AN ASSESSMENT OF EFFECT OF AGRICULTURAL KNOWLEDGE MANAGEMENT ON FALL ARMY WORM (FAW) CONTROL TECHNOLOGIES AMONG SMALLHOLDER MAIZE FARMERS IN KILUNGU, MAKUENI COUNTY, KENYA

AOKO PAULINE

A56/35781/2019

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF MASTER OF SCIENCE IN AGRICULTURAL INFORMATION AND COMMUNICATION MANAGEMENT

DEPARTMENT OF AGRICULTURAL ECONOMICS

FACULTY OF AGRICULTURE

UNIVERSITY OF NAIROBI

2023

DECLARATION

This thesis is my original work and has not been presented for the award of a degree in any other academic institution.

Aoko Pauline

A56/35781/2019

Signature: Date: 28th August 2023

This thesis has been submitted with our approval as supervisors.

Dr. Evans L. Chimoita

Department of Agricultural Economics

University of Nairobi

Signature: Date: 29th August 2023

Dr. Felister Mbute Nzuve

Department of Plant Science and Crop Protection

University of Nairobi

Signature: Date: 29th August 2023

Dr. Dennis Maina

Department of Agricultural Sciences

Karatina University

Signature: Date: 29th August 2023

DECLARATION OF ORIGINALITY

Name of Student: Aoko Pauline

Registration Number: A56/35781/2019

School/Faculty/Institute: Agriculture

Department: Agricultural Economics

Course Name: MSc. Agricultural Information and Communication and Management

Title of the work: *An Assessment of the Effect of Knowledge Management of Fall Armyworm (FAW) Control Technologies on Maize Yield in Makueni County, Kenya.*

1. I understand what originality is and I am aware of the university's policy in this regard
2. I declare that this thesis is my original work and has not been submitted elsewhere for examination, award of a degree or publication. Where other people's work or my own work has been used, this has been properly acknowledged and referenced according with the University of Nairobi's requirements.
3. I have not sought or used the services of any professional agencies to produce this work.
4. I have not allowed and shall not allow any person to copy my work with the intention of passing it off as his/her own work.
5. I understand that any false claim in respect of this work shall result to disciplinary action, in accordance with University Plagiarism Policy.

Signature: 

Date: 28th August 2023

DEDICATION

I dedicate this work to my beloved family for the moral, emotional and academic support they showed me during the study.

ACKNOWLEDGEMENT

I gratefully appreciate my supervisors Dr. Evans L. Chimoita, Dr. Felister Nzuve and Dr. Dennis Maina for their support and commitment during this study. Additionally, I acknowledge Prof. Jonathan Nzuma, the Chairman of the Department of Agricultural Economics for the coordination and facilitation on the academic writing process. I also recognize the support from the community in Kilungu, Makueni County during data collection.

Finally, I humbly appreciate the backing from the Regional Forum for Capacity Building in Agriculture (RUFORUM) (RU/2018/Post Doc/18) research grant under the Carnegie Corporation and NUFFIC – KEN 281 project through Kenya School of Agriculture (KSA) and Q-Point B.V. Limited for facilitating the implementation of this study.

ABSTRACT

Maize has a significant influence towards achieving food security in Kenya, given that it is the staple food in most rural communities. However, its production has drastically reduced, which is partly attributed to fall armyworm (FAW) infestation. This has led to losses of yield amounting to 37 % of the annual maize production over the last three years in Kenya. Despite innovators and breeders developing interventions and wealth of knowledge towards FAW infestation management and control, the annual maize yield remains low particularly in Makueni County. Further, the dissemination of knowledge on management interventions towards FAW management is limited among the smallholder farmers leading to a knowledge gap and huge maize pre-production losses. The diffusion of innovation theory emphasizes the impact of dissemination channels on adoption or application rate of any innovation or technology. It highlights interpersonal sources and channels as positive determinants for growth and development expected from adoption of an innovation. With apparent limited access to FAW infestation management practices and thus inadequate knowledge management structures, the study set out to assess the effect of knowledge management of fall armyworm (FAW) control technologies on maize yield in Kilungu, Makueni County, Kenya. The study conducted a survey using a structured questionnaire with key informants and households. The study sampled 387 respondents registered with the Ministry of Agriculture as maize producers in Kilungu, Makueni County. The study used purposive and multi-stage sampling procedures to reach the selected farmers. Study findings indicated a positive correlation between use of pesticides (p=0.002) and maize yield. From the study, there is a significant relationship between selection of FAW control practice (s) and farmer education, household size, land size under maize production. There is also a positive correlation between the use of ash and age as well as the area under maize production. There exists a negative correlation between selection of handpicking and farmer education. Further analysis showed a significant difference in productivity for respondents that used grouped sources (p=0.002) as opposed to single sources, with an above average (712 kg/acre) productivity for respondents that used sources from both documentary and non-documentary categories. Respondents that used non-documentary sources only had an average maize productivity of 257 kg/acre (p= 0.003) against 126 kg/acre for those that did not have access to any information on management of FAW infestation. Analysis of the sharing platforms found a significant difference in productivity for public gatherings known as *barazas* users (p= 0.033: 735 kg/acre) against the non- users. The study therefore recommends *barazas* facilitated by agronomists or researchers and farmer-to-farmer extension approaches as avenues for sharing knowledge on effective FAW management practices to reduce pre-harvest losses caused by FAW infestation in maize production.

TABLE OF CONTENTS

DECLARATION ii
DECLARATION OF ORIGINALITY iii
DEDICATION iv
ACKNOWLEDGEMENT v
ABSTRACT vi
LIST OF FIGURES ix
LIST OF TABLES x
ABBREVIATIONS AND ACRONYMS xi
CHAPTER ONE 1
INTRODUCTION 1
1.1 Background Information 1
1.2 Statement of the Research Problem 8
1.3 Research Objectives 9
General objective 9
1.3.1 Specific Objectives 9
1.3.2 Research Questions 9
1.4 Justification of the Study 9
CHAPTER TWO 11
LITERATURE REVIEW 11
2.1 Empirical Review 11
2.1.1 Fall Army Worm (FAW) Control Practices 11
2.1.2 Knowledge Management 13
2.2 Theoretical Review 16
2.3 Conceptual Framework 18
CHAPTER THREE 20
METHODOLOGY 20
3.1 Research Design 20
3.2 Study Area 20
3.2.1 Study Area Description 20
3.2.2 Map of the Study Area 21

3.2.3 Target Population 21
3.3 Sampling Procedure 22
3.4 Data Collection 24
3.4.1 Data Collection Methods 24
3.5 Data Analysis 25
3.5.1 Applied FAW Control Practices 25
3.5.2 Socioeconomic factors influencing selection and/or adoption of FAW practices 25
3.5.3 Sources of information on FAW control practices 25
3.5.4 Sharing methods/platforms of FAW control practices 26
CHAPTER FOUR 27
RESULTS AND DISCUSSION 27
4.1 Descriptive Statistical Analysis 27
4.2 Effect of Applied FAW Control Practices 30
4.3 Socioeconomic Factors Influencing Selection of FAW Control Practices 34
4.4 Sources of FAW Management Knowledge 35
4.5 Knowledge Exchange of FAW Control Practices 37
CHAPTER FIVE 42
SUMMARY, CONCLUSIONS AND RECOMMENDATIONS 42
5.1 Summary 42
5.2 Conclusions 43
5.3 Recommendations of the study 44
5.3.1 Areas for further research 44
REFERENCES 45
APPENDICES 49
Appendix 1: HH Questionnaire 49
Appendix 2: Key informants' /Focus group discussion questionnaire 57
Annex 3: Pictorials used during data collection 62

LIST OF FIGURES

Figure 1: Food insecurity levels across the globe by regions….. 1
Figure 2: Cereal production across 5 years in Sub-Saharan Africa and Kenya…….2
Figure 3: Harvested area of selected primary crops in Kenya. 3
Figure 4: Agricultural growth rate in Kenya from 2017-2021….. 3
Figure 5: Maize production sales in Kshs. Million from 2016-20204
Figure 6: Percentage of farmers affected by FAW and maize crop loss over the last 3 seasons by AEZ in Kenya…………. 5
Figure 7: October – December rainfall anomalies for the period 1984-2020 in Makueni County………..6
Figure 8: Maize production in Kenya for the period 2017-2020……. 7
Figure 9: Application and effectiveness of FAW control methods reported by farmers in Ghana and Zambia ……. 12
Figure 10: Conceptual framework. 19
Figure 11: A demographic map of Makueni County.…… 21
Figure 12: Distribution of maize farming households in Makueni County, by Sub County. ……. 22
Figure 13: Distribution of maize production in Makueni County per Sub County…...............................22

LIST OF TABLES

Table 1: Ward distribution of respondents by gender 27
Table 2: Summary statistics of variables from sampled households 29
Table 3: Level of crop destruction by FAW in relation to land size. 30
Table 4: T-test comparing yield differences against application of FAW control practices 31
Table 5: Frequency table of applied FAW control practices 32
Table 6: ANOVA comparing yield differences for selected variables 33
Table 7: Differences (P values) in means of socioeconomic factors for FAW control practices 34
Table 8: Analysis of number of years in school versus applied FAW control practice. 35
Table 9: Distribution of farmers using various sources for FAW management information. 36
Table 10: ANOVA –Tukey post hoc of sourcing channels versus maize productivity. 36
Table 11: Willingness to exchange information on FAW interventions. 37
Table 12: Independent t-test of willingness against productivity 39
Table 13: Frequency of the methods used to exchange FAW information. 39
Table 14: One-way ANOVA comparing barazas against a control group. 40

ABBREVIATIONS AND ACRONYMS

AEZ	Agro ecological zones
ALF	Agriculture, Livestock and Fisheries
ASTGS	Agriculture Sector Transformation and Growth Strategy
AU	African Union
CAADP	Comprehensive Africa Agriculture Development Programme
CAK	Communication Authority of Kenya
FAW	Fall Army Worm
FAO	Food and Agriculture Organization
FIES	Food Insecurity Experience Scale
GoK	Government of Kenya
ICT	Information and Communication Technology
IFAD	International Fund for Agricultural Development
KALRO	Kenya Agricultural and Livestock Research Organization
KM	Knowledge management
KNBS	Kenya National Bureau of Statistics
MoALF	Ministry of Agriculture, Livestock and Fisheries
MT	Metric tons
NAFIS	National Agriculture Farming Information System
NEPAD	New Partnership for Africa's Development
SDGs	Sustainable Development Goals
USD	United States Dollars
USSD	Unstructured Supplementary Service Data
WFP	World Food Programme
WHO	World Health Organization

CHAPTER ONE

INTRODUCTION

1.1 Background Information

Food insecurity is on the rise in Africa with 20 % of the population (Figure 1) projected to be facing hunger in the near future (FAO, IFAD, UNICEF, WFP & WHO, 2023). Food security refers to a situation in which everyone, at all times, has physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life (MoALF, 2011). Food security is measured using the Food Insecurity Experience Scale (FIES) by assessing food accessibility, safety, nutritive value and sufficiency all year round per involved household.

