequently, productivity.

Ransom et al (2003) and Donkoh and Awumi, (2011) found that long years of farming are associated with being familiar with technologies; such that when new technologies are introduced, experienced farmers tend to adopt them faster than less experienced farmers. They stress that farmers who have more experience with technologies in general are more likely to test and adopt improved varieties.

Radio Mang'elete was established 2009, owned by (MCIDP), an organization of 33 ladies' *chamas* in Nthongoni area in Makueni, to counter perpetual lack of adequate food in Makueni as well as Eastern Province, by providing reliable information on rainfall and weather patterns.

2.6 Theoretical framework

How and why people adopt innovations has induced a lot of research. A theoretical background to adoption and diffusion of Zai pit farming technology is highlighted in this section. Several models describe the influences on approval or rejection of a technology such as the Technology Acceptance Model (Venkatesh and Bala, 2008) and the Diffusion of Innovations by Everett Rogers (2003). This section provides a description of these frameworks.

2.6.1 Technology Acceptance Model

This is the commonest model of acceptance and use of technology (Venkatesh, 2000). Developed by Fred Davis and Richard Bagozzi (Davis 1989, Bagozzi, Davis and Warshaw 1992), its main assumption is that when a person intends to act, they will be free to act unhindered (Davis, 1989). However, practically, acceptance and adoption is constrained by limited ability (cognitive, psychomotor or materials), time, environmental or even unconscious habits that hamper the autonomy to act. The model asserts that when users are faced with a novel technology, the choice about how and when they will apply it, is influenced to a large extent, the perceived usefulness (PU) described by Davis (1989) as "the degree to which a person believes that using a particular system would enhance his or her job performance" and the perceived ease-of-use (PEOU) described as "the degree to which a person believes that using a particular system would be free from effort" (Davis 1989).

PEOU together with PU are subject to external variables (Surendran, 2012), mainly social factors, cultural factors and political factors. Social factors are language skills and enabling conditions, while political factors are the effect of use of technology in politics and political crisis. Attitude is about the user's evaluation of the attractiveness to employ a certain technology. Behavioral intention is the measure of the probability of an individual to apply the technology. TAM helps in understanding the role of perceptions on usefulness and ease of use in determining the desire to apply the technology and the level to which the technology will be adopted. Further, external variables influence the behavioral intention to use and the actual usage of the technology given their indirect effect on PEOU and PU.

Integrating the two models, this paper proposes that technology adoption is a multifaceted, inherently social, developmental process; individuals create distinct yet flexible views of technology that impact their adoption choices. The adoption is affected by the perception of inherent features of the technology, social-economic factors such education levels, involvement of males in the adoption process and post-implementation extension services offered to farmers to determine the extent of consequent spread. Therefore, successful propagation of technology adoption needs to address cognitive and contextual issues.

2.6.2 Rogers's Innovation Diffusion Theory

Rogers prepared a doctoral dissertation in 1957 while studying rural and agricultural sociology, focusing on the trend of use of a new weed spray by Iowan farmers. Rogers appraised related findings on the way people embraced a new technology or idea; studies in varied disciplines such as medicine, agriculture, and marketing, and realized several similarities and he used it to formulate an overarching, theoretical framework.

Rogers (2003) defined innovation as a new object, idea, technology, or practice. An innovation may be a tangible, physical object such as a new device or medicine or intangible, for example a new design method or educational method. Moreover, the concept of an innovation's novelty could relate to both place and population. This model is general in nature giving it extensive application.

Diffusion can be termed as the spatial and temporal movement of the new technology to different economic units. Rogers (2003) differentiated between adoption and diffusion defining diffusion (aggregate adoption) as the process in which a technology is transferred through various channels over time amongst the members of a community. Four elements are denoted: (1) the technology that is the new idea, practice, or object being spread, (2) communication channels which represent how information on the new technology moves from change agents (extension, technology suppliers) to final consumers or adopters (e.g., farmers), (3) the time period over which a technology is adopted in a social system, and (4) the social system.

Rogers (2003) asserts that adoption is where a farmer is inclined to either using or failing to use a novel technology by a farmer at a certain period. Feder et al. (1985) differentiated between individual adoption (farm level) and aggregate adoption, whereby individual adoption is the degree of use of a new technology (innovation) in the long-run where an individual has adequate information on the new technology and its potential while aggregate adoption (diffusion) is the progression of a technology in an area. This implies that aggregate adoption is measured by the aggregate level of use of a given technology within a given geographical area. Equally, Thirtle and Ruttan (1987) described aggregate adoption as the spread of a new technique within a population. The difference between adoption and diffusion is essential for theoretical and empirical evaluation of the levels of the two economic phenomena.

The notion of early and late adopters gave the primary hypothesis for explaining the S shape in the adoption path. Rogers (2003), and Mahajan and Peterson (1985), delivered reasons for the process of attaining information and the time intervals created in regard to the rate of adoption by people in the society. The S-shaped curve shows that merely a small number of (farmers take up a novel approach in the initial phase of circulation.

2.7 Conceptual Framework

A conceptual framework is a group of ideas and principles taken from a relevant field of inquiry, used to structure subsequent presentations (Reichel and Ramey, 1978) as cited in Kombo and Tromp, (2006). The conceptual framework forms ideas about relationships between variables in the study and showing these relationships graphically or diagrammatically (Mugenda and Mugenda, 2003). Based on the above theoretical framework, the study was guided by the following conceptual framework.

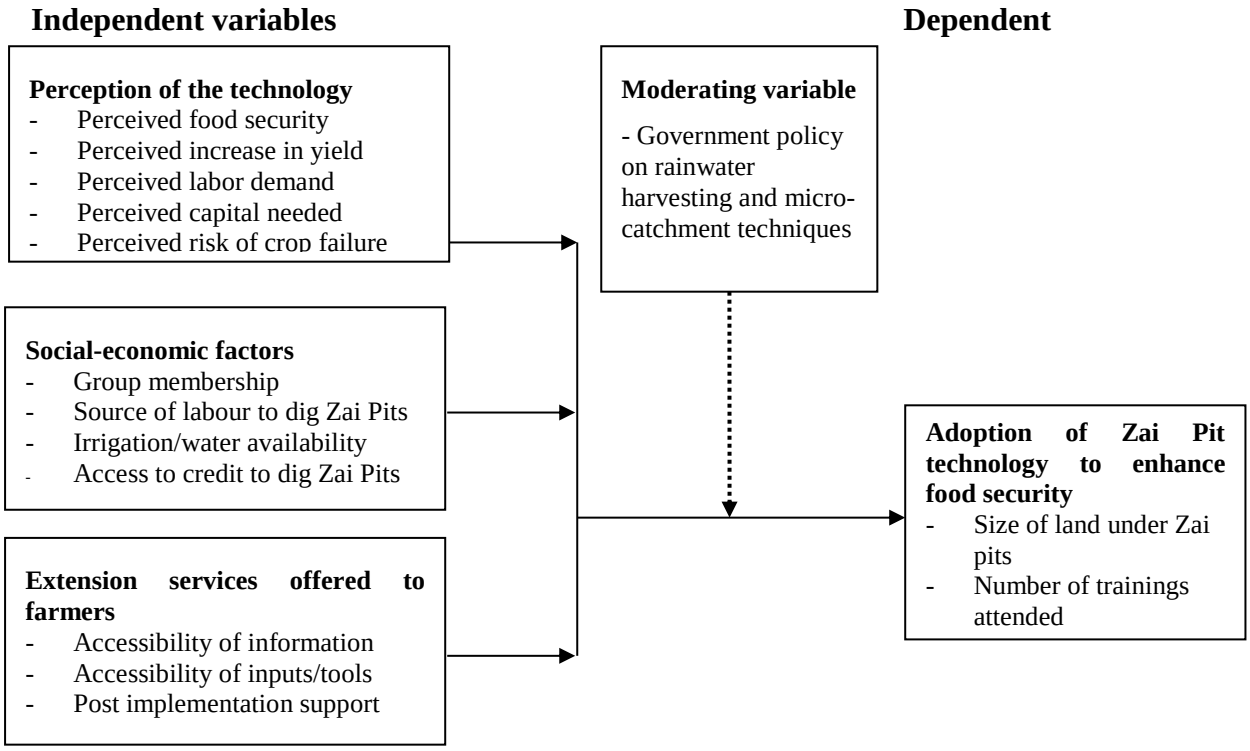

Figure 1: Conceptual Framework for factors influencing adoption of Zai pit farming technology to enhance food security

This study was guided by the conceptual framework which has the following independent variables: perception of the technology, the social-economic factors and extension services offered. The moderating variable is government policy on micro-catchment techniques. The dependent variable is the adoption level of Zai pit farming technology in terms of the yield of crops grown and adequacy of food for the household.