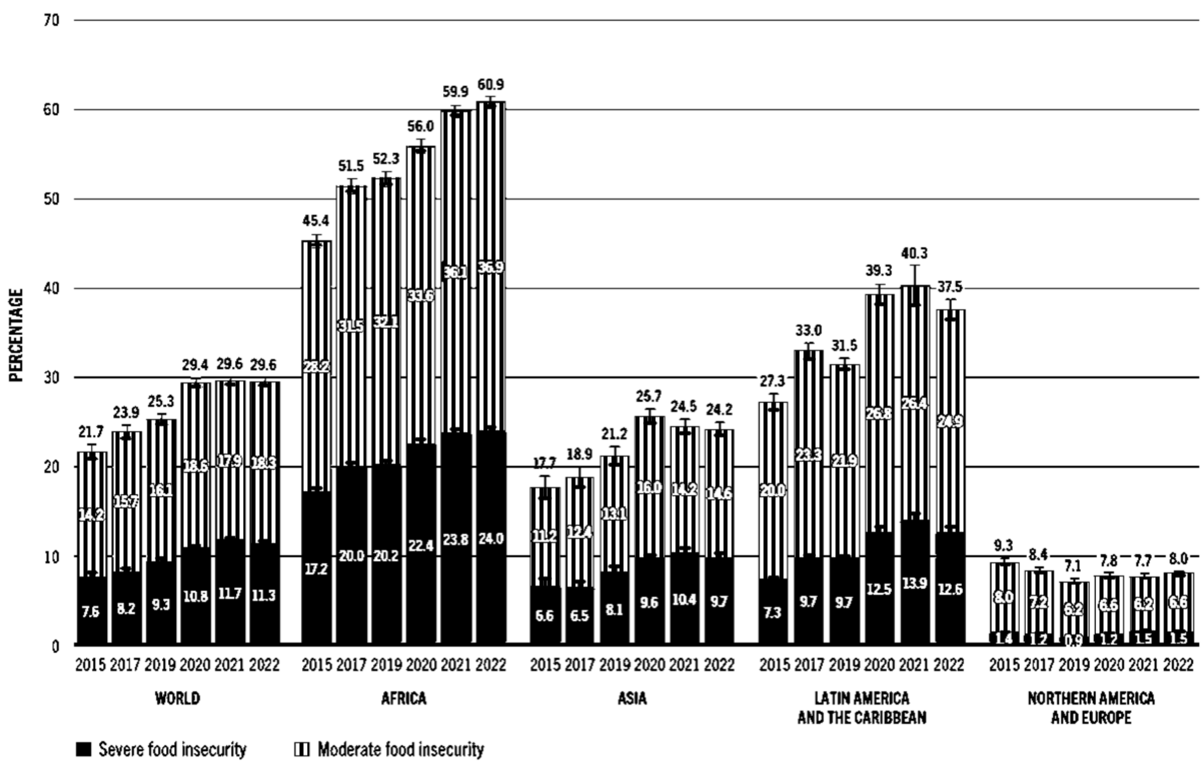


Figure 1: Food insecurity levels across the globe by regions. Source: FAOSTAT, (2023)

Cereal production on the other hand has declined (Figure 2) over the past years due to climate extremes, economic changes within and outside Africa (FAO, 2023).

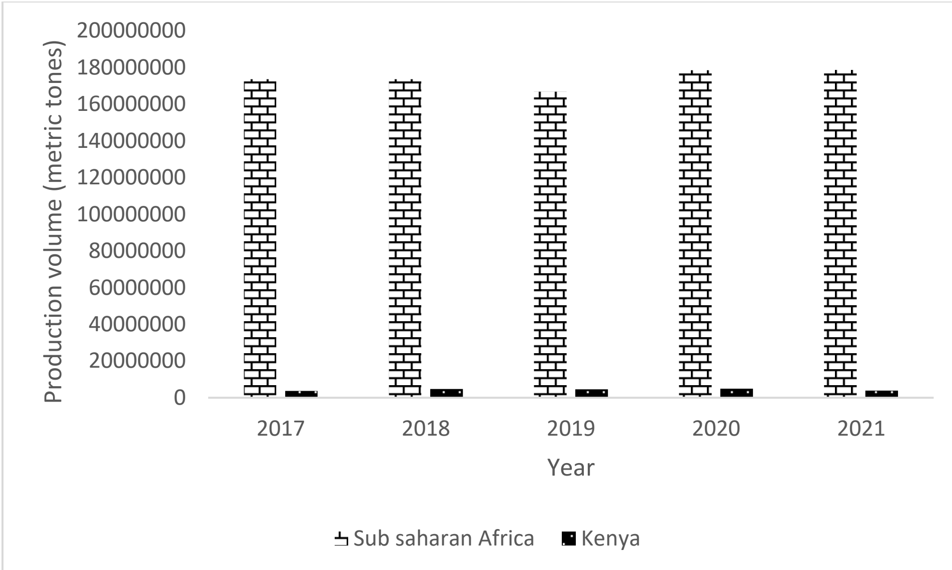


Figure 2: Cereal production across 5 years in Sub-Saharan Africa and Kenya. Source: world Bank Databank, (2023)

These climate extremes have occasioned the emergence and reemergence of pests and diseases such as desert locusts, fall armyworm, African armyworm among others. The impacts of these outbreaks has adversely affected cereal production causing significant losses across the continent leading to food shortages.

Kenya's population growth rate is at 2.2 % per annum (KNBS, 2019) consequently leading to an increased demand for food. This requires that the country expeditiously fast track the attainment of the national food security to avoid future starvation. Food security is anchored on agricultural productivity and particularly for Kenya, maize production. Maize is a staple food in Kenya and accounts for 40 % (Figure 3) of total area of crop production (Tsedeke, *et al*., 2015). In subsequent years, maize production has increased with regard to production area expansion as opposed to increased productivity per unit area.

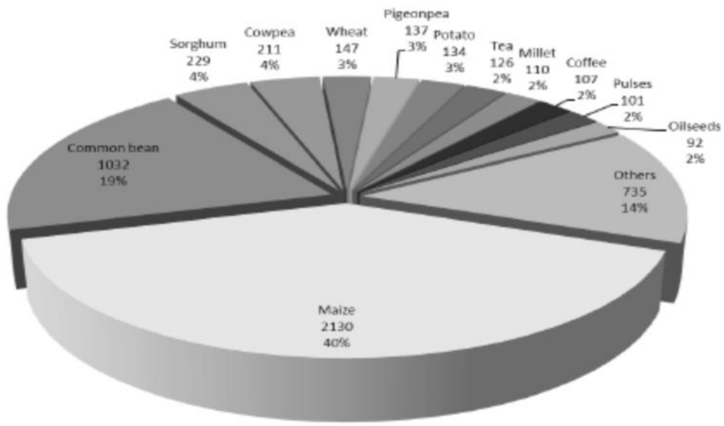


Figure 3: Harvested area of selected primary crops in Kenya. Source: FAOSTAT, (2015)

In achieving food security, Kenya has adopted and developed several approaches to stabilize, if not accelerating growth rate. An analysis of the agricultural growth rate depicts a fluctuation caused majorly by erratic rainfall, soil infertility, climate change, pest and disease infestation.

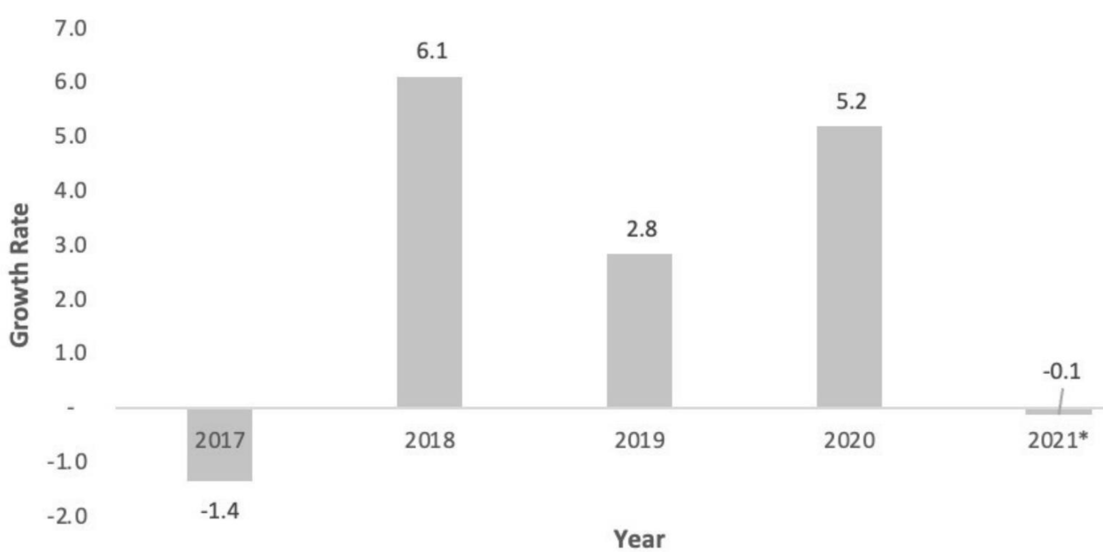


Figure 4: Agricultural growth rate in Kenya from 2017-2021. Source: Economic Survey report, (2022)

Despite the recent increase in agricultural growth rate (80 %) between 2019 and 2020, maize production has reduced by 4 % (KNBS, 2019). Furthermore, the income from the sale of maize also reduced from Kshs. 10,681,200 million to 8, 232,500 million (Figure 3).

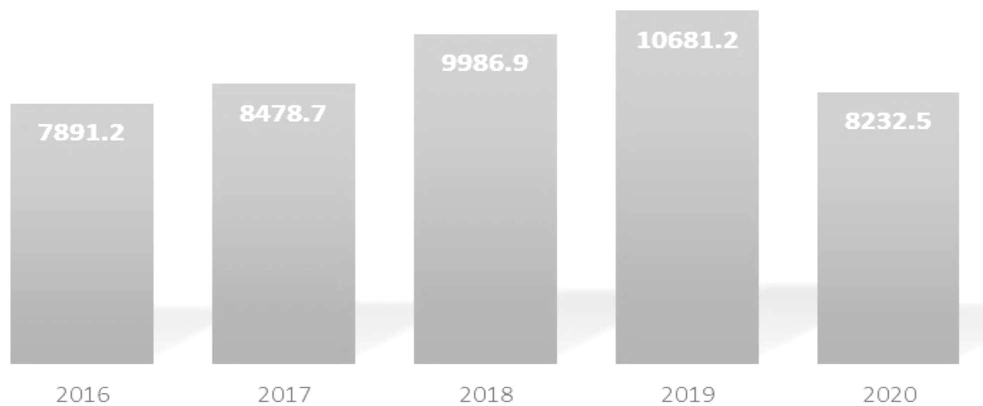


Figure 5: Maize production sales in Kshs. [Million] from 2016-2020. Source: Economic Survey, (2021)

This has negatively affected the livelihoods of households reliant on maize production as the primary source of income. Some of the challenges attributed to reduced maize production include COVID-19 pandemic, inadequate and erratic rainfall patterns, pest infestation (KNBS, 2021).

The Kenyan government has developed strategies and policies to achieve national food security. The Agriculture Sector Transformation and Growth Strategy (ASTGS) highlights nine flagships that drive the food security goal; among this, Anchor 2 and 3 aims to increase agricultural output, value addition and boost household food resilience respectively (MoALF, 2019). One of the highlighted transformational approaches is the establishment of a rapid response coordination unit, tasked with forecasting, oversight and preparation for all disaster management efforts with clear standard operating procedures (MoALF,2019).

Of particular concern with regard to disaster management, is one of the invasive species, Fall Army Worm (FAW). In Africa, this pest has caused significant damage to agricultural production, with maize yield losses of up to 37 % of the annual average production over three years (Abrahams, *et al*., 2017).

A study by De Groote, *et al*., (2020) found that by 2017, Kenya's maize farmers had a 30 % loss in yield with the small and medium potential agro ecological zones (AEZs) recording more than 50% of the losses. Notably, in 2018 these regions were able to reduce incurred losses to 20% following the application of various control practices. However, this reduction in maize yield loss was not evident in the high potential areas of Kenya as they recorded a 33% loss in 2018 compared to the 30% loss in 2017 (Figure 4).

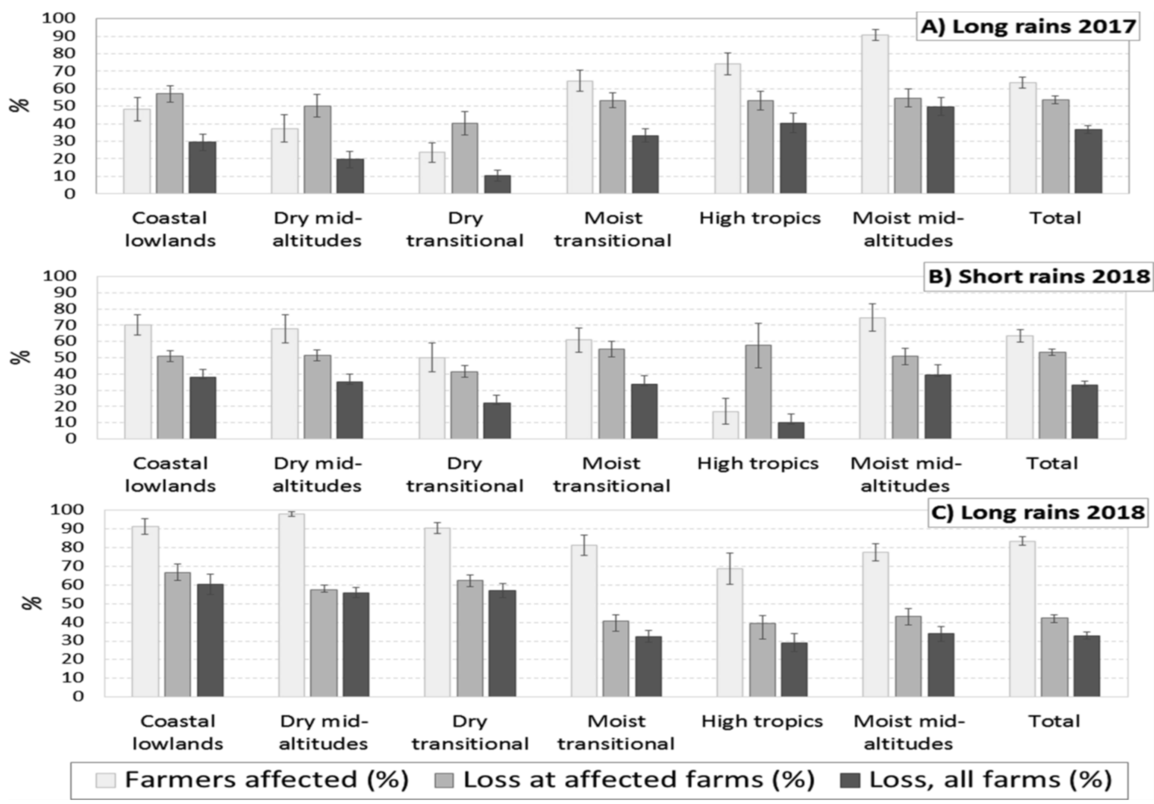


Figure 6: Percentage of farmers affected by FAW and maize crop loss over the last 3 seasons by AEZ in Kenya. Source: De Groote, *et al.*, (2020)

Of the studied AEZs, Makueni County has more than two of the adversely affected AEZs and thus stands as a representative area for study of the effects and management of FAW in Kenya. The county's AEZ ranges from Upper Midlands (UM) 2 to 5 and Lower Midlands (LM) 3 to 5. These zones are characterized by bimodal rainfall with heavy rains occurring from October to December. However, the area has experienced rainfall extremes over the last two decades creating an environment that hinders crop production.

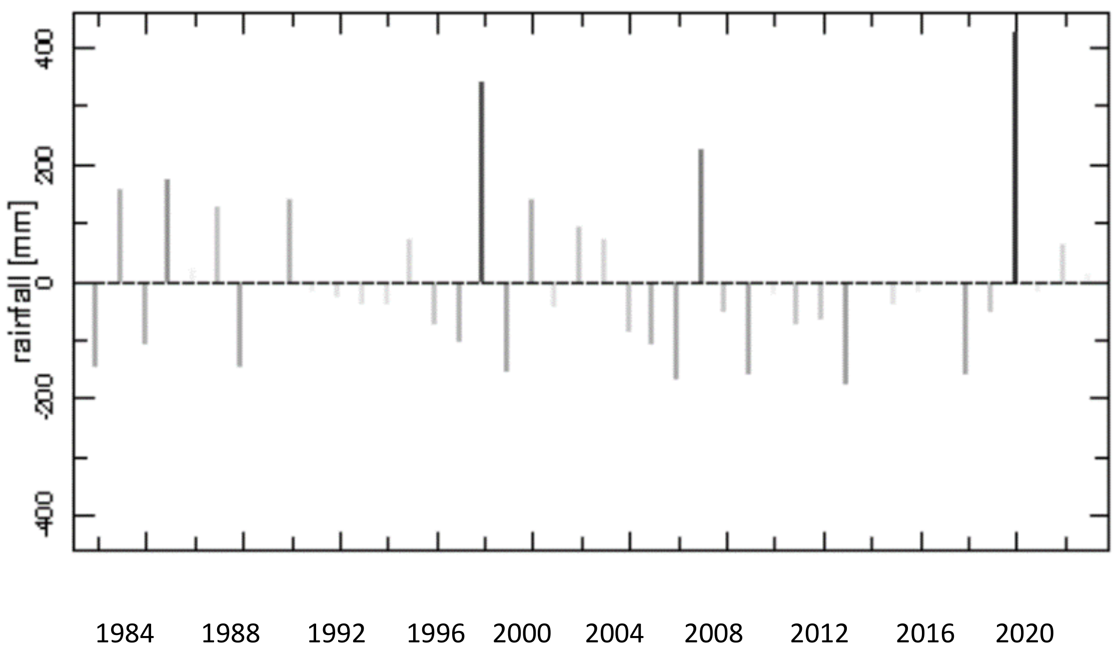


Figure 7: October – December rainfall anomalies for the period 1984-2020 in Makueni County. Source: Kenya Metrological Department (KMD) Map Room

Following the adverse effects of FAW infestation and rainfall extremes to the Kenyan economy and SSA at large, control strategies or methods against FAW have been developed through research and experiences from previously affected regions. These control practices are shared through mass communication campaigns, workshops, communities of practice, extension programs, farmer field schools, farmer associations (Salilou, *et al.*, 2021). Agricultural stakeholders through agricultural extension officers utilized mass media, printed materials, focus group discussions and farm visits to disseminate knowledge on FAW spread, impact and management across Kenya (Murray, *et al.,* 2021; Republic of Kenya, 2018; FAO, 2018). Despite all the knowledge available and disseminated to farmers on FAW management, maize production declined by 20.56% in 2019 (FAOSTAT, 2023).

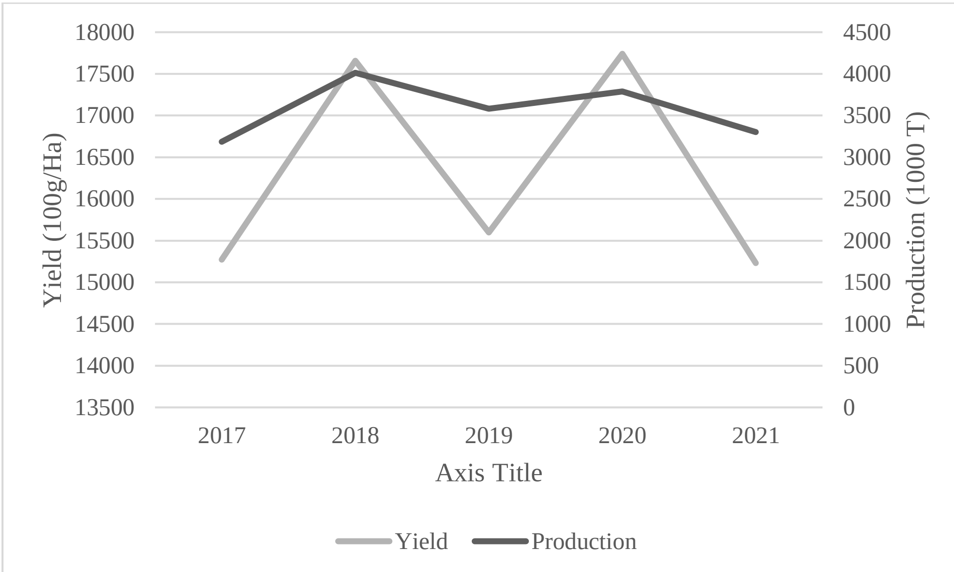


Figure 8: Maize production in Kenya for the period 2017-2020. Source: FAOSTAT, (2023)

The decline in production in 2019 is attributed to rainfall extremes as well as FAW infestation across smallholder maize farms in Kenya. Given the apparent availability of knowledge on FAW management to enhance maize productivity as stated earlier, there is a knowledge management gap between innovators, researchers, disseminators and farmers leading to substantial losses in production.

Knowledge management refers to the structure and organization of knowledge creation, acquisition, storage, transfer, application/utilization and evaluation (Chiliban, *et al*., 2014). The role of knowledge management is to transfer tacit or knowledge from knowledge workers to knowledge users so that they can make informed decisions. To bridge a knowledge management gap, studies recommend the assessment of communication channels and/or platforms used to disseminate the knowledge or innovation or technology of interest.

1.2 Statement of the Research Problem

Knowledge on modern and improved methods or practices against FAW includes chemical, biological, mechanical or integrated pest management (Abrahams, *et al*., 2017). The improved methods are effective at different stages of development of both the crop and pest. For instance, use of mechanical or cultural practices such as trapping or hand picking at the early stages of plant growth or the egg and/or larvae is ineffective. Additionally, the egg and the larvae are microscopic or too small to be detached without damaging the crop. Similarly, use of agrochemicals that do not contain effective active ingredients renders the practice or method inefficient. This form of knowledge is tacit in nature and thus not easily transferred from one person to the other, hence creating a knowledge gap during the dissemination process.

A study by Okari, (2021) on the assessment of yield losses related to FAW infestations showed an indirect relationship between the number of farmers affected by FAW and the control practices applied against FAW. However, the study did not evaluate the communication channels used to disseminate the FAW control practices. Furthermore, studies by De Groote, *et al.,* (2020) showed an increased loss of maize yield due to FAW infestation over three maize growing seasons in the lower midlands AEZs, notably, the study did not assess the influence of knowledge management of FAW control practices on maize production.

Such observations reveal a knowledge gap regarding the relationship between knowledge management of FAW control practices and maize production in Kenya. This study therefore set out to assess the effect of knowledge management of fall armyworm (FAW) control technologies on production of maize in Kilungu, Makueni County.

1.3 Research Objectives

General objective

To assess the effect of knowledge management of fall armyworm (FAW) control technologies on maize yield in Kilungu, Makueni County.

1.3.1 Specific Objectives

1. To evaluate the effect of applied FAW control practices on maize yield in Kilungu, Makueni County.
2. To determine socio economic factors that influence selection of FAW control practices in Kilungu, Makueni County.
3. To determine the influence of selected sources of FAW control practices information on maize yield in Kilungu, Makueni County.
4. To determine the effect of selected methods of sharing FAW control practices information on maize yield in Kilungu, Makueni County.

1.3.2 Research Questions

1. What is the effect of applied FAW control practices on maize yield in Kilungu, Makueni County?
2. What is the influence of socioeconomic factors on the selection of FAW control practices in Kilungu, Makueni County?
3. Is there a difference in maize yield between selected sources of information on FAW control practices in Kilungu, Makueni County?
4. Is there a difference in maize yield between selected methods of sharing information on FAW control practices in Kilungu, Makueni County?

1.4 Justification of the Study

Pest-related yield losses in maize production are approximately 57% in Kenya with major pests identified as the maize stem borer, dessert locusts and FAW. In cases where no control measures are applied, farms record total crop failure. This is quite devastating to the farmer and detrimental to the national economy of Kenya, where agricultural production contributes about 30 % to the gross domestic product (GDP). For this reason, the government through the Ministry of Agriculture has developed coping strategies and mechanisms to enhance national, community and household level agricultural output /production. The Agricultural Sector Transformational Growth Strategy (ASTGS) highlights two flagships that aim to digitalize research and innovation as well as monitoring and coordinating risks associated to the food systems e.g., climate change, pest attacks/outbreaks. Additionally, recent studies on organizational performance, with reference to SMEs, acknowledge the significant impact of tacit knowledge management on profit margins.

This study provides necessary data and information on the knowledge management of FAW control practices in Kilungu, Makueni County and enhances the linkage between knowledge workers and managers. Findings on the knowledge sources and sharing strategies will guide innovators and technology disseminators to identify efficient and effective communication channels to increase technology adoption rates.

At a regional level, through the 2014 Malabo declaration, the study aligns to African Union (AU)'s goal to increase food security and nutrition by strengthening producers' resilience to shocks/risks as well as the data and statistics required for systemic capacity to implement agricultural developmental projects and deliver expected outputs and outcomes.

CHAPTER TWO

LITERATURE REVIEW

2.1 Empirical Review

2.1.1 Fall Army Worm (FAW) Control Practices

Fall Army Worm (FAW) *Spodoptera frugiperda,* is a polyphagous insect pest that infests cereal crops particularly maize, sorghum, finger millet. The first occurrence in Africa was in 2016 given that the pest is native to the Americas continent. FAW infestation has adversely affected agricultural productivity in Sub Saharan Africa (SSA) with losses amounting to an approximate value of 100 billion USD per annum (Salilou, *et al*., 2021). FAW manifests a migratory habit that exacerbates yield loss given the fact that it does not diapause as well as the fact that agricultural productivity occurs all year round in SSA.