2.8 Knowledge Gap

Despite many factors that influence technology adoption Feder *et al.* (1985), Kaliba *et al.* (2000), argued that much research on soil management has focused on technical aspects of soil management without consideration of determinants and attributes of the adoption process, which are important in guiding technical research. Njeru *et al.* (2013) noted that more research is needed to understand the gaps that exist between scientific research findings and farmers' perceptions towards these technologies. With regard to this research study there is a critical need for stakeholders to understand how an intangible factor like perception of a technology introduced affect its effective adoption.

Organizations such as World Vision, World Agroforestry, Yagrein and Act! have been supporting farmers in Makueni to adopt the Zai pit farming technology. However, there has been no consolidated study on the levels of adoption of the technology. Given that Zai pit farming technology has been successfully used in arid and semi-arid areas in Mali, Burkina Faso and Niger, which are comparatively drier areas, stakeholders need to develop targeted initiatives in view of the unique factors influencing the adoption of Zai pits in Makueni.

2.9 Summary of Literature

This chapter reviewed the literature on food security Zai pit farming technology, the influence of perception of technology and adoption of Zai pit farming technology to enhance food security in Makueni County, the influence of social-economic factors and adoption of Zai pit farming technology to enhance food security in Makueni County and the influence of extension services offered to farmers and adoption of Zai pit farming technology to enhance food security in Makueni County. The theoretical framework was illustrated using the TAM and Rogers's innovation diffusion theory. The conceptual framework explained the relationship between independent and dependent variables, with the independent variables being the perception of technology by farmers, social-economic factors and the extension services offered to farmers and the dependent variable being the adoption of Zai pit farming technology. Finally, the chapter concludes by discussing the gaps to be filled by the study. As shown in Table 2.3.

Table 2.3: Summary of Empirical Literature

Variable	Indicators	Author (year)	Title of the study	Findings	Knowledge gap
Perception of technology	- Perceived food security - Perceived increase in yield - Perceived labor demand - Perceived capital needed - Perceived risk of crop failure	Drechsel, P., et al (2005)	Adoption Driver and Constraints of Resource Conservation Technologies in sub-Saharan Africa	Attributes of a technology such as how it improves nutrient availability, water availability, yields, amount of labour needed, ability to secure land tenure, capital, level of perceived risk and access to information	There is need to study the influence of perception(level) as an intangible factor on the level of adoption of the technology
Social-economic factors	- Group membership - Sources of income - Source of labour used in digging Zai Pits - Income from Zai Pits - Irrigation Access to credit to dig Zai Pits	Murgor (2013)	Factors influencing farmers decision to adapt rain water harvesting	Limitations for farmers in adopting modern technologies are high costs of hired labour, transportation of agricultural products, construction material and lack of credit or capital.	There has been no consolidated study on the influence of social-economic factors on the level of adoption of the technology

Extension services offered to farmers	- Accessibility of information - Accessibility of inputs/tools - Communication channels - Post implementation support Duration of extension	Swanson and Rajalahti, (2010).	Analyzing agricultural technology systems: Some methodological tools	The roles of non-governmental organizations (NGOs) and farmer-based organizations (FBOs) are increasingly being recognized as key for information sharing on specific crops and cropping systems	There is need to study the influence extension services offered to farmers on the level of adoption of the technology
Adoption of Zai pit farming technology	- Number of adopters - Size of land under Zai pits - Number of trainings attended - Increase in yield Increase in income	Sanginga and Woomer, 2009	Integrated Soil Fertility Management in Africa: Principles, Practices, and Developmental Process	Techniques of gathering water which intensify water penetration up to 50% could increase grain yields up to 60 to 90% subject to rainfall and soil fertility	The evidence-based number of adopters

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter describes the research design, target population, and research methodology that was used to respond to the research questions, the sampling method, sample size, method of data collection and tools, methods of data analysis, ethical issues and operationalization of the variables table.

3.2 Research Design

The research applies a descriptive survey design. The design was used because it assesses occurrences, happenings and matters the way they are (Mugenda and Mugenda, 2003). The design discussed the factors which influence the adoption of Zai pit farming technology in Makueni County. Descriptive survey examines the problem comprehensively to explain it, shed light on it and acquire relevant information useful for stakeholders in dryland farming in Makueni and other ASAL areas in Kenya. The design caters well for huge sample sizes hence appropriate for generality of the findings. It was also easy to oversee data collection when using descriptive design.

3.3 Target Population

This study targeted 1500 farmers in Makueni County, who have applied Zai pit farming technology. The farmers were the primary target as they were the ones who implemented the technology in their farming and were the recipients of training information and the beneficiaries of successful implementation. Their experiences in the changing climate patterns and unreliable rainfall in the region give insight as to why they may consider or reject the use of Zai pit farming technology. The researcher purposively worked with the 10 available officers hence the entire population of 10

field staff of local organizations was used as the sample. The field staff were the primary contact with the community hence useful in providing feedback on the factors influencing adoption of Zai pit farming technology in Makueni.

3.4 Sample Size and Sampling Procedure

This section describes the sample size and the sampling procedure used in the study.

3.4.1 Sample Size

This study employed a sample size of 48 farmers from a target population of 1500 farmers using Zai pit farming technology selected using purposive sampling. The officers were purposively selected by census as they were few within the County. The selected sample size was 10 officers.

3.4.2 Sampling Procedure

The sample size for farmers was obtained using purposive sampling, where one sets the purpose they want participants to fulfill, then find them (Bernard, 2006:189). It is convenient in circumstances where one must access the target sample speedily and where sampling proportionately is not the chief concern (Trochim, 2006). With purposive sampling, one may acquire information from the target population, but may also overweight more accessible subgroups in the population. The 48 farmers belonging to 10 chamas were most accessible given the large distances between members of 'chamas' and since they represented the characteristics of the population, they were deemed representative.

The study used purposive sampling by census to select the officers to participate in the study from the target population of Makueni County, Kenya. Census sampling was used as the officers were few, the entire population set was used. The sample size in this

study could be affected by several factors, such as the purpose of the study, population size, the risk of selecting a "bad" sample, and the allowable sampling error (Israel, 1992).

3.5 Research Instruments

Primary and secondary data methods were applied in collection of qualitative data. Hamel (1993) noted that data gathered under case studies is largely qualitative, but it could also be quantitative. Primary data was gathered using a semi-structured questionnaire issued to respondents.

The semi-structured questionnaire issued to farmers contained the first section requesting demographic information, second section on perception and adoption of Zai Pit farming technology, and the third section on social-economic factors and adoption of Zai Pit farming technology. The extension officers were issued with a questionnaire containing a section on demographic information and a section on extension services offered to farmers and adoption of Zai Pit farming technology. A likert scale assessed the perception of the role of Zai pit farming technology in increasing yields, ensuring food security, the amount of labor needed when the technology was used, its influence on the level of capital required for its use and the level of perceived risk of crop failure when the technology was used. A likert scale was also used to assess the extension services offered to farmers influence adoption of Zai Pit technology. The questions contained in the semi-structured questionnaire reflected the fact that people comprehend the world in varying ways.

Secondary data was obtained from publications which include magazines and newsletters as well as brochures, examination of appropriate reports, policies and working papers from research organizations. This was utilized along with the analyzed

primary data to help develop relevant conclusions from the data collected. Background data (socio-economic, demographic elements) on Makueni County was collected and collated from secondary sources.

The presentation of qualitative data partially depended on how the data looks (Berg, 2007:46). Authenticity of data collection from the respondents was guaranteed by presenting and revising data collection instruments accordingly.

3.5.1 Pilot Testing

A pilot test was conducted in the County featuring 5 farmers in Tharaka Nithi County that have adopted Zai Pit farming technology (about 10% of the study sample size) but were not part of the study according to Mugenda & Mugenda (2003) theory where a pretest sample of between 1% and 10 % guarantees a sufficient sample size to solicit solid data for a pilot test. Participants of the pilot test were picked randomly. Analysis was conducted to ascertain that the data collection tool could be adopted and revisions made accordingly.