FAW has a four-stage life cycle that starts with the Egg: Larvae: Pupa and Adult, each of these stages affect different crop phenological stages. The egg and larval stage predominantly affect the early and whorl stages. The vegetative and reproductive stages are heavily infested by the adult FAW (Salilou, *et al.,* 2021).

Studies by Ansah, *et al*., (2021) and Kumela, *et al*., (2019) in Ethiopia and Kenya outline practices applied by farmers to control FAW infestations. These practices are either mechanical/cultural, biological/botanical, chemical or Integrated Pest Management methods. Among the physical methods, handpicking, use of traps, egg crushing proved effective at the early plant stage and the whorl stage. During the vegetative and / or reproductive stages, chemical application or biological methods are applied. Some of the biological methods in use include use of pheromones, natural enemies.

Recent studies by Salilou, *et al*., (2021); Ihza, *et al*., (2021); Ansah, *et al*., (2021); Kumela, *et al*., (2019); Rhett, *et al*., (2019) showed practices that are commonly applied. These practices include handpicking, crop uprooting and disposal, use of luferon-based insecticides in Kenya, use of transgenic cultivars or varieties, crop rotation, intercropping, push pull technology, use of NPV - based pheromones and release of natural predators or enemies.

Previous studies on the application of FAW control practices in Ghana and Zambia by Abrahams, *et al*., (2017) found that farmers rarely apply these methods with regard to the perceived effectiveness of the practice. Consequently, this leads to the evidenced reduced agricultural productivity particularly, maize production.

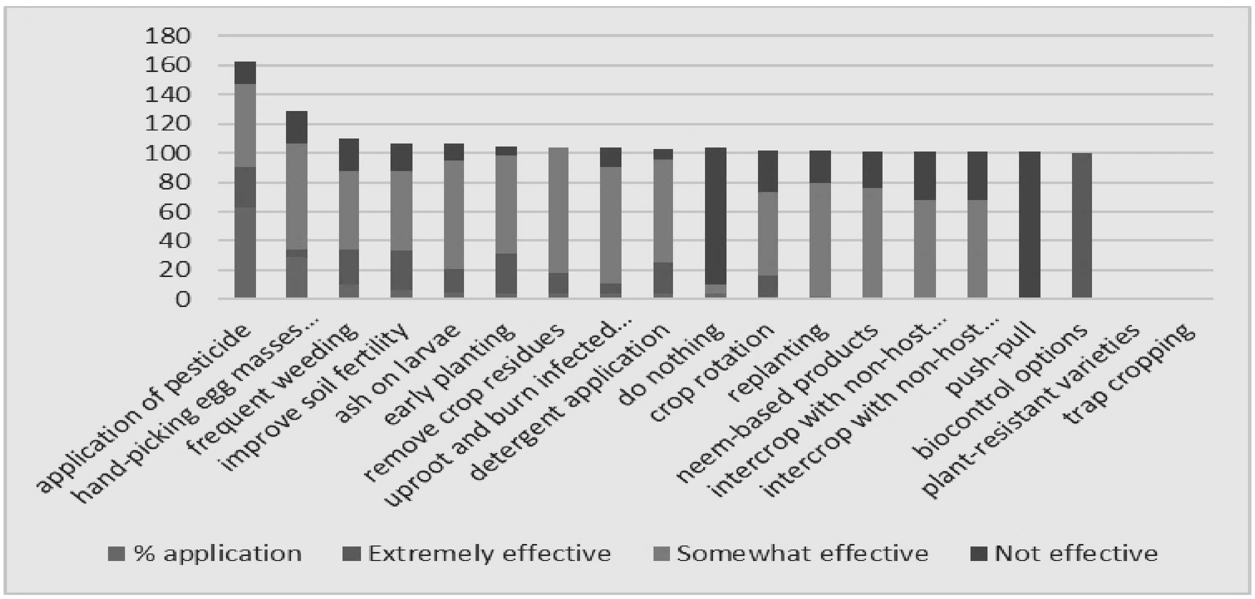


Figure 9: Application and effectiveness of FAW control methods reported by farmers in Ghana and Zambia. Source: Abrahams, *et al*., (2017)

According to Diskin, (1997) indicators for measurement of agricultural productivity include yield per acreage, yield gap i.e. the variation between potential and actual yield, losses incurred due to biotic factors and adoption of relevant practices. These indicators are predominantly determined by farm practices applied to control or manage biotc and abiotic factors of production. This is evidenced by a study by Muna, *et al*., (2013) which showed a significant increase in agricultural productivity in farms that applied organic or inorganic fertilizer compared to those that did not. Fertilizer application was adopted as a way to manage soil infertility which leads to poor agricultural productivity. Therefore, the adoption or application of FAW control practices has a significant impact on total productivity per unit area.

2.1.2 Knowledge Management

There are numerous definitions of knowledge management within the epistemology field of study. Despite the lack of a consensus (Nonaka and Peltokorpi, ((2006) or a classification scheme to guide knowledge management research (Serrenko, 2013); knowledge management involves the creation, acquisition, storage, transfer, application and exploitation. It is a cyclic (Bogdan, *et al*., 2014) process to enhance knowledge performance.

Knowledge is a human resource that is either tacit or explicit. Hislop, (2005) discussed knowledge as either objective (explicit) based or practice (tacit) based. Explicit knowledge is well documented, structured, and codified (Stevens, *et al*., 2010). Tacit knowledge on the other hand is not easily codified, not easily documented and is relative to the bearer or owner of such knowledge. For instance, scientific research findings are a form of explicit knowledge since there are laid out procedures or methodologies that guide the creation, storage, dissemination and integration of such knowledge, relative to the field of study.

Tacit knowledge on the other hand refers to the inherent skills or capabilities to conduct scientific or social research and is thus subjective as well as not easily shared. Contextually, interventions applied towards FAW management are both tacit and explicit knowledge. Case in point, the biology and mode of action of FAW is common knowledge within the entomology practitioners, however, the knowledge on management practices, application and effectiveness against FAW attack on maize field/farms is relative to farmers, agricultural extension officers and scientific researchers and thus tacit.

Remarkably, exchange of tacit knowledge is commonly practiced through direct interactions such as story-telling, demonstrations and collaborative meetings (Haradhan, 2016: Jordan, 2020). A study by Shem & Maxwell, (2019) outlined key determinants of tacit knowledge exchange as culture, ICT infrastructure, social relations, organizational structure and autonomy. Additionally, studies by Chan and Chau, (2008) emphasize on the impact of effective knowledge management on organizational performance with regard to operations and adaptability to change.

However, further studies on knowledge sharing have shown that knowledge workers might not be intrinsically motivated to share this knowledge due to the fear (Renzl, 2008) of losing value at the work place or the society. A knowledge worker refers to anyone that applies knowledge, skills and attitude from formal or informal training to create or develop products and services. Furthermore, the knowledge workers may not be aware that this knowledge is needed, required or vital to the knowledge users or disseminators, innovators. Subsequently, tacit knowledge is rarely coded, transferred or documented.

2.1.2.1 Knowledge Management Models

A model refers to a representation of the actual object or subject or process. Knowledge management studies apply more than one model to enhance the desired level of objectivity insofar as discipline maturity (Serrenko, 2013) is concerned. Another study by Ibrahim (2017) on knowledge management methodology recommends the realistic and idealist perspective with regard to research focus area or scope and the methodology used to achieve a middle- range thinking approach for any given phenomena within the discipline.

Bogdan, *et al*., (2014) analyses six knowledge management models highlighting the strengths and weaknesses of each of the models. These models include the knowledge tower (KT); knowledge management process model (KMPM); Knowledge Wheel (KW); Practical Knowledge management Model (PKMM); knowledge Life cycle (KLC) and Integrated knowledge management Model for Production processes (IKMMPP).

The KT model outlines a hierarchical system towards knowledge management hinged on knowledge infrastructure and led by the assessment of knowledge management. However, this model fails to recognize the vitality of knowledge transfer, which is a key determinant in an enterprise's or organizations' competitive advantage (Harlow, 2008). Additionally, the KW model presents KM as an agile process, borrowing from Deming's Plan Do Check Act (PDCA) cycle. It outlines the socio-cultural factors that affect the KM process as well as the dynamics of the identified relationships. Nonetheless, this model does not consider organizational objectives for growth and development.

Of all of these models, KMPM proves to be all encompassing of the knowledge management processes or perceived definition with modifications to include interactiveness and knowledge measurement aspect. The model recognizes creation, acquisition, manipulation, storage, exchange and utilization as key processes in ensuring effective knowledge management and thus enhanced organizational performance.

2.1.2.2 Knowledge Management Process

KM process constitutes the activities required for effective knowledge management. The process is dependent on the form of knowledge in question, that is, either tacit or explicit. There is no standard sequence that is adapted by practitioners or researchers. The KMPM explains that the starting point is different for each form, that is, Knowledge creation for tacit knowledge and knowledge acquisition for explicit knowledge. For example, researchers and innovators refer to FAW entomology (explicit knowledge) prior to developing management practices against FAW attack in comparison to farmer knowledge and perceptions (tacit knowledge) to identify effectiveness of various management practices applied to manage FAW infestations.

Gao, *et al.,* (2017) reviews several scholarly works on knowledge management activities and concluded that at the very core, KM process include knowledge creation or acquistion, knowledge retention or storage, knowledge exchange, knowledge application and measurement. Each of these processes are largely facilitated by information and communication technology (ICT). These processes are hinged on the following perspectives i.e. knowledge representation, organization, exchange and measuring performance.

2.2 Theoretical Review

Agricultural stakeholders advocate for adoption of relevant agricultural technologies or innovations to enhance farm productivity. The adoption rate of a given technology anchors on several factors as explained in the diffusion of innovations theory (Rodgers, 1962). The theory defines adoption as the decision to utilize or use the technology/innovation as the best available option. The innovation decision process occurs in five stages namely: knowledge, persuasion, decision, implementation and confirmation.

The decision making process is guided by determinants such as the characteristics of the innovation, communication channel, time and existing social structure or system. In this study, the innovation/technology of concern is FAW control practice (s).

According to Rogers (1983), key characteristics such as relative advantage, simplicity, observability, triability and compatibility have a positive correlation to adoption rates. This study assesses relative advantage by comparing the maize yield of selected FAW control practice (s). Furthermore, it evaluates the observability of FAW control practices by determining the losses from FAW infested maize fields.

Dissemination of FAW control practices occurs through channels and between sources, that is, the transfer of information from one person to another in a given media. The theory categorizes sources as either interpersonal or mass media centered, with each being effective at certain stages of decision making. Mass media sources such as television (TV), radio, newspapers, and internet are effective at the knowledge stage and interpersonal sources such as fellow farmers, extension officers, and traditional experts tend to be powerful in the persuasion stage. The study assesses both sources by comparing yield differences for each of the sources when used singly, grouped or combined. Additionally, the sharing channels/means are evaluated by determining the willingness and frequency to share information on FAW control practices. These channels include; communities of practice, farmer field schools, *barazas*, storytelling, workshops, *et cetera.*

A literature review study by Ruzzante, *et al.*, (2021) reported a positive correlation between adoption rate of agricultural technologies and farmer education, household size, land size, access to credit, land tenure, access to credit services and group membership. Moreover, the diffusion of innovation theory highlights similar socioeconomic characteristics as determinants of adoption rates with age found to have no influence on all adopter categories. The study evaluates the effect of selected socio-economic characteristics on selection and adoption of FAW control practices.

2.3 Conceptual Framework

The study sought to assess the effect of knowledge management of fall armyworm (FAW) control technologies on maize yield in Kilungu, Makueni County. It anchors on the notion that FAW control practices have been disseminated to a significant proportion of maize farmers through various platforms, channels and methods. The study is based on the theory that different sources and sharing platforms have relative effects on the innovation-decision process i.e. knowledge stage, persuasion stage, decision stage, implementation stage and confirmation stage. Therefore, inappropriate selection of sources or sharing platforms at a given stage of the process is bound to have a reverse effect leading to either adoption or rejection of the innovation which in turns affects maize yield in the study's context.

An insight into the selected/applied FAW control practices highlights the adoption rate and effect on maize yield. Findings on the communication channels (sources and sharing channels) give an insight of the structure of knowledge management in Kilungu, Makueni County. These findings will guide disseminators towards enhancing the adoption rates of FAW control practice as well as reducing maize losses due to FAW infestation.

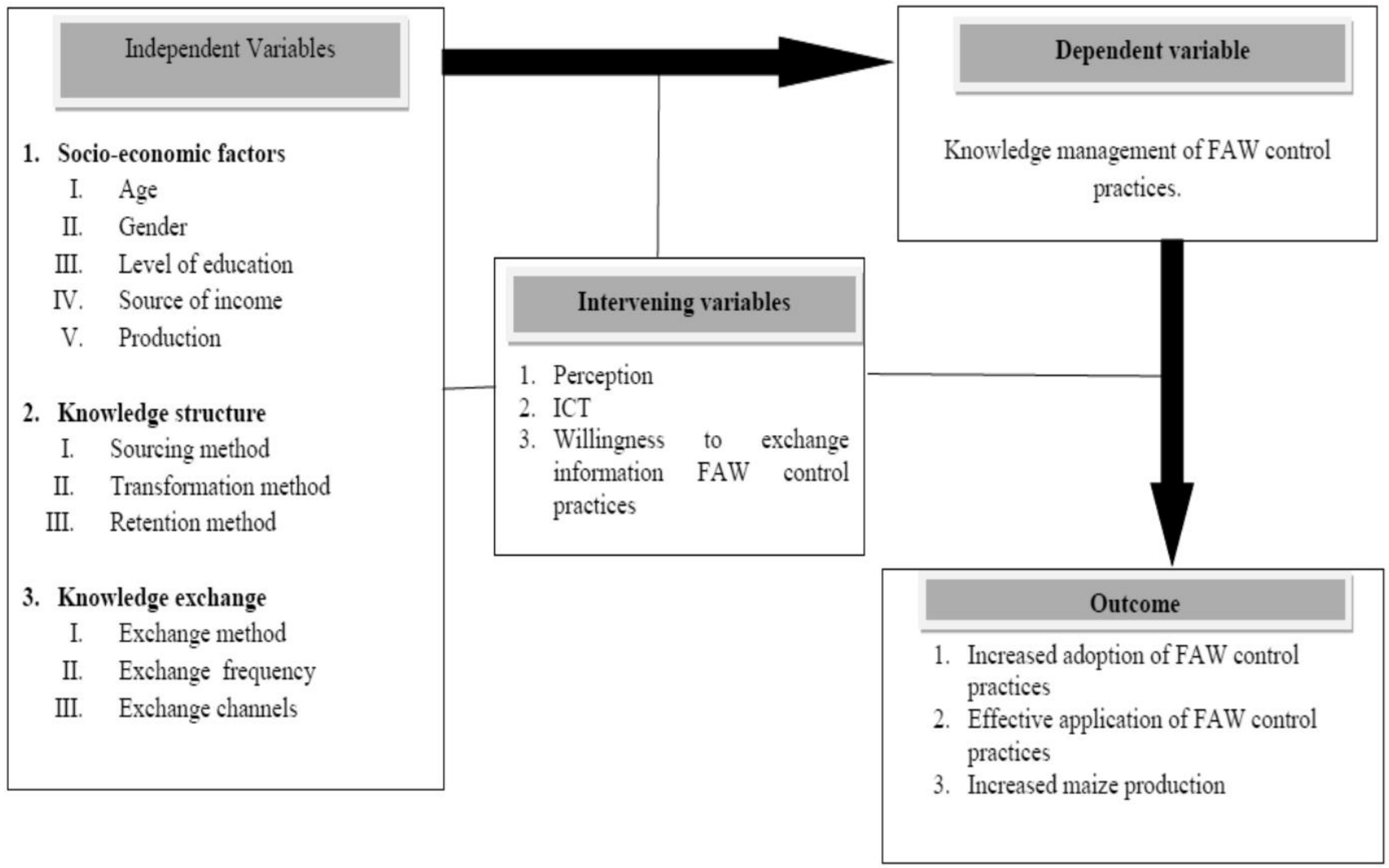


Figure 10: Conceptual framework.

CHAPTER THREE

METHODOLOGY

3.1 Research Design

The study adopted a descriptive research design methodology to profile the knowledge management process and effectiveness of FAW control practices in Kilungu, Makueni County.

3.2 Study Area

3.2.1 Study Area Description

Makueni County is part of the South East Kenya Economic block of Kenya. The county borders Machakos, Kitui, Taita Taveta and Kajiado to the North, East, South and West respectively. It covers an area of 8,008.9 $km^{2\ with}$ six sub counties as shown in Figure 11. Makueni County is one of the Arid and Semi-arid Lands (ASALs) regions of Kenya, with an altitude of 1108 meters above sea level and higher regions receiving rainfall ranging from 800mm to 900mm compared to 250mm to 400mm for the lower regions. The temperatures range between 15^0C – 26^0C (MoALF, 2016). The area has a population density of 100-150 people per square meter, practicing mixed farming system on clay loam to sandy loam soils (MoALF, 2010). The crops planted in the area include maize, cowpea, green grams, finger millet, sorghum under recommended fertilizer rates based on soilf fertility.

Makueni County identifies as a climate risk region in Kenya according to the Kenya Agricultural Productivity Programme (KAPP) and as such, it is prone to disastrous shocks and risks such as heat stress, drought, moisture stress, increased temperatures and precipitation as well as emergent pest infestations that negatively affect agricultural productivity. Additionally, the county is characterized as AEZ II: Dry mid altitude and is at the risk of high pest prevalence and particularly FAW as evidenced by De Groote, *et al.*, (2020).

3.2.2 Map of the Study Area

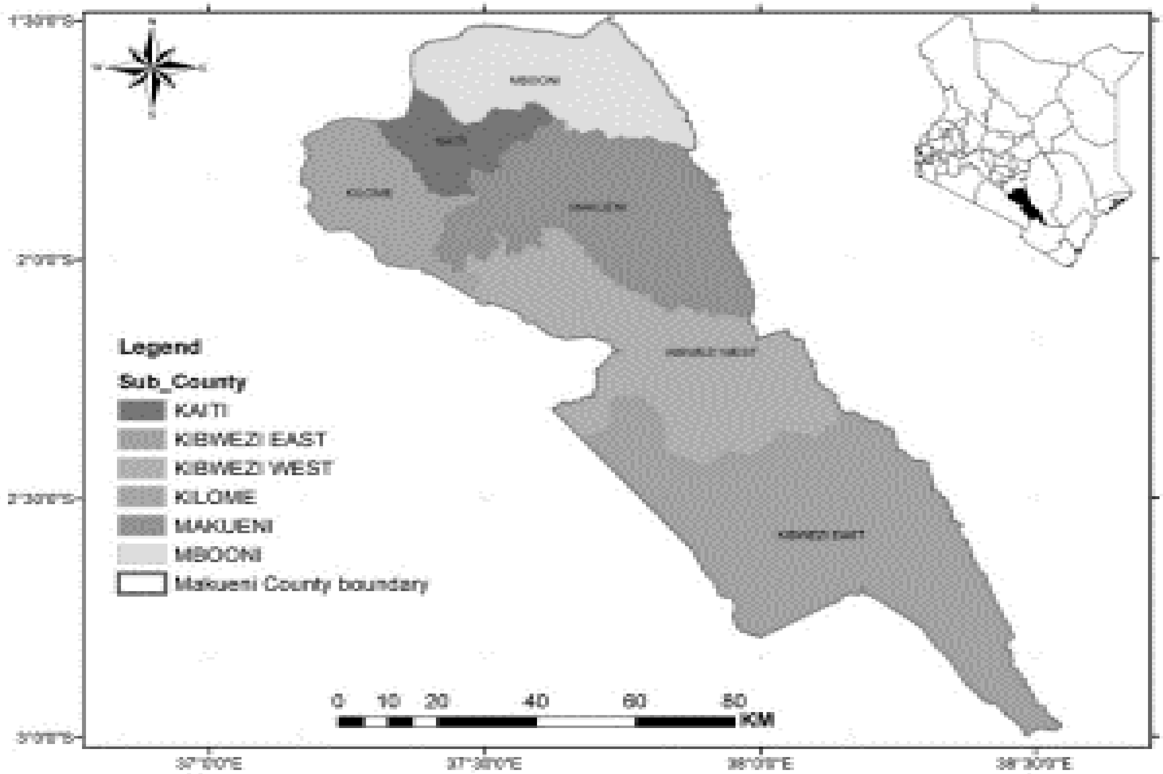


Figure 11: A demographic map of Makueni County. Source: MoALF, (2010)

3.2.3 Target Population

The target population was maize farmers in Makueni County, 176,503 households as reported in the 2019 national population census. The population is clustered into the nine sub counties, that is, Kathonozwei, Kibwezi, Kilungu, Makueni, Mbooni East, Mbooni West, Mukaa and Nzaui. The distribution of maize farmers across the county is as shown in Figure 12.

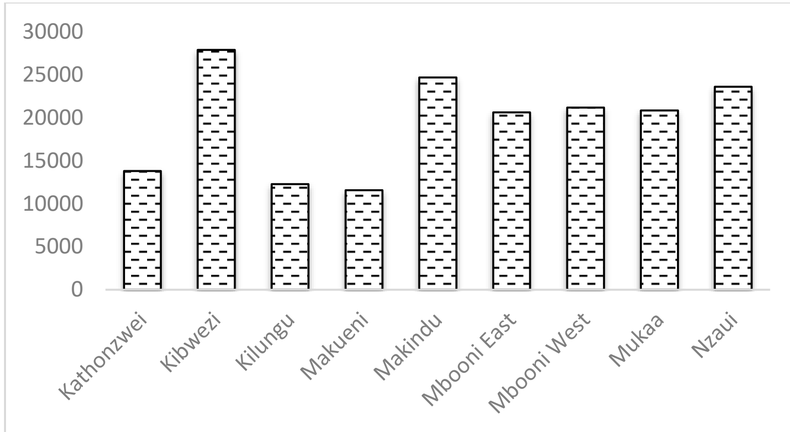


Figure 12: Distribution of maize farming households in Makueni County, by Sub County. Source: KNBS, (2019)

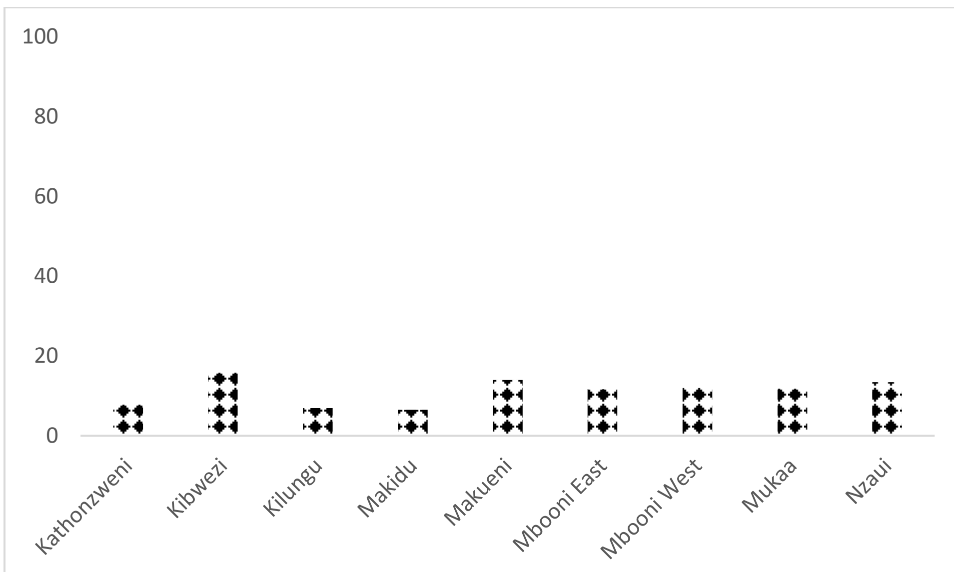


Figure 13: Distribution of maize production in Makueni County per Sub County. Source: KNBS (2019)

3.3 Sampling Procedure

The study used multi (3) stage sampling method to identify respondents since the population is widely dispersed in Makueni County given that it is an ASAL region with a population of 987,653 against 8,008.9 km^2 ground cover.

The sample size was determined using Yamane's Formula with a confidence interval of 95% as follows:

$$n = \frac{N}{1 + Ne^2}$$

Where:

n= Number of samples

N= Total population

E = Error tolerance (level)

$n = N/1 + Ne^2 = 12,264 / 1 + (12,264 * 0.05^2)$

$= 12,264/ 31.66$

$= 387$

Kilungu sub-county was selected purposively in the first stage, as it is one of the lowest producing sub-counties with minimal variability in production attributed to prevailing climatic conditions.