3.5.2 Validity of Instruments

The primary instrument for data collection in this study was a well-structured, simple and understandable semi-structured questionnaire. Validity is the usefulness of a measure: does the tool measure what it claims to measure Wilson (1993: 54). The validity of an instrument is an assessment of the level to which the tool mirrors the construct being measured (Burns & Grove, 2001:399). Consultation with supervisors who have expertise in area of research was applied before data collection to ascertain the validity of the selected instruments. The supervisors checked whether the questions contained in the questionnaire collect data that is valid to respond to the research questions in the study.

3.5.3 Reliability of Instruments

To safeguard reliability of measures (consistency, accuracy, and precision) in the use of the research instruments, the reliability goal was to measure how internally consistent an instrument was tested using the Cronbach's alpha coefficient Equation 5 where *n* equals the number of items comprising the Likert scale.

Cronbach's alpha = $\frac{n}{n-1}\left(1 - \frac{Variance_{Error}}{Variance_{Observed\ Scores}}\right)$

$= \frac{11}{11-1}\left(1 - \frac{0.16}{0..5}\right) = 0.75$

To eliminate bias during the study, the data was collected with the assistance of two trained research assistants. Moreover, the responses were sampled and analyzed in terms of mean and percentages to check if the process yielded consistent results.

3.6 Data Collection Procedure

This entailed obtaining an introductory letter from the University of Nairobi, and a research permit by NACOSTI. A letter was presented to the respondents to get their consent to administer the questionnaires. The researcher physically administered the questionnaires in the field with assistance by two trained research assistants and immediately collected them back for analysis after each respondent finished the process.

3.7 Data Analysis Techniques

Data from this study was coded and cleaned before analysis. The questionnaires were edited to check the level of completeness, clarity and consistency within which respondents answered the research questions. The data was then tabulated and analyzed using MS Excel based on study objectives. Quantitative data was presented using frequency and percentage tables and interpreted using computed descriptive statistics

such as means and percentages. Qualitative data was analyzed by categorizing responses into themes based on the research objectives and labeling them for discussion. Non-quantitative data such as verbal comments were sorted, taken through content analysis for relevance and captured in the discussions verbatim as direct quotes.

3.8 Ethical Issues

There was an introductory letter issued to obtain consent from respondents before administering questionnaires. Further, the respondents were treated to a high level of confidentiality regarding their responses and would have the findings of the study shared with them through the Makueni County Department of Agriculture contact person.

3.9 Operationalization of the Variables

Operational definition of variables means defining a concept to make it measurable. Measures can be objective or subjective (Polit & Hunger, 1997). Variables used in this study were operationally defined as shown by Table 3.1.

Table 3.1: Operational definition of variables

Objectives	Variables	Indicators	Measure	Measurement scale	Statistical analysis	Tool of Analysis
To determine the influence of perception of technology on adoption of Zai pit farming technology	Perception of the technology	- Perceived food security - Perceived yield increase - Perceived labor demand - Perceived capital needs - Perceived risk of crop failure	- Level of perceived food security - Level of perceived yield increase - Level of labour demand - Level of capital - Level of perceived risk	Ordinal	Descriptive statistics	Percentages Means
To determine the influence of social-economic factors on adoption of Zai pit farming technology	Social-economic factors	- Group membership - Source of labor - Access to credit - Irrigation/water availability - Household income	- Group membership - Source of labour used in digging Zai Pits - Irrigation - Access to credit to dig Zai Pits	Nominal Ratio Ordinal	- Descriptive statistics - Inferential statistics	Percentages Means

To determine the influence of extension services offered to farmers on adoption of Zai pit farming technology	Extension services	- Access to information - Access to inputs/tools - Post implementation support	- Number of trainings held per year - Number of farmers trained	Ratio Ordinal	- Descriptive statistics - Inferential statistics	Percentages Means
Dependent variable Adoption of Zai Pit farming technology in Makueni County	Adoption of Zai pit farming technology	- Adoption rate	- Number of trainings attended - Size of land under Zai Pits - Increase in yield - Increase in income	Ratio	- Descriptive statistics - Inferential statistics	Percentages Means

CHAPTER FOUR

DATA ANALYSIS, PRESENTATION AND INTERPRETATION

4.1 Introduction

This chapter details the data analysis, presentation and interpretation of findings of the factors influencing the adoption of Zai pit farming technology to enhance food security in Makueni County, Kenya. The chapter is divided into these sections: questionnaire return rate, demographics, factors namely perception of technology and adoption of Zai pit farming technology, social-economic factors and adoption of Zai pit farming technology and extension services offered to farmers influencing adoption of Zai pit farming technology as per research objectives.

4.2 Questionnaire Return Rate

The questionnaire return rate was 100%, achieved by ensuring that the researcher and the two research assistants collected the questionnaires from respondents immediately the respondents completed them.

4.3 Demographic Characteristics of the Respondents

4.3.1 Demographics of farmers

Demographics of farmers in this study comprised of gender, age, marital status, education levels, size of households, duration one has been a farmer and group membership of the farmers. Results are shown in Table 4.1.

Table 4.1: Demographic characteristics of farmers in Mbooni

Demographics of farmers	Frequency	Percentage %
Gender of farmers		
Female	39	81.3
Male	9	18.7
Total	**48**	**100**
Age bracket of farmers		
Below 35	7	14.6
36-45	16	33.3
46-55	13	27.1
56-65	6	12.5
Above 65	6	12.5
Total	**48**	**100**
Marital status of farmers		
Married	40	83.3
Single	2	4.2
Widow	6	12.5
Total	**48**	**100**
Academic qualification of farmers		
KCPE	29	60.4
KCSE	15	31.3
Diploma	3	6.3
Bachelors	1	2.1
Total	**48**	**100**
Size of household		
3 to 5	25	52.1
6 to 8	14	29.2
Below 3	2	4.2
Over 8	7	14.6
Total	**48**	**100**

The gender distribution of the sample size was at 39(81.7%) females and 9(18.3%) males. More females belong to the groups (chamas) which is the channel where the technology was introduced hence were majority of the adopters. The age category featured a majority between 36-45 years at 16(33.3%), those below 35 years being 7(14.6%), 46-55 years being 13(27.1%), 56-65 years were 6(12.5%) while those above 65 were 6(12.5%). The respondents that had adopted the Zai Pit technology were mostly

those leading active lifestyles and were able to adopt technology. However, men 9(18.3%) have also adopted the technology. The majority of farmers, 40(83.3%) were married, 2(4.2%) were single and 6(12.5%) were widows. These farmers who were providers to their households were mostly the married and had families and thus had to ensure they provide food security for their families. Around 43(89.6%) of the farmers belonged to a 'chama' or group with only 5(10.4%) reported not to affiliate to any group. The Zai Pit farming technology was introduced through the group channel. Majority 29(60.4%) of the farmers in Mbooni Sub-County in Makueni County had attained primary school level of education followed by secondary level of education 15(31.3%). Only 3(6.3%) and 1(2.1%) had attained diploma and bachelor's degree respectively. The low level of education indicated the low level of understanding the technology as most farmers only practiced the technology on a small section of their land. The size of household/family of the respondents were 3 to 5 children at 25(52.1%), 6 to 8 children at 14(29.2%), below 3 found to be 2(4.2%) and over 8 at 7(14.6%). The large household size hence a strong need for food security depicts that it's important for the farmers to adopt the Zai Pit farming technology to prevent the likelihood of hunger in their households.

4.3.2 Demographics of Extension Officers

Demographics of extension officers in this study comprised of gender, age, marital status, education levels, the duration one has worked as an officer and the duration one has worked in the Mbooni area specifically. Results are shown in Table 4.2.

Table 4.2: Demographic characteristics of extension officers

Demographics of extension officers	Frequency	Percentage %
Gender of officers		
Female	4	40
Male	6	60
Total	**10**	**100**
Age bracket of officers		
Below 35	2	20
46-55	6	60
56-65	2	20
Total	**10**	**100**
Marital status of officers		
Married	8	80
Single	2	20
Total	**10**	**100**
Academic qualification of officers		
Diploma	6	60
Bachelors	2	20
Masters	2	20
Total	**10**	**100**
Duration worked as an officer		
Below 1 year	2	20
5 – 10 years	2	20
Over 10 years	6	60
Total	**10**	**100**
Duration worked in Mbooni area		
Below 1 year	2	20
2 – 5 years	2	20
5 – 10 years	4	40
Over 10 years	2	20
Total	**10**	**100**

The gender distribution of the sample size was at 4(40%) females and 6(60%) males. The age category featured a majority between 46-55 years at 6(60%), those below 35 years being 2(20%), and between 56-65 years being 2(20%). The majority of the extension officers, 8(80%) were married, 2(20%) were single. Majority 6(60%) of the extension officers in Mbooni Sub-County in Makueni County had attained a diploma,

2(20%) had a Bachelor's degree and 2(20%) had a Master's degree. Most of the respondents 6(60%) had worked as extension officers for more than 10 years, while 2(20%) had worked for 5- 10 years and 2(20%) less than 1 year. 4(40%) of the officers had specifically worked in Mbooni Sub-County for 5-10 years, 2(20%) had worked for less than 1 year, 2(20%) had worked 2-5 years and 2(20%) had worked for more than 10 years.