Subsequently, for the second stage, two wards were selected using simple random sampling and conclusively five development clusters from each ward were randomly selected. Forty farmers were randomly selected from each development cluster.

The respondents in a given cluster were selected using line transect random sampling method by interviewing the *third* household across the identified transect. A transect in this case was a river (geographical feature) or a minor road/path within a village.

3.4 Data Collection

3.4.1 Data Collection Methods

Studies on KM align towards theoretical development to grant the discipline the much-needed classification scheme with definition, theories and procedures to enhance academic maturity. An aspect or perspective that proves to be lacking is the investigation into small micro and medium enterprises (SMEs) with a focus on field studies, field experiments, ethnography, key informant interviews, focus group discussions (FGD) (Serrenko, 2013).

A field study refers to an investigation in a real-life situation with stakeholders or practitioners of a given discipline, or field. Field studies are carried out to enhance research findings validity, credibility and ambiguity. Key informant interviews are interviews carried out amongst selected participants known to be knowledge bearers or owners within a community of practice. The study conducted a field study through key informant interviews, FGD and household survey in Kilungu, Makueni County. Key informant interviews and FGD were used to provide an in-depth comprehension of the community's motivations, beliefs and perceptions on the approaches used for effective knowledge management with respect to FAW control practices.

The study involved five key informant interviews of 15 to 30 minutes and a focus group discussion with 17 participants. The key informant participants were Kilungu sub county agricultural officer, Kilungu ward agricultural and livestock officers, and agrochemical suppliers selected using purposive sampling. The household survey was conducted using a questionnaire structured into three sections: farmer's characteristics, Knowledge Structure and organization, Knowledge exchange methods. Ten trained research assistants conducted face-to-face interviews with selected respondents to answer a blend of open-ended questions and closed ended questions.

3.5 Data Analysis

Data from the research findings was analyzed using STATA statistical package. Qualitative data was subjected to content and thematic analyses to identify the FAW control practices applied in Makueni County. Descriptive and inferential analyses were used on quantitative data to determine and evaluate FAW management knowledge sources and sharing methods/platforms.

3.5.1 Applied FAW Control Practices

The data collected on FAW control practices include the number of respondents that applied control practices after FAW infestation and the type of FAW control practice. These data was analyzed by comparing the percentiles and frequency of each variable and thus determining the differences in yield for each variable. Additionally, an ANOVA was used to establish whether there was any correlation. Regression analysis was used to determine the relationship between the variables and maize yield as well as determining the relative advantage and observability of the FAW control practices.

3.5.2 Socioeconomic factors influencing selection and/or adoption of FAW practices

Socioeconomic factors analysed in the study include; farmer characteristics, farm biophysical characteristics and financial characteristics. These variables were analyzed using measures of central tendency, dispersion and ANOVA. Regression analysis was used to determine the relationship between these variables and selected FAW control practice as well as maize yield.

3.5.3 Sources of information on FAW control practices

The data collected on the knowledge sources of FAW control practices was analyzed by comparing the channels, methods and platforms used through the use of cross tabulations, frequencies and ANOVA of grouped versus individual sources as well as single versus combined sources.

3.5.4 Sharing methods/platforms of FAW control practices

The data collected on the knowledge sharing methods of FAW control practices was analyzed by comparing the willingness to exchange FAW knowledge, sharing methods and platforms used. This was done using independent T-test and ANOVA as well as frequency tables.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Descriptive Statistical Analysis

The study sampled 387 respondents from two wards as represented below, analysis showed fair representation from both wards. The sampled respondents' distribution by gender showed that both males and females are almost equally involved in maize farming, particularly FAW control to enhance productivity.

Table 1: Ward Distribution of Respondents by Gender

	Gender			
Wards	**Male**		**Female**	
	Freq	**%**	**Freq**	**%**
Kaiti	190	49	186	48
Kilungu	197	51	201	52

N=387

Summary statistics as shown in Table 2 indicate the average age of the farmers is approximately 47 years, with a notable standard deviation of 14.3, highlighting a broad age range spanning from 18 to 83 years. This statistics is in contrary to a study by Adeyanju, *et al.,* (2023) on; assessing food security among young farmers in Kenya, which found an average age of 29 years. The number of years in school (education level) shows an average of 10 years spent in education, with a standard deviation of 4.37, and a range of education from 0 to 44 years. Moreover, the dataset reveals that the average household size is about 4.7 individuals, with a standard deviation of 2, and a range of household sizes varying from 1 to 15 people.

The sampled respondents reported their occupation to be farmers at 51 % followed by business owners at 19 % . This analysis affirms the 2021 Economic Survey report by KNBS on the highest percentage of employment being in the agricultural sector both directly and indirectly. The report states that small scale agriculture and pastoralist account for 82 % of the total employment in Kenya.

Further analysis into the occupation data shows the primary source of income as mixed farming at 51 % and maize production at 14 %. Mixed farming refers to farming maize and other crops as well as livestock rearing. The study found that highest total income earner receives KES 320,000 from selling of green grams (KES 270,000) and the least earner being at KES 800 from maize production. Averagely, the total income is at KES 24,882. Further disaggregation of the income data shows highest income from maize at KES 140,000, lowest at KES 800 and KES 9610 on average. The analysis indicates maize farming potential in the region to improve the community's livelihood.

Additionally, the major crop grown is maize with a preference for improved hybrid varieties such as Duma, DK, and Pioneer. Kinyanya is the local variety in production as it is slightly resistant and/or tolerant to FAW in the region.

Table 2: Summary Statistics of Variables from Sampled Households

Variable	Mean	SD	Min	Max
Farmer characteristics				
Age	47.41	14.3	18	83
Number of years in school	10.2	4.37	0	44
Household size	4.7	2	1	15
Farm biophysical characteristics				
Land size	1.136	0.98	0.0625	5
Area under maize production	0.6933	0.6733	0	5
Yield	478.91	443.59	0	4000
Financial characteristics				
Income from maize	9610.1	11619.11	800	140000
Off farm income	16402.37	33037.58	0	315000

N= 387

Disaggregation by age showed that females represent both the youngest and oldest within the community as the average age for both males and females is at 47 years. Further analysis by gender and number of years in school revealed that females have both the highest and lowest number of schooling years compared to males. This phenomenon is associated to the societal roles and responsibilities assigned to females forcing them to pull out of school or take longer to study (Andiema & Manasi, 2022). Averagely, males have one more year of schooling compared to females. These findings are consistent with studies carried out in Siaya, Kericho and West Pokot, which found that girls/females have a higher dropout and class repetition rates compared to boy/males (Luganza, *et al*., (2017); (Andiema & Manasi, 2022); (Koech, *et al*., 2017). These studies sought to determine the reason (s) for high dropout rates as early pregnancies, early marriages and early engagement in labour provision activities such as fishing in order to afford sanitary towels.

4.2 Effect of Applied FAW Control Practices

Data analysis showed that 35 % of respondents recorded up to 26 % -100 % losses due to FAW (see Table 3). The stage of attack, with regard to maize growth and developmental stage, proved to be the n^{th} leaf stage i.e., whorl stage. A study by Prasanna, *et al*., (2018) on FAW attack found that the whorl stage management, early and late, pre-determine the success or failure of the crop in relation to effective pesticide application to control the pest. The study reported that during this stage, pesticide application/exposure is limited by accumulation of FAW excreta (frass) on the whorl, thus limits pesticide contacts with the larvae to facilitate action i.e., pesticidal effect.

Table 3: Level of crop destruction by FAW in relation to land size.

Level of destruction	0%	1- 25%	26-50 %	50 -100 %
Frequency	48	209	83	47
%	12.41	54.13	21.38	12.07

Further analysis found that of the sampled respondents, 19 % reported that they did not apply any control measures. These farmers cited lack of information and cost of implementation of the FAW control practices as one of the reasons of not applying any control practice. Comparatively, the adoption rate in Kenya is higher than that of other affected African countries (Ghana and Zambia) as reported by Tambo, *et al.*, (2020). The study found that only 75 % of the sampled respondents (465) had adopted at least one FAW control practice.

T - tests comparing means between respondents that applied FAW control practices and those who did not showed no significant differences in yield (Table 4).

Table 4: T-test Comparing Yield Differences Against Application of FAW Control Practices.

	Mean	Std.Dev	Std. Error
Did not apply	502.05	534.91	64.39
Applied	472.12	413.95	27

Ha: diff < 0	Ha: diff != 0	Ha: diff > 0
Pr (T < t) = 0.6885	Pr (|T| > |t|) = 0.6229	Pr (T > t) = 0.3115

Among the 81 % that applied FAW control practices to enhance maize productivity, chemical control by use of pesticides was found to be the most common control practice with a frequency of 149 out of the 235 respondents (see Table 5). Likewise, studies by Kumela, *et al*., (2019) also found chemical control as the most applied FAW control practice in Ethiopia and Kenya (Bungoma and Trans Nzoia County). The study sought to determine farmers' knowledge, perception and management practices of FAW; remarkably, it established that 60 % of Kenyan farmers perceived chemical control not effective in controlling FAW infestations.

Additionally, the use of pesticides was highly applied despite the recent studies that highlight sustainability (environmental and financial) concerns and pest resistance as challenges to this control practice, Dara, (2019); Matova, *et al*. (2017). The most purchased and applied pesticides used to control FAW attack in Kilungu, Makueni County include: Match, Escort, Belt and duduthrin as reported by the key informants, particularly the agro dealers. The manufacturing company recommended as distributing the most effective FAW control chemicals was found to be Syngenta. Studies by Abrahams, *et al*., (2017) evaluated effectiveness of active ingredients against FAW in Africa (Ghana and Zambia) and found cypermethrin and lambda cyhalothrin as the most effective. On the contrary, the pesticides perceived as effective contain lufenuron, metsulfuron methyl and flubendiamide as active ingredients. This observation confirms the knowledge and perception established in Kumela, *et al.*, (2019) study that reported use of pesticides against FAW as ineffective in Kenya in comparison to Ethiopia.

Table 5: Frequency table of applied FAW control practices

FAW control practice	Handpicking	Use of resistant	Use of detergents	intercropping	Use of pheromones	rogueing	Use of botanical	Push pull technology	IPM	Use of pesticides	Sand or soil	Crop rotation	traps	ash
Frequency	60	2	22	15	1	21	1	2	3	139	75	23	0	22
(%)	15.63	0.48	5.77	3.85	0.24	5.53	0.24	0.48	0.72	35.82	19.47	6.01	0	5.77

The least applied category of control practices is botanical/biological control such as use of pheromones, resistant varieties; push pull technology and use of botanical extracts. On the contrary, FAW botanical control has been reported as effective and thus recommended Abrahams, *et al*., (2017): FAO report (2018). Furthermore, studies by Midega, *et al*., (2018) reported push-pull as an effective FAW control practice recording reductions of 82.7 % and 86.7 % larvae per plant and plant damage per plot respectively. The study was carried out in East Africa with a focus on drier areas of Kenya i.e. Bungoma, Busia, Siaya, Homabay, Migori and Vihiga to determine the effectiveness of push pull technology against FAW as it is used against stemborer and striga weed. Similarly, Abrahams, *et al.,* (2017) reported biological control with regard to use of pheromones and resistant varieties against FAW in Africa as not available in Africa and recommended use of neem products recommended by the government as an alternative to industrial pesticides. Remarkably, use of traps, pheromones and predators as a FAW intervention was reported to be a novel intervention and thus yet to be practiced.

The study carried out further analysis to compare productivity against category of FAW practices, number of FAW control practices and specific FAW control practiced. The results showed no significant difference (p-value of 0.55) in productivity with regard to the number of practices applied towards FAW management (Table 6). There was a significant (p-value of 0.002) difference between those that applied pesticides against those that did not apply these methods. Respondents that applied pesticides recorded a higher average productivity compared to those who did not .Conversely, groups that applied sand/soil or ash recorded a lower mean in comparison to those who did not. Conclusively, application of sand, soil or ash negatively influenced unit productivity as opposed to pesticide application, which recorded higher productivity per unit area irrefutably, pesticide application has a higher relative advantage amongst all the practices applied with regard to production per unit area of affected farms.