4.4 Adoption of Zai Pit Farming Technology to Enhance Food Security

The farmers were asked to indicate the size of land they farmed using Zai Pits the number of trainings attended and the number of trainings attended. The results are shown in Table 4.3.

Table 4.3: Proof of farming and practising Zai pit farming technology

Aspect	Frequency	Percentage %
Period a farmer		
Below 5 years	1	2.1
5-10 years	7	14.6
Over 10 years	40	83.3
Total	**48**	**100**
Size of land under Zai pits		
Less than 1acre	44	91.7
2-5 acres	3	7.8
Over 5 acres	1	2.5
Total	**48**	**100**
Number of trainings attended		
Less than 2	4	8.33
2-5	12	25
Over 5	32	66.7
Total	**48**	**100**
Benefits derived from farming using Zai		
Food security	35	89.79
Increased yield	36	92.3
Increased fodder	11	28.2
Increased income	10	25.6

4.5 Perception of Technology and Adoption of Zai Pit Farming Technology to Enhance Food Security

The study sought to find out the perception of Zai pit farming technology by farmers in Makueni County.

Rating the perception of technology to influence adoption of Zai Pit farming technology

This section is a Likert scale that rated the role of perception of technology in influencing the adoption of Zai Pit farming technology by farmers in Makueni County. The results were as shown below. A scale of 1-5 was used in rating perception with regard to adoption of Zai Pit farming technology. The scores "very low" and "low" represented strong agreements, represented by mean score, equivalent to 1 to 2.5 on the continuous Likert scale (1 < low< 2.5). The scores of 'moderate' represented indecision, equivalent to 3 on the scale. This was equivalent to 2.6 to 3.5 on the Likert scale (2.6 < moderate < 3.5). The score of "high" and "very high" represented strong agreements with the statements on the perception of Zai Pit farming technology. This was equivalent to 3.6 to 5.0 on the Likert Scale (3.6 < high< 5.0). The results are shown in Table 4.4.

Table 4.4: Rating the perception of technology to influence adoption of Zai Pit farming technology

	Item/Scale	1	2	3	4	5	Mean	Std Dev
1.	Zai Pits are easy to use	1(2.1%)	2(4.2%)	1(2.1%)	14(29.2%)	30(62.5%)	4.4583	0.8981
2.	Zai Pits are useful for farming	1(2.1%)	0	0	23(47.9%)	24(50%)	4.4375	0.7113
3.	The implementation of Zai Pits is in the area is sustainable or reliable to ensure food security for your household	1(2.1%)	0	2(4.2%)	23(47.9%)	22(45.8%)	4.3541	0.7576
4.	The implementation of Zai Pits is in the area will lead to higher yields or harvests	1(2.1%)	0	3(6.3%)	19(39.6%)	25(52.1%)	4.3958	0.7919
5.	Digging Zai Pits requires low labour	13(27.1%)	14(29.2%)	6(12.5%)	12(25%)	3(6.3%)	2.5416	1.3039
6.	Digging Zai Pits requires low capital that is manageable for me	11(23%)	16(33.3%)	6(12.5%)	10(20.7%)	5(10.5%)	2.625	1.3308
7.	The risk of failed harvests is reduced with Zai Pits	1(2.1%)	0	3(6.3%0	32(66.7%)	12(25%)	4.125	0.7033
8.	The rainfall is adequate if Zai Pits are used to ensure my farming guarantees food security for my family	1(2.1%)	1(2.1%)	5(10.4%)	33(68.7%)	8(16.7%)	3.9583	0.7425
9.	I expect increased yield when I practice farming maize using Zai Pits	0	0	4(8.3%)	9(18.8%)	35(72.9%)	4.6458	0.6354
10.	I expect increased yield when 1 practice farming crop 2 using Zai Pits	0	0	5(10.4%)	14(29.2%)	29(60.4%)	4.5	0.6841
11.	I expect increased yield when 1 practice farming crop 3 using Zai Pits	0	0	24(50%)	7(14.6%)	17(35.4%)	3.8541	0.9222
	Mean of mean						**3.9905**	**0.8619**

The researcher found that majority of the farmers 44(91.7%) agreed that Zai pits were easy to use hence they adopt the Zai Pit farming technology while 2(4.2%) disagreed on the ease of use. This means that farmers use the pits easily by planting around the edges of the pits. Zai pits were perceived by majority of the farmers 47(97.9%) as useful for farming with only 1(2.1%) disagreeing. The Zai pits serve as a rainwater harvesting method and micro-catchment conservation method meaning crop production goes on smoothly due to the water and nutrient concentration within the pits. 45(93.7%) of the farmers felt strongly that Zai pits enhance food security and only 3(6.3%) disagreed. Zai Pits conserve water hence reduce the risk of crop failure and concentrate nutrients for the crops. 44(91.7%) felt that Zai Pit farming technology increases the crop yields. However 4(8.4%) felt that the yields do not increase with use of Zai Pits.

Majority of the farmers 27(56.3%) disagreed that Zai Pits require low labor to dig. “If I dig them myself I take so long, it’s hard” some of the farmers asserted. However, 15(33.6%) agreed that the labor requirement is low. Most of the respondents 27(56.3%) disagreed that Zai Pit farming technology requires low capital that is manageable for them “We pay about 50 shillings per pit, that a lot!” they indicated. However, 15(31.2%) agreed that the capital requirement was low enough for them to manage. 44(91.7%) of the farmers agreed that use of Zai Pit farming technology reduces the risk of crop failure while only 1(2.1%) felt that the risk was not significantly reduced. These two factors, labor and capital seem to be negatively affecting adoption of Zai Pit farming technology.

Majority 41(85.4%) agreed that the rainfall was usually adequate if Zai Pits were used to ensure farming guaranteed food security for their families while only 2(4.2%) disagreed. Use of Zai Pits ensures water is collected in the pit for use by plants even when rains fail or low rainfall is experienced, guaranteeing the farmers a harvest. Most

farmers agreed that planting maize 44(91.7%) or crops such as beans 43(89.6%) and vegetables 24(50%) in Zai Pits assured increased yields.

4.6 Social-economic Factors and Adoption of Zai Pit Farming Technology to Enhance Food Security

The study sought to find out how social-economic factors such as group membership, sources of income from farming using Zai Pits and other sources, source of labor, access to credit to dig Zai Pits, availability of water for irrigation influence the adoption of Zai pit farming technology by farmers in Makueni County. In addition, the farmers responded on the constraints they experience while applying Zai Pit farming technology. The results are shown in Table 4.5.

Table 4.5: Social-economic factors and adoption of Zai farming technology to enhance food security

Social-economic factor	Frequency	Percentage %
Group Member		
No	5	10.4
Yes	43	89.6
Total	**48**	**100**
Income sources		
Farming	44	93.7
Other	4	6.3
Total	**48**	**100**
% of income from farming where it's not the main source		
10-30%	1	25
31-50%	1	25
less than 10%	2	50
Total	**4**	**100**
Income from Zai Pits		
5000-20000	9	18.8

Above 50000	10	20.8
Below 5000	29	60.4
Total	**48**	**100**
Source of labour to dig Zai Pits		
Myself	16	33.3
My family assists me	5	10.4
Employee	9	18.8
Myself, my family	10	20.7
Myself, my family & Employee	2	4.2
Myself & Employee	3	6.3
My family & Employee	3	6.3
Total	**48**	**100**
Accessed credit to dig Zai Pits		
Yes	4	8.4
No	44	91.6
Total	**48**	**100**
Carries out Irrigation		
Yes	19	39.6
No	29	60.4
Total	**39**	**100**

Majority of farmers 43(89.6%) belong to groups; only 5(10.4%) were non-members. The Zai Pit farming technology was introduced in Mbooni Sub-County through the group channel hence most of the adopters of the technology were trained by Zinduka Afrika in the groups and implemented the technology. 45(93.7%) of the farmers were found to derive their major income from farming while 3(6.3%) had other main sources of income. Most of the residents of Makueni County acquire their livelihood through farming. For farmers whose main income came from sources other than farming, 2(50%) earned less than 10% from farming, while 1(25%) earned 10-30% and 1(25%) earned 30-50% from farming. This means that farming is still the main economic

activity in the area under study. In terms of income levels from farming using Zai pits in the last year, 2016, 29(60.4%) earned below Ksh. 5,000, 9(18.8%) earned between Ksh. 5000-20000 and 10(20.8%) earned above Ksh. 50,000 as per Table 4.5. Zai Pits farming is mostly for subsistence hence the income levels are low. Moreover, the size of land where the pits have been dug is significantly low with 44(91.7%) farming in less than 1acre, 3(7.8%) farming in 2-5 acres and only 1(2.1%) farming over 5 acres.

Most of the farmers 24(50%) dug the Zai pits themselves 22(33.3%) have their families assist in digging while 22(45.7%) hire an employee to assist in digging pits. The cost of digging is high hence most farmers dig the pits themselves or enlist family support especially children. Very few 4(8.4%) of the farmers reported to have taken credit to dig the Zai pits in their farms and 44(91.6%) had not taken credit at all. Some farmer groups had received a seed grant from Zinduka, the organization that sponsored the Zai pit pilot project in Mbooni sub-county in Makueni while others did not see the need to access credit.

The rainfall pattern in the area is bimodal and the soil is mostly loam in nature. This rainfall pattern means that farmers plant and harvest twice in the year. The researcher found that only 19(39.6%) of the farmers practised irrigation while majority did not 29(60.4%). This means that Zai Pit technology is independent of irrigation but irrigation supplements the use of Zai Pit technology for farmers who have access to water from sand dams and seasonal rivers near their farms.

The constraints that farmers faced while farming using Zai pit farming technology were highlighted in Table 4.6.

Table 4.6: Constraints when using Zai pit farming technology

Constraint	Frequency	Percentage %
Capital to finance labour to dig seeds	7	17.9
Labour intensive	6	15.4
Late timing in delivery of seeds	2	5.1
Poor quality of seeds	6	15.4
Pests	9	23.1
Lack of fertilizer	7	17.9
Low rainfall	5	12.8
Silting	1	2.6
Low follow up by extension officers	1	2.6

4.7 Extension Services Offered to Farmers and Adoption of Zai Farming Technology to Enhance Food Security

The officers came from the government since the non-government organizations were inaccessible. However, the officers comprised both those who had been directly involved in the project along with Zinduka Africa and those who had not been there during the project implementation but were now providing extension services to farmers in the ward. The goal was to get views from previous and current extension officers. The core duties the officers carried out included agricultural extension and support to farmers, livestock extension, training and supervision of projects.

Rating the extension services offered to farmers in influencing adoption of Zai Pit farming technology.

This section is a Likert scale that rated the role of extension services offered to farmers in influencing the adoption of Zai Pit farming technology by farmers in Makueni County. The results were as shown below. A scale of 1-5 was used in rating extension services offered to farmers with regard to adoption of Zai Pit farming technology. The

scores "very low" and "low" represented strong agreements, represented by mean score, equivalent to 1 to 2.5 on the continuous Likert scale (1 < low< 2.5). The scores of 'moderate' represented indecision. This was equivalent to 2.6 to 3.5 on the Likert scale (2.6 < moderate < 3.5). The score of "high" and "very high" represented strong agreements with the statements on the perception of Zai Pit farming technology. This was equivalent to 3.6 to 5.0 on the Likert Scale (3.6 < high< 5.0). The results are shown in Table 4.7.

Table 4.7: Extension services offered to farmers

Item/Scale	1	2	3	4	5	Mean	SD
1. Zai Pits are easy to use	0	0	0	8(80%)	2(20%)	4.2	0.4216
2. Zai Pits are useful for farming	0	0	0	8(80%)	2(20%)	4.2	0.4216
3. In the local area the food security situation was worse before the use of Zai Pits	0	0	0	6(60%)	4(40%)	4.4	0.5163
4. The implementation of Zai Pits is in the area is sustainable or reliable to ensure food security for households	0	0	0	10(100%)	0	4	0
5. The implementation of Zai Pits is in the area will lead to higher yields or harvests	0	0	0	6(60%)	4(40%)	4.4	0.5163
6. Digging Zai Pits requires low labour	4(40%)	6(60%)	0	0	0	1.6	0.5163
7. Digging Zai Pits requires low capital that is manageable for farmers	4(40%)	6(60%)	0	0	0	1.6	0.5163
8. The risk of failed harvests is reduced with Zai Pits	0	0	0	10(100%)	0	4	0
9. The rainfall adequate if Zai Pits are used to	0	0	0	6(60%)	4(40%)	4.4	0.5163

	ensure farming guarantees food security for families							
10.	I expect increased yields are expected when farmers plant maize using Zai Pits	0	0	0	0	10(100%)	5	0
11.	I expect increased yields are expected when farmers plant crop 2 using Zai Pits	0	0	0	0	10(100%)	5	0
12.	I expect increased yields are expected when farmers plant crop 3 using Zai Pits	0	0	0	0	10(100%)	5	0
13.	I knew about Zai Pits before they were used in the area	0	0	0	0	10(100%)	5	0
14.	The idea to use Zai Pits arose from the donors	0	4(40%)	0	2(20%)	4(40%)	3.6	1.4298
15.	The idea to was accepted by the community as a useful farming technology	0	0	0	0	10(100%)	5	0
16.	There is adequate government support to implement the Zai Pit technology	0	2(20%)	0	4(40%)	4(40%)	4	1.1547
17.	The community was involved in the implementation of the Zai pit pilot project	0	0	0	4(40%)	6(60%)	4.6	0.5163
	Mean of mean						**4.1176**	**0.3838**

All the 10(100%) of the extension officers felt that Zai Pit farming technology was easy to use. Moreover, 10(100%) of the extension officers felt that Zai Pit farming technology was easy to use. Zai Pits are relatively easy to use and very useful for farming in arid and semi-arid areas such as Makueni County. They all felt that the food security situation was worse before the community began farming using Zai Pits. The

entire set 10(100%) agreed that implementation of Zai Pits is in the area is sustainable or reliable to ensure food security for households and reduce the risk of failed harvests since rainfall was adequate as opposed to when Zai Pits were not applied.

The project implementers came in contract with 60% of the officers involved through a written contract. However, 40% were not involved in any contract despite knowing about the project. They commented that this in a huge way contributed to some hitches in sustainability of application of Zai pit farming technology in Makueni County. 60% of the officers reported that they check the number of Zai Pits and exact dimensions of Zai Pits. Only 20% of the officers reported that they check the wellbeing of crops. The researcher found that 60% of the officers merely offered support to the community trainer of trainers (ToT) but do not check directly with the farmers.

The strengths highlighted by the officers about Zai pit farming technology is that it is very suitable for water harvesting in dry season and contributing to higher yields. On the contrary, the drawback were that the technology was labor intensive, involved high capital levels for digging and low funding levels to involve more officers during implementation of the pilot project and to support post pilot project extension to farmers. Overall officers learnt that Zai pit farming technology is most useful when entrenched in regular extension activities, is very beneficial if farmers grow several crops, dig many pits(for scale) and that it’s a useful water harvesting method in Makueni County that manifests semi-arid climate.

CHAPTER FIVE

SUMMARY OF FINDINGS, DISCUSSION, CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This chapter contains the summary of the study, discussion of findings, conclusions drawn by the researcher and recommendations for further research.

5.2 Summary of Findings

The summary of findings was presented following the three objectives of the study.

5.2.1 Perception of technology and adoption of Zai pit farming technology to enhance food security

This is the summary of the findings of the first objective which was to determine how perception of technology influences the adoption of Zai pit farming technology to enhance food security in Makueni County. The findings revealed that 91.7% agreed that Zai pits were easy to use hence they adopt the Zai Pit farming technology while 4.2% disagreed on the ease of use.

Zai pits were perceived by majority of the farmers (97.9%) as useful for farming with only 2.1% disagreeing. 93.7% of the farmers felt strongly that Zai pits enhance food security and only 6.3% disagreed. 91.7% felt that Zai Pit farming technology increases the crop yields. However, 8.4% felt that the yields do not increase with use of Zai Pits.