Table 6: ANOVA comparing yield differences for selected variables

	SS	MS	F	Prob >F
Variable				
Category of FAW practice				
Between groups	1941828	485457.117	2.74	0.031
Within groups	24972359.1	1777108.93		
Number of FAW control practices				
Between groups	973317.48	162219.58	0.82	0.55
Within groups	58629318.5	197405.11		
Pesticide application				
Between groups	1835812.9	1835812.9	9.6	0.002
Within groups	57766823.1	191280.87		
Use of sand/soil				
Between groups	1566069.05	1566069.05	8.15	0.0046
Within groups	58036566.9	192174.06		
Use of Ash				
Between groups	872111.21	872111.21	4.48	0.035
Within groups	58730524.7	194471.94		

4.3 Socioeconomic Factors Influencing Selection of FAW Control Practices

Socioeconomic factors considered in the analysis include age, number of years in school, household size and area of land under maize production. Summary statistics show an average age of 47 years and 10 years of education. Further analysis to determine differences in means for the selected FAW control practices showed a significant difference between household size, number of years in school and area of land under maize production (Table 7).

Table 7: Differences (P values) in means of socioeconomic factors for FAW control practices

	Age	Household size	Number of years in	Area under maize
Handpicking	0.5383	0.0136*	0.0272*	0.3278
Plant rogueing	0.1368	0.7934	0.5398	0.9948
Use of pesticides	0.9397	0.2215	0.3457	0.4029
Use of resistant	0.9797	0.2674	0.6209	0.1432
Use of botanical	0.1496	0.7006	0.2226	0.9594
Sand/soil	0.9621	0.8879	0.9285	0.0939
Use of detergents	0.5410	0.9615	0.4352	0.0329*
Push pull technology	0.6122	0.9629	0.7852	0.7674
Crop rotation	0.4506	0.8792	0.6777	0.8159
Intercropping	0.6037	0.6865	0.8987	0.9614
IPM	0.2357	0.4354	0.2182	0.4927
Traps	-	-	-	-
Use of pheromones	0.8859	0.1039	0.7194	0.1427
Ash	0.0442*	0.0734	0.1654	0.0521*

These findings are consistent with Ruzzante, *et al.*, (2021) study on socioeconomic factors affecting agricultural technologies. The study found a positive correlation between adoption rate and factors such as farmer education, household size , size of land among others. Likewise, this study found a positive correlation between selection of use of ash and age as wellas land size under maize production. However, further analysis showed a negative correlation between farmer education, household size and selection of handpicking as the FAW control practice. Similarly, Rodgers, (1983) assessessed the influence of age on adoption rate of technologies in education and found no significant difference between adoption rate and age.

Linear regression analysis found a statistically significant influence of number of years in school on the selected and applied FAW control practice (Table 8). The results show that respondents that selected handpicking as the FAW control practice spent an average of 8 years in school which is an equivalent of primary school education. Given that handpicking requires little to no technical expertise, it is easier to implement and thus the preferred practice for such farmers.

Table 8: Analysis of number of years in school versus applied FAW control practice

	Hand Picking	Plant Rogueing	Use Of Pesticides	Use Of Resistant Varieties	Use Of Botanical Plants	Sand Or Soil	Use Of Detergents	Push Pull	Crop Rotation	Intercropping	IPM	Use Of Pheromones
T-Value	-2.14	-0.59	1.18	0.53	1.26	0.46	-0.3	0.34	0.31	-0.11	1.34	0.42
P-Value	0.033**	0.553	0.238	0.6	0.21	0.64	0.4	0.735	0.753	0.911	0.18	0.677

4.4 Sources of FAW Management Knowledge

The knowledge structure with regard to sourcing (acquisition or creation), retention/storage and manipulation is a factor towards enhanced maize productivity through effective knowledge management and application of the concepts and practical aspects of maize production. The study categorized sources into documentary and/or documentary sources. Documentary sources include printed materials, audio, visual and audio- visual sources. Non-documentary sources comprised of individual experts, institutions and internet. The results indicate that the most preferred sources of information are non-documentary sources such as farmer-to-farmer, institution-based agents to farmer (Table 9).

Table 9: Distribution of farmers using various sources for FAW management information

Source	Documentary	Non-Documentary	Both	None
Frequency	0	240	58	89
% Representation	0	62	15	23

N=387

Similarly, Wanyama, *et al*. (2015) found public and private not for profit organizations as key sources of agricultural information in Kenya. The study categorized extension officers and research scientists as public organizations and fellow farmers, farmer groups, Non-Governmental Organizations (NGOs), Community Based Organizations (CBOs), Faith Based Organizations (FBOs) as private nonprofit organizations. Of the two categories, public organizations represented 59 % of the 6152 sampled respondents across 38 counties in Kenya. Data analysis shows documentary sources as the least used source due to the capital investment required to facilitate the utilization of such platforms. Remarkably, documentary sources are not solely used to source for information on FAW management. Rather, respondents prefer a combination with non - documentary sources.

The study conducted a one-way ANOVA to determine if maize productivity differed based on the grouped sources. The analysis found a statistically significant difference between groups as shown by ANOVA ($F(2,299) = 6.33$, $p=0.002$). A Tukey post –hoc test revealed that productivity was statistically higher for respondents that used both sources compared to non-documentary sources only (236+/-71.93, $p= 0.003$). However, there were no statistically significant differences between no sources and non-documentary sources as well as no sources and both sources (Table 10).

Table 10: ANOVA –Tukey post hoc of sourcing channels versus maize productivity

	contrast	std. err.	t	p
both Vs Non- Documentary	236.03	71.93	3.28	0.003**
none Vs Non-Documentary	128.89	61.25	3.10	0.091
None Vs Both	-107.14	82.91	1.29	0.401

Moreover, a report by AGRA, Peters and Page (2020) reported that fellow farmers and extension officers (non-documentary) are key sources of agricultural information due to perceived credibility and ease of access of the information sought. The study analyzed communication strategies, methods and effects on FAW management in Uganda and found fellow farmers, extension workers and radio as key information channels used to disseminate FAW management information.

Hudson, *et al*., (2017) evaluated the impact of radio, as a communication channel, on food security in sub-Saharan Africa and reported that ICT-enhanced radio campaign approach significantly increases the rate of adoption of agricultural technologies and thus enhances agricultural productivity.

4.5 Knowledge Exchange of FAW Control Practices

Knowledge exchange refers to the transfer or sharing of information (tacit or explicit) from one person to another using various methods and /or channels. The analysis shows that 70 % of the key informants reported to disseminate information on how to manage FAW infestation all the time or as needed or requested by stakeholders: majorly through seminars, workshops and/or trainings. On the contrary, only 29 % of the farmers admitted to exchanging FAW information all the time or as requested or needed. Remarkably, less than 50 % of the respondents stated to be very willing to exchange information on FAW interventions against 3 % that are not willing to exchange knowledge (Table 11).

Table 11: Willingness to exchange information on FAW interventions

Willingness	**Not Willing**	**Somewhat Willing**	**Willing**	**Moderately Willing**	**Very Willing**
Frequency	13	8	168	24	174
% Representation	3.29	1.97	43.42	6.25	45.07

N=387

A tacit knowledge sharing review conducted by Mohajan (2016) found that sharing of tacit knowledge is uncommon. The review highlighted technology, intra and interpersonal skills as barriers to tacit knowledge sharing. Knowledge workers and managers may be unaware of the importance of the knowledge possessed to others or choose not to risk exposing their knowledge due to fear of judgment and thus discrimination. Nevertheless, knowledge exchange/sharing plays a key role in enhancing performance/productivity as compared to explicit knowledge. However, since tacit knowledge is unwritten, unspoken, acquired through various stakeholder interactions, owners of such knowledge rarely exchange or transfer it consciously. Moreover, the study outlined meetings, knowledge fairs (farmer field day (s), visits and participation as effective avenues to enhance tacit knowledge sharing to promote organizational performance and/or productivity.

The study carried out an independent t-test to determine whether there are differences in productivity with regard to willingness to exchange information on FAW management. The responses from the Likert scale were grouped into two categories: not willing and willing. The results showed that there was no statistically significant difference between those not willing to exchange information and those willing to exchange information on FAW management (Table 12).

Table 12: Independent t-test of willingness against productivity

Group	Observation	Mean	Std.Err	Std.Dev.	(95 % Conf.Interval)	
1	10	384.93	103.23	326.45	151.41	618.46
2	291	482.11	26.07	447.03	430.80	533.43
Combined	304	478.92	25.44		428.86	528.97
diff		-97.18	142.74		-378.08	183.72

Ho: diff = 0 *t = -0.6808*

Ha: diff < 0 *Ha: diff! = 0* *Ha: diff > 0*

Pr (T<t) = 0.25 *Pr (|T|>|t|) = 0.50* *Pr (T>t) = 0.75*

Further analysis found out that the most used method of exchange is through story telling at 89 %. Story telling refers to casual/ informal conversations. Outstandingly, less than 1 % of the respondents reported mass communication campaigns as an exchange method used to transfer or share information on FAW interventions (Table 13).

Table 13: Frequency of the methods used to exchange FAW information

Exchange Method	**Cop**	**FFS**	**Barazas**	**Seminars**	**Storytelling**	**Workshops**	**Group Meetings**	**Internet**
Frequency	66	20	17	19	200	9	47	9
% Representation	17.05	5.17	4.45	4.39	51.68	2.33	1.21	2.33

N=387

Contrary to the respondents' preferences, an ANOVA used to determine a difference in productivity between respondents that used certain exchange platforms against those who did not show a statistically significant difference (p-value of 0.033) for barazas only (Table 14).

Table 14: One-way ANOVA comparing barazas against a control group

Source	SS	Df	MS	F	Prob>F
Between Groups	893275.49	1	893275.49	4.59	0.033
Within Groups	58709360.5	302	194401.86		
Total	59602636	303	196708.34		

Notably, the farmers disseminate information amongst each other through church meetings, farmer groups; farmer field schools (FFS) and community-based organizations (CBOs). Likewise, the FAO, (2018) report on integrated management of FAW on maize emphasized on the use of farmer field schools to disseminate FAW management technologies. The report provides a guide on FFS implementation through a FAW management curriculum based on demonstration as the training methodology through use of word of mouth and observation. Furthermore, Fabregas, *et al*., (2017) evaluated dissemination of agricultural information in Western Kenya and found that farmer field day (s) had a statistically insignificant influence on the adoption of agricultural technology. However, the approach had an impact on the awareness or farmer knowledge and perceptions on the technology.

Disaggregation of internet as a platform revealed that 41 % of the respondents are very willing to use online tools such as websites, USSD and mobile applications to exchange information on FAW intervention (s). They reported that online tools are great alternatives especially when physical meet ups are challenging e.g., during Covid-19 pandemic, geographically dispersed stakeholders. Additionally, online tools are also a challenge when ICT infrastructure is limited.

Correspondingly, a study by Tata & McNamara, (2018) showed that fluctuating cost of electric power, limited information technology resources and ICT infrastructure are barriers towards effective utilisation of online tools for agricultural extension. Furthermore, Tambo, *et al*., (2019) compared radio, videos and text messages used to disseminate FAW management information in Uganda and found that radio, ICT ehanced radio campaign, had an impact on behavioral change of farmers in managing FAW as well as enhancing their knowledge capacity on sustainable FAW management. Further analysis of the online tools as separate platforms showed a preference for USSD compared to websites and mobile applications. Respondents cited cost implications and usability as challenges to utilize these platforms. Similarly, a study by Gichamba, *et al*., (2017) reported limited technical capacity, internet conectivity and high costs of electricity as obstacles in achieving the full potential of online tools for agricultural extension. Conversely, the study found that 32 % and 25 % of the sampled respondents preferred websites via a computer and mobile phone respectively; only 25 % preffered USSD as e-extension tools and/or platforms.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary

The study sought to assess the effect of knowledge management of FAW control practices on maize yield in Kilungu, Makueni County. The study was based on the diffusion of innovation theory, highlighting determinants of adoption of technology or innovation. It applied the knowledge management process model (KMPM) to evaluate the processes/activities that determine effective knowledge management with regard to dissemination sources and channels/ methods and platforms used to promote adoption of FAW control practices so as to reduce yield losses. It applied a descriptive research design, used household surveys, key informant interviews and focus group discussions to collect data, and analyzed it using STATA statistical package.

The aim of the study was to answer the following research questions:

1. What is the effect of applied FAW control practices on maize yield in Kilungu, Makueni County?
2. What is the influence of selected socioeconomic factors on the selection of FAW control practices in Kilungu, Makueni County?
3. Is there a difference in maize yield between selected sources of information on FAW control practices in Kilungu, Makueni County?
4. Is there a difference in maize yield between selected methods of sharing information on FAW control practices in Kilungu, Makueni County?