Majority of the farmers (56.3%) disagreed that Zai Pits require low labor to dig. However, 33.6% agreed that the labor requirement is low. Most of the respondents (56.3%) disagreed that Zai Pit farming technology requires low capital that is manageable for them However, 31.2% agreed that the capital requirement was low enough for them to manage. 91.7% of the farmers agreed that use of Zai Pit farming

technology reduces the risk of crop failure while only 2.1% felt that the risk was not significantly reduced. These two factors, labor and capital were found to be negatively affecting adoption of Zai Pit farming technology.

Majority (85.4%) agreed that the rainfall was usually adequate if Zai Pits were used to ensure farming guaranteed food security for their families while only 4.2% disagreed. Most farmers agreed that planting maize (91.7%) or crops such as beans (89.6%) and vegetables (50%) in Zai Pits assured increased yields.

5.2.2 Social-economic factors and adoption of Zai pit farming technology to enhance food security

This highlights the summary of the findings of the second objective which was to examine the extent to which social-economic factors influence the adoption of Zai pit farming technology to enhance food security in Makueni County. Majority of farmers (89.6%) belong to groups; only 10.4% were non-members. 93.7% of the farmers were found to derive their major income from farming while 6.3% had other main sources of income. For farmers whose main income came from sources other than farming, 50% earned less than 10% from farming, while 25% earned 10-30% and 25% earned 30-50% from farming. In terms of income levels from farming using Zai pits in the last year, 2016, 60.4% earned below Ksh. 5,000, 9(18.8%) earned between Ksh. 5000-20000 and 10(20.8%) earned above Ksh. 50,000 as per Table 4.5. Most of the farmers (50%) dug the Zai pits themselves, 33.3% have their families assist in digging while 45.7% hire an employee to assist in digging pits. Very few (8.4%) of the farmers reported to have taken credit to dig the Zai pits in their farms and 91.6% had not taken credit at all for digging Zai pits. The researcher found that only 39.6% of the farmers practised irrigation while majority did not (60.4%).

5.2.3 Extension services offered to farmers and adoption of Zai farming technology to enhance food security

The third objective was to assess how extension services offered to farmers influence the adoption of Zai pit farming technology to enhance food security in Makueni County. 80% of the officers agreed that Zai pit farming technology was found to be easy to use and useful for farming in Mbooni Sub-County in Makueni County. 60% of the officers agreed that the food security situation was worse before the use of Zai Pits in the area. 100% of the field officers agreed that the food security situation had significantly improved which matches the statements from farmers (93.7%). The officers agreed (60%) that Zai pits increase crop production yields given the nutrient concentration and better water management. Extension providers disagreed strongly (60%) with the assertion that Zai pits require low labour and low capital that is manageable for the farmers. The officers in full (100%) strongly agreed that Zai pits reduced risk of failed harvests for farmers and assert that the rainfall is adequate when Zai pits were used in farming. The extension providers all (100%) strongly agreed that farming using Zai pits leads to increased yields of maize and any other crops. All (100%) of the officers knew about Zai pits before the technology was introduced in Mbooni Sub-county. The respondents agreed (80%) that the government gave adequate support for the project.

5.3 Discussions

The purpose of the study was to determine the factors influencing the adoption of Zai pit farming technology to enhance food security in Makueni County, Kenya. Three research objectives directed the research. The first objective was to determine how perception of technology influences the adoption of Zai pit farming technology. The second objective was to examine the extent to which social-economic factors influence

the adoption of Zai pit farming technology while the third objective was to assess how extension services offered to farmers influence the adoption of Zai pit farming technology. The study assumed a descriptive survey design. The sample comprised of 48 farmers and 10 extension officers. Data was collected using questionnaires and analyzed using a qualitative and quantitative technique.

5.3.1 Perception of Technology and Adoption of Zai Pit Farming Technology to Enhance Food Security

It is significant to identify how farmers perceive technology for enhanced appreciation of their decision to adopt the technology or not (Chi and Yamanda, 2002). The study established that Zai pits were easy to use (91.7% positive) and useful for farming (97.9% positive). This is consistent with assertions of the technology adoption model that “when users are faced with a novel technology, the choice about how and when they would apply it, is influenced to a large extent, the perceived usefulness (PU) described by Davis (1989) as "the degree to which a person believes that using a particular system would enhance his or her job performance" and the perceived ease-of-use (PEOU) described as "the degree to which a person believes that using a particular system would be free from effort" (Davis 1989).

The farmers felt strongly (93.7%) that Zai pits enhance food security. Zai pits conserve water hence reduces the risk of crop failure and concentrate nutrients for the crops. This is in agreement with findings that water harvesting methods improve food security and increase resilience and adaption to climatic changes by ensuring more efficient use of scarce water resources (Ramboll Natura, 2010). The farmers perceived strongly (91.6%) that Zai pit farming technology helps to increase crop yields. This is consistent with Sanginga and Woomer (2009), who asserted that water harvesting technologies

that increase precipitation by 50% can increase grain production by 60 to 90% depending upon precipitation and soil fertility.

Zai pit farming technology was also found to be perceived as labor intensive (56.2% negative perception as compared to 31.3 positive perception) and requiring high levels of capital (56.2% negative perception as compared to 31.2 positive perception) especially during the initial digging of pits. Therefore 89.7% of the farmers implemented the farming technology to a small scale of less than one acre. Some of them never dug beyond the project pilot pits dug during the training while others never scooped the holes as required for consecutive planting seasons.

91.7% of the farmers felt that Zai pit farming technology reduces the risk of harvests failing. This can be explained by the high concentration of nutrients within the pit close to the plants and the collection of water to be readily available to the plants. Moreover, most farmers used the Zai pits alongside manure, kitchen waste water that had been treated using ash and even commercial fertilizer. In this consideration, the risk of crop failure was greatly reduced.

ASALs are characterized by agro-pastoralism, including some extensive irrigated areas, wetlands, and protected areas such as national parks (Oxfam, 2006). Water harvesting needs to be integrated with other management strategies particularly soil fertility management, but also tillage, timing of operation, pest management and choice of cropping systems (Rockström, 2002). Maize was found to be the principal crop and farmers indicated that the yield of maize crop increased as well as most of the other crops such as arrow roots, beans, butternuts, capsicum, cow peas, green grams, kales, moringa, pawpaws, pigeon peas, potatoes, pumpkins, spinach, tomatoes and watermelon.

5.3.2 Social-economic Factors and Adoption of Zai Pit Farming Technology to Enhance Food Security

The Zai Pit farming technology was introduced through the group channel. The low level of education indicated the low level of understanding the technology as most farmers only practiced the technology on a small section of their land. There is need for the training to be conducted better at the level of understanding of the farmers. This will serve to eliminate the contradiction that the farmers had adopted the technology but only to a small extent despite having sizable land and continuing with the traditional farming techniques that do not collect more water and concentrate nutrients for the crops as Zai pit farming technology does. The large household size hence a strong need for food security depicts that it's important for the farmers to adopt the Zai Pit farming technology to prevent the likelihood of hunger in their households. Some farmer groups had received a seed grant from Zinduka, the organization that sponsored the Zai pit pilot project in Mbooni sub-county in Makueni while others did not see the need to access credit. The rainfall pattern in the area is bimodal and the soil is mostly loam in nature hence suitable for farming using Zai Pit farming technology.

5.3.3 Extension Services Offered to Farmers and Adoption of Zai Pit Farming Technology to Enhance Food Security

Majority of the officers agreed that Zai pit farming technology was easy to use and useful for farming in Mbooni Sub-County in Makueni County. Most of the officers agreed that the food security situation was worse before the use of Zai Pits in the area. With the implementation of the Zai pit pilot project by Zinduka Africa, the field officers agreed that the food security situation had significantly improved which matches the statements from farmers. The officers agreed that Zai pits increase crop production

yields given the nutrient concentration and better water management. Extension providers disagreed strongly with the assertion that Zai pits require low labour and low capital that is manageable for the farmers.

The officers in full strongly agreed that Zai pits reduced risk of failed harvests for farmers and assert that the rainfall is adequate when Zai pits were used in farming. All the extension providers strongly agreed that farming using Zai pits leads to increased yields of maize and any other crops. The officers knew about Zai pits before the technology was introduced in Mbooni Sub-county. There was no agreement on whether the idea to implement Zai pits came from the donors or was from other sources. However, all the officers agree that the community accepted the idea to implement the Zai pit farming technology project. Regarding involvement of farmers, Botha *et al* (2004) postulate that the collective and commercial sustainability of water harvesting methods depends principally on the level of participation by farmers and the community (Vohland and Barry, 2009:124). According to Bangoura (2002), the more the local people participate in planning, the higher the likelihood that rainwater harvesting constructions will be preserved and benefits shared (Vohland and Barry, 2009).

The respondents agreed that the government gave adequate support for the project. It should however be noted that these officers also mentioned that monitoring the project post-pilot phase has been weak hence the field extension officers should be more involved in field projects since they were always on the ground.

5.4 Conclusions

From the findings of the research, it was concluded that perception of technology has great influence on the adoption of Zai pit farming technology. Farmers' strong perception on the positive aspects of Zai pit farming technology influenced their

adoption. Farmers' strong perception that Zai pit farming technology is highly labor intensive and utilizes high levels of capital to achieve scale that would ultimately enable more crops hence tangible benefits influence their adoption of the Zai pit farming technology as most of the farmers only use it on less than one acre. The farmers also felt that Zai pit farming technology enhances food security, increases yields and reduces the risk of crop failure.

It was also concluded that social-economic factors such as group membership highly influence the adoption of Zai pit farming technology by farmers in Makueni County. Majority of the farmers who were members of chamas were females and consequently the females were majority of the adopters of the technology. This can be explained that the chamas were the main platforms for offering initial training of the technology and follow up extension services. Sources of labor were mainly individual then family assisted with hired labor taking the lowest place. This in turn affected the adoption of Zai pit farming technology as indicated by the low scale of adoption in less than one acre of land and the subsequent low earnings of less than Ksh. 5,000 despite farmers asserting that they derive most of their income from farming. Most of the farmers did not carry out irrigation highlighting the low water supply in the area for domestic use and farming activities, therefore irrigation does not significantly influence the adoption of Zai pit farming technology.

Further it was concluded that extension services offered to farmers significantly influence the adoption of the Zai pit farming technology. Most of the extension officers had been in contract with the Zai Pit project implementers but only for the duration of the pilot phase. The government collaboration with the NGOs was cited as poor which contributed to hitches in sustainability of application of Zai pit farming technology in Makueni County. Most of the officers reported that they check the number of Zai Pits

and exact dimensions of Zai Pits (only during the pilot phase), few checked the wellbeing of crops but mostly the officers merely offered supported the community trainer of trainers (ToT) but do not check directly with the farmers.

The contradiction posed that Zai pit farming technology is low in Makueni County can be assessed as coming from perception of the technology as being labour-intensive and requiring low capital, the dominant involvement of females in *chamas (*the main conduit for training) and champions of the technology as opposed to males who are majorly household heads hence decision makers and the post-implementation extension support and monitoring and evaluation of progress by government and non-government actors.

5.5 Recommendations

The researcher made the following recommendations from the findings of the study:

Extension officers should be more involved in providing support to farmers. They visit *chamas* (groups) regularly hence are the best suited to monitor the project progress post-implementation. They are extremely knowledgeable as about 60% have been officers for over 10 years.

Monitoring and evaluation of farming technology projects implemented by NGOs should be enforced after pilots to make sure there is a reliable body of information for both County and national government agricultural departments to make decisions.

Collaboration between NGOs and government should be better as findings indicate that the government support was there but most farmers were not able to roll out the Zai Pits to land above one acre. The place of local media such as Radio Mang'elete should be strongly considered.

5.6 Suggestions for Further Research

Based on the findings, the researcher made the following suggestions for further research that will add to the body of knowledge and provide possible solutions for farmers in Makueni County.

I suggest that further research be conducted on the role of behavioral intention to adopt Zai pit farming technology for non-adopters in other geographical locations in Makueni where the farmers have not been exposed to the Zai pit farming technology.

I suggest a study to find out viable income generating activities which can be supported by Zai pit farming in Mbooni, Makueni County should be carried out

I also suggest a study to find out how to reduce the labour used in digging Zai Pits to increase the scale of use.

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APPENDICES

Appendix 1: Authority Letter to Carry out Research Work

UNIVERSITY OF NAIROBI
OPEN & DISTANCE e-LEARNING CAMPUS
SCHOOL OF OPEN AND DISTANCE LEARNING
DEPARTMENT OF OPEN LEARNING
NAIROBI LEARNING CENTRE

Your Ref:

Our Ref:

Telephone: 318262 Ext. 120

Main Campus
Gandhi Wing, Ground Floor
P.O. Box 30197
N A I R O B I

17th August, 2017

REF: UON/ODeL/SODL/NLC/275

TO WHOM IT MAY CONCERN

RE: KOOME DORCAS NKATHA -REG NO – L50/73470/2014

This is to confirm that the above named is a student at the University of Nairobi, Open Distance and e-Learning Campus, School of Open and Distance learning, Department of Open learning pursuing Master of Arts Degree in Project Planning and Management.

She has done the course work and currently working on her research projet entitled **"Factors Influencing the Adoption "ZAI" Pit Farming Technology to Enhance Food Security: A Case Makueni County Kenya."** Being supervised by Professor Charles Rambo and now ready to collect data.

Any assistance accorded to her will be highly appreciated.

UNIVERSITY OF NAIROBI C.E.E.S. P O Box 30197 08 DEC 2017 NAIROBI NAIROBI EXTRA MURAL CENTRE

CAREN AWILLY
CENTRE ORGANIZER
NAIROBI CENTRE

Appendix II: Letter Requesting Respondents to fill Questionnaire

P.O. Box 5803
NAIROBI.

Dear Sir/Madam,

I am a graduate student undertaking a Master of Arts Degree in Project Planning and Management at the University of Nairobi. I am conducting a research study entitled "Factors influencing the adoption of Zai pit farming technology for enhanced food security in Kenya: a case of Makueni County."

You have been selected to assist in providing the required information because your views are considered important to this study. I kindly request that you fill this questionnaire as comprehensively and truthfully as possible. Please note that any information given will be treated with utmost confidentiality and will only be used for the purpose of this study.

Thank you for your support.

Yours faithfully,

DORCAS KOOME
L50/73470/2014

Appendix III: Research Permit

CONDITIONS

1. The License is valid for the proposed research, research site specified period.
2. Both the Licence and any rights thereunder are non-transferable.
3. Upon request of the Commission, the Licensee shall submit a progress report.
4. The Licensee shall report to the County Director of Education and County Governor in the area of research before commencement of the research.
5. Excavation, filming and collection of specimens are subject to further permissions from relevant Government agencies.
6. This Licence does not give authority to transfer research materials.
7. The Licensee shall submit two (2) hard copies and upload a soft copy of their final report.
8. The Commission reserves the right to modify the conditions of this Licence including its cancellation without prior notice.

REPUBLIC OF KENYA

NACOSTI

National Commission for Science, Technology and Innovation

RESEARCH CLEARANCE PERMIT

Serial No.A 15350

CONDITIONS: see back page

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THIS IS TO CERTIFY THAT:
MS. DORCAS NKATHA KOOME
of UNIVERSITY OF NAIROBI, 0-200
Nairobi,has been permitted to conduct
research in *Makueni County*

on the topic: *FACTORS INFLUENCING THE ADOPTION OF "ZAI" PIT TECHNOLOGY TO ENHANCE FOOD SECURITY: THE CASE OF MAKUENI COUNTY, KENYA*

for the period ending:
17th August,2018

Permit No : NACOSTI/P/17/60963/18645
Date Of Issue : 17th August,2017
Fee Recieved :Ksh 1000

.....
Applicant's Signature

.....
Director General
National Commission for Science, Technology & Innovation

Appendix IV: Research Questionnaire for Farmers

Instructions

The purpose of this questionnaire is to obtain information on adoption of Zai Pit technology in Makueni County. Please fill the relevant boxes and blank spaces.

SECTION A: Demographic Information

1. ***Where do you practice farming?***

   County_____Sub-county_____
   Ward_____

   Location_____Sub-location:_____Village_____

2. ***Select the appropriate gender:*** Male [ ] Female [ ]

3. ***Select the appropriate age:*** Below 35 [ ] 36 – 45 [ ] 46 – 55 [ ] 56 – 65 [ ] Above 65 [ ]

4. ***Marital status:*** Married [ ] Single [ ] Divorced [ ] Widow [ ] Widower [ ]

5. ***Highest academic qualification:*** KCPE [ ] KCSE [ ] Diploma [ ] Bachelor's degree[ ] Master's degree [ ]PhD[ ] Others (please specify)_____

6. ***Size of household/family:*** Below 3 [ ] 3 – 5[ ] 6-8 [ ] Over 8 [ ]

7. ***How long have you been a farmer?*** Below 5 years [ ] 5- 10 years [ ] Over 11 yrs [ ]

8. ***What size of land have you farmed using Zai pits (in acres)*** Less than 1 acre [ ] (2 -5 acres [ ] Over 5 acres [ ]

9. ***What crops do you farm using Zai Pits?*** Maize [ ] Sorghum [ ] Millet [ ] Green grams [ ] Cow Peas [ ] Other (specify).....

10. What benefits did you derive from using Zai pits:

Food security [ ] Increased yield [ ] Increased fodder [ ] Increased income [ ] No difference [ ] Other (specify).....

SECTION B: Perception and adoption of Zai Pit technology

11. The statements below relate to perception of smallholder farmers on the effects of Zai Pit technology on food security. Supplied also are five options corresponding to these statements: Strongly agree(SA)=5, Agree(A)=4, Undecided(U)=3, Disagree(D)=2, and Strongly Disagree(SD)=1. Please tick the option that best suits your opinion on the statement given.

	Statement	**1**	**2**	**3**	**4**	**5**
1.	Zai Pits are easy to use					
2.	Zai Pits are useful for farming					
3.	The implementation of Zai Pits is in the area is sustainable or reliable to ensure food security for your household (adequate, accessible food)					
4.	The implementation of Zai Pits is in the area will lead to higher yields or harvests					
5.	Digging Zai Pits require low labour					
6.	Digging Zai Pits require low capital that is manageable for me					
7.	The risk of failed harvests is reduced with Zai Pits					
8.	The rainfall adequate if Zai Pits are used to ensure my farming guarantees food security for my family					
9.	I expect increased yield when I practice farming maize using Zai Pits					
10	I expect increased yield when 1 practice farming crop 2 using Zai Pits (please specify)					
11	I expect increased yield when 1 practice farming crop 3 using Zai Pits (please specify)					

SECTION C: Social-economic factors and adoption of Zai Pit technology

12. ***Are you a member of any group/Chama?*** Yes [ ] No [ ]

13. If Yes, what is the name of the group? .....

14. ***What the membership numbers:*** Female ..... Males .....

15. ***Who does digging of the Zai pits in your household?*** Myself [ ] My family assists me [ ] Employee [ ] Group [ ]

Access to credit and adoption of Zai Pit technology

16. ***Is farming your main source of income?*** Yes [ ] No [ ]

17. ***If the answer to question. 21 is No, please indicate the percentage of farming as a source of your income:*** Less than 10% [ ] 10-30% [ ] 31-50% [ ] 51-80% [ ]More than 80% [ ]

18. ***How much money did you obtain from farm yields produced through use of Zai Pits last one year?*** Less than Kshs.5000 [ ] Kshs.5001-20,000 [ ] Kshs.20,001-50,000[ ] More than Ksh. 50,000 [ ]

19. Did you or other household member (18 years and above) receive any cash and or input (formal or informal) credit in the last one year for implementing Zai Pit technology?

Yes [ ] No [ ]

If yes, provide the following details

Household member who accessed credit 1=Male >35 yrs. 2=Female >35 yrs. 3=Male 18-35yrs 4=Female18-35yrs	Product/Services	Main source of agricultural loan	Amt. Borrowed (KS.) Amount paid in cash equivalent back	What Collateral used if any	What was the interest rate for the loan (%)	Main purpose of the loan	Household head satisfaction with the credit services

Zai Pit Integrated Soil Fertility and Water management practices constraints

20. ***Please indicate the pattern of rainfall received in your area?*** Evenly distributed [ ] Bimodal in nature [ ] Unimodal [ ] Any other please specify……..

21. ***Please indicate the dominant soil type in your farm:*** Sandy soil [ ] Clay soil [ ] Loam soil [ ] Any other type (please specify)……..

22. ***Do you practice irrigation in your farm?*** Yes [ ] No [ ]

23. What challenges (constraints) do you face when you use Zai Pits plus manure and or fertilizer?

ISFM Technology	Please mention three major constraints of the following ISFM structures in relation to input used during different farm operations; constraint 1 being the major one		
	Constraint 1	Constraint 2	Constraint 3
Zai Pits for Maize seed			
Zai Pits for Maize seed + Cattle Manure (CM)			
Zai Pits for Maize seed + Cattle Manure (CM) + Mineral Fertilizer (MF)			
Zai Pits for Crop 2 seed			
Zai Pits for Crop 2 + Cattle Manure (CM)			
Zai Pits for Crop 2 seed + Cattle Manure (CM) + Mineral Fertilizer (MF)			
Zai Pits for Crop 3 seed			
Zai Pits for Crop 3 seed + Cattle Manure (CM)			
Zai Pits for Crop 3 seed + Cattle Manure (CM) + Mineral Fertilizer (MF)			

Appendix V: Research Questionnaire for Field Officers

Instructions

The purpose of this questionnaire is to obtain information on adoption of Zai Pit technology in Makueni County. Please fill the relevant boxes and blank spaces.

SECTION A: Demographic Information

1. Please indicate the area where you carry out extension services

   County_____ Sub-county_____
   Ward_____
   Location_____Sub-location:_____
   Village_____

2. ***Select the appropriate gender:*** Male [ ] Female [ ]

3. ***Select the appropriate age:*** Below 35 [ ] 36 – 45 [ ] 46 – 55 [ ] 56 – 65 [ ] Above 65 [ ]

4. ***Marital status:*** Married [ ] Single [ ] Divorced [ ] Widow [ ] Widower [ ]

5. ***Highest academic qualification:*** KCPE [ ] KCSE [ ] Diploma [ ] Bachelor's degree [ ] Master's degree [ ] PhD [ ] Others (please specify)_____

6. ***How many years have your served as a field officer?*** Below 1 year [ ] 2-5 years [ ] 5- 10 years [ ] Over 11 years [ ]

SECTION B: Extension services and adoption of Zai Pit technology

7. ***Please indicate the name of the organization you represent***

   .....

8. ***Please indicate your core duties out in the area***

   .....

9. ***Please indicate how long have you worked in the area*** Below 1 year [ ] 2-5 years [ ] 5- 10 years [ ] Over 11 years [ ]

10. The statements below relate to perception of smallholder farmers on the effects of Zai Pit technology on food security. Supplied also are five options corresponding to these statements: Strongly agree(SA)=5, Agree(A)=4, Undecided(U)=3, Disagree(D)=2, and Strongly Disagree(SD)=1. Please tick the option that best suits your opinion on the statement given.

	Statement	1	2	3	4	5
1.	Zai Pits are easy to use					
2.	Zai Pits are useful for farming					
3.	In the local area the food security situation was worse before the use of Zai Pits					
4.	The implementation of Zai Pits is in the your area is sustainable or reliable to ensure food security for households (adequate, accessible food)					
5.	The implementation of Zai Pits is in the area will lead to higher yields or harvests					
6.	Digging Zai Pits require low labour					
7.	Digging Zai Pits require low capital that is manageable for you					
8.	The risk of failed harvests is reduced with Zai Pits					
9.	The rainfall adequate if Zai Pits are used to ensure farming guarantees food security for families					
10	I expect increased yields are expected when farmers plant maize using Zai Pits					
11	I expect increased yields are expected when farmers plant crop 2 using Zai Pits (please specify)					
12	I expect increased yields are expected when farmers plant crop 3 using Zai Pits (please specify)					
13	I knew about Zai Pits before they were used in the area					
14	The idea to use Zai Pits arose from the donors					
15	The idea to was accepted by the community as a useful farming technology					
16	There is adequate government support to implement the Zai Pit technology					
17	The community was involved in the implementation of the Zai pit pilot project					

11. How did the project implementers come in contract with you?

.....

.....

12. ***What do you check when carrying out extension support in the farms?*** Number of Pits [ ] Exact dimensions [ ] Wellbeing of crops [ ] Others (please specify) .....

13. What are your general thoughts on the use of Zai Pits?

.....

14. Are there strengths or drawbacks of the implemented method?

.....

15. What have you learned about the Zai Pits introduced in the area?

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