The findings from this study are summarized as follows:

1. Adoption/application of FAW control practice (s) has marginal influence on the maize yield from an infested farm. However, the use of chemicals to control FAW infestation leads to higher maize yields compared to physical, cultural and botanical methods. Applying at most two practices, including chemical based control leads to higher than average yields.

2. Selection of a particular FAW control practice is influenced by factors such as farmer education, household size and land size under maize production. There is a correlation between selection of certain FAW control practices and socioeconomic factors.

3. Non-documentary sources such as farmer-to-farmer or institution (Extension and research) are most preferred compared to documentary sources such as printed text/ material on FAW management. Remarkably, respondents that used both sources reported a higher maize productivity in comparison to those that used non-documentary sources only.

4. Among all the channels and/or platforms used to exchange knowledge on FAW management, *barazas* had a direct proportionality to maize productivity. *Barazas* are organized fora for the local community to share ideas, new information as well as experiences with regard to issues at the time.

5.2 Conclusions

In conclusion, the knowledge management of FAW control practices revolves around the farming community with non–documentary sources such as fellow farmers and extension officers being the preferred source (s) of information on the account of credibility, validity and reliability. Disseminators of FAW control practices have a better chance of increasing adoption rate of FAW control practices and reducing maize yield losses due to FAW attack by utilizing interpersonal sources and channels, especially during the persuasion stage of the adoption decision process.

The farming community understands that knowledge sharing is paramount to reducing yield losses and thus is willing and often exchange knowledge on FAW control practices as needed or requested. The preferred exchange methods include barazas, group meetings and communities of practice through story telling. These methods are pre-determined based on effectiveness from previous encounters/experiences or the triability aspect of the practice. Storytelling stands out as the most preferred exchange channel due to its convenience; however, it is subject to manipulation in terms of transformation, translation and misinterpretation. Consequently, it compromises the credibility and reliability of the information as the manipulation methods enhance information distortion, which may prove fatal. Therefore, online tools such as websites, USSD and mobile applications are alternatives to overcome this challenge. However, it requires considerable capital investment with regard to ICT infrastructure to enhance its effectiveness. Nevertheless, FAW identification and control practices information can still be provided with a focus on USSD.

Chemical control by using pesticides is an effective management practice against FAW infestation. However, farmers lack the capacity to select the most effective pesticide based on the efficacy of the active ingredient. Therefore, they are unable to achieve the desired outcome which is high yields despite FAW infestations.

5.3 Recommendations of the study

Given that the farming community relies heavily on non-documentary sources such as fellow farmers and extension officers to source FAW management information, technology innovators and disseminators should focus on strengthening the capacity of farmers and extension officers through *barazas* and/or storytelling to enhance technology accessibility and application. However, they should pay attention to information distortion and keep it at a minimum.

Online tools that are developed to serve as alternative sources of disseminating FAW control intervention or any agricultural information should take account of user friendliness, cost effectiveness and available ICT infrastructure. This will enhance the effectiveness of such platforms and thus improve agricultural productivity.

Scientific research on FAW control interventions should be regularly shared with farmers and extension officers through *barazas*, group meetings, workshops, communities of practice to enhance technology adoption and eventual maize productivity. Particularly research on effectiveness of the applied control practices.

5.3.1 Areas for further research

The following areas could be advanced to fill the identified gaps in knowledge.

1. Effectiveness of selected online tools such as; USSD, websites and mobile applications with respect to user friendliness and cost implications.
2. Comparative analysis of the pesticides used to control FAW to determine the most effective active ingredient and/or pesticide in Kenya.

REFERENCES

Abrahams, P., Bateman, M., Beale, T., Clottey, V., Cock, M., Colmenarez, Y., Gareth. (2017). *Evidence note on Fall Armyworm: Impacts and Implications for Africa.* CABI.

African Union (AU)- New Parnerships for Africa's Development (NEPAD). (2003). *Comprehensive Africa for Agricultural Development Programme (CAADP).* AU-NEPAD.

African Union (AU) (2014).New Partnerships for Africa's Development (NEPAD). Malabo Declaration. South Africa: AU-NEPAD.

Andiema, N., & Manasi, E. (2022). School and Pupil based factors influencing girls'dropout rates in Primary Schools in West Pokot,Kenya. *European Journal of Education studies, 1*(9). DOI: 10.46827/ejes.v9i1.4113

Ansah, I. G., Fidelis, T., & Bright K. D, T. (2021). Farmers' Control Strategies against Fall Armyworm and Determinants of Implementation in Two Districts of the Upper West Region of Ghana. *International Journal of Pest Management*.

Bogdan, C., Lal, M. B., & Claudiu, V. K. (2014). *Review of Knowledge Management Models for Implementation within Advanced Product Quality Planning.* Switzerland: Springer International Publishing .

Chan, I., & Chau, P. Y. (2008). Eliciting Knowledge Management research themes and issues: results from a Focus Group study. *International Journal of Knowledge Management Studies, 2*(2), 175-197.

Dara, S. K. (2019). The New Integrated Pest Management Paradigm for the Modern Age. *Journal of Integrated Pest Management*, 1-9.

De Groote, H., Simon, C. K., Bernard, M., Sebastian, P., Menale, K., & Anani, B. (2020). Spread and impact of fall armyworm (Spodoptera frugiperda J.E. Smith) in maize production areas of Kenya. *Elsevier : Agriculture, Ecosystems and Environment*. doi:https://doi.org/10.1016/j.agee.2019.106804

Diskin, P. (1997). Agricultural Productivity Indicators Measurement Guide. Washington D.C.: Food and Nutrition Technical Assistance Project, Academy for Educational Development.

Fabregas, R., Kremer, M., Robinson, J., & Schilbach, F. (2017). *Evaluating agricultural informatin dissemination inWestern Kenya,3ie Impact Evaluation Report 67.* New Delhi, India: International Initiative for Impact Evaluation (3ie).

Food and Agriculture Organization. (2023). *Crop Prospects and Food Situation – Quarterly Global Report No. 2.* Rome: FAO. doi:https://doi.org/10.4060/cc6806en

Food and Agriculture Organization for the United Nations. (2018). Integrated management of the Fall Armyworm on maize: A guide for Farmer Field Schools in Africa. FAO.

Food and Agriculture Organization; International Fund for Agricultural Development; United Nations Childrens Programme; World Food Programme. (2023). The State of Food Security and Nutrition in the World 2023.Urbanization, agrifood systems transformation and healthy diets across the rural–urban continuum. Rome: FAO. doi:https://doi.org/10.4060/cc3017en

Gichamba, A., Wagacha, P. W., & Ochieng, D. O., (2017). An Assessment of e-Extension Platforms in Kenya. *International Journal of Innovative Studies in Sciences and Engineering Technology, 3*(7).

Haradhan, K. M., (2016). Sharing of Tacit Knowledge in Organizations: A Review. *American Journal of Computer Science and, 3*(2), 6-19.

Harlow, H., (2008). The effect of tacit knowledge on firm performance. *Journal of knowledge management, 12*(1), 148-163. doi:10.1108/13673270810852458

Hislop, D., (2005). *Knowledge Management in Organisations.* New York: Oxford University Press.

Hudson, H. E., Leclair, M., Pelletier, B., & Sullivan, B. (2017). Using radio and interactive ICTs to improve food security among smallholder farmers in Sub-Saharan Africa. *Telecommunications Policy*, 1-15. doi:http://dx.doi.org/10.1016/j.telpol.2017.05.010

Ibrahim, F., (2017). Knowledge management methodology :Developing a Phenomenalogical Middle Range thinking approach for knowledge management research. *Journal of Management Research*.

Ihza, R. F., Farida, H., Ali, K., & Toni, B. (2021). Optimal Pest Control Strategies with Cost-effectiveness Analysis. *The Scientific World Journal*.

Jordan, R. G., (2020). Tacit vs explicit Knowledge as Antecedents for organizational Change. *Journal of Organizational Change*. doi:10.1108/JOCM-04-2020-0121

Kenya National Bureau of Statistics. (2019). *2019 Kenya National Population and housing census: Distribution of population by socio-economic characteristics Volume IV.* Nairobi: Republic of Kenya.

Kenya National Bureau of Statistics. (2019). *Economic Survey.* Nairobi: Republic of Kenya.

Kenya National Bureau of Statistics. (2019). *Kenya Population and Housing Census.* Kenya: Repulic of Kenya.

Kenya, R. o. (2018). *Fall armyworm technical brief maize crop in Kenya.* CABI.

Koech, M., Makero, S. C., & Kosgei, A. (2017). Pupils' Personal Factors that Lead to Girls Drop-Out from Primary Schools in the Tea Estate Schools in Kericho County. *Journal of Education, 7*(5), 96-99. doi:10.5923/j.edu.20170705.02

Kumela, T., Simiyu, J., Sisay, B., Likhayo, P., Mendesil, E., Gohole, L., & Tefera, T. (2019). Farmers' knowledge,perceptions, and management practices of the new invasive pest, fall armyworm (Spodoptera frugiperda) in Ethiopia and Kenya. *International Journal of Pest Management*, 1-9.

Luganza, H. M., Chege, F., & Wawire, V. (n.d.). Factors Contributing to the High Drop out of Girls in the Secondary Schools around Lake Victoria: A Case Study of Nyangoma division in Siaya County, Kenya. *Greener Journal of Education Research, 7*, 049-060. doi:10.15580/GJER.2017.4.061817077

Matova, P. M., Kamutando, C. N., Magorokosho, C., Kutywayo, D., Gutsa, F., & Labuschagne, M. (2017). Fall-armyworm invasion, control practices and prospects of breeding fall-armyworm armyworm-resistant. *Agronomy Journal*. doi:10.1002/csc2.20317.

Midega, C. A., Pittchar, J. O., Pickett, J. A., Hailua, G. W., & Khana, Z. R. (2018). A climate-adapted push-pull system effectively controls fall armyworm, Spodoptera frugiperda (J E Smith), in maize in East Africa. *Crop Protection*, 10 -15. doi:10.1016/j.cropro.2017.11.003

Ministry of Agriculture, L. A. (2010). *Farm managaement Handbook- Eastern Province* (Vols. II, Part II C1). Republic of Kenya.

Ministry of Agriculture, Livestock and Fisheries (MoALF). (2011). *National Food and Nutrition Security Policy*. Nairobi, Kenya: Government of Kenya.

Ministry of Agriculture, Livestock and Fisheries (MoALF). (2016). Climate Risk Profile for Makueni. Kenya County Climate Risk Profile Series.

Ministry of Agriculture, Livestock and Fisheries (MoALF). (2019). Agriculture Sector Transformation and Growth Strategy. Nairobi, Kenya: Government of Kenya.

Mohajan, H. K., (2016). Sharing of Tacit Knowledge in Organizations: A Review. *American Journal of Computer Science and Engineering, 3*(2), 6-19.

Muna, M., Mugendi, D., Pypers, P., Mugwe, J., Kungú, J., Vanlauwe, B., & Merckx, R. (2013). Enhancing maize productivity and profitability using organic inputs and mineral fertilizer in Central Kenya, small hold farms.

Murray, K. J., (2021). *Fall Armyworm Management by Maize Smallholders in Kenya: An Integrated Pest Management Strategic Plan.* USAID & CIMMYT.

Nonaka, I., & Peltokorpi, V. (2006). Objectivity and subjectivity in knowledge manageemnt: a review of 20 top articles. *Knowledge and Process Management*, 73-82.

Okari, C., (2021). Assessment of yield losses and farmers' perceptions on control practices of fall armyworm: The case of maize infestation in Trans-Nzoia County, Kenya. Kenya.

Peters, D., & Page, S. (2020). *Communication Strategies and Effects on Fall Armyworm Management in Uganda.* AGRA. Retrieved from https://www.agrilinks.org/sites/default/files/media/file/Communications%20Strategies%20and%20Effects%20on%20FAW%20Management%20in%20Uganda_Final.pdf

Prasann, B., H, J. E., Regina, E., & Pescheke, V. M. (2018). *Fall Armyworm in Africa: A GUIDE FOR INTEGRATED PEST MANAGEMENT.* Mexico: CIMMYT.

Renzl, B. (2008). "Trust in management and knowledge sharing: The mediating. *Omega*.

Rhett D., H., Christian, T., Frédéric, B., Peter, C., Charles, M., Urs, S., & Bergg, J. v. (2019). Agro-ecological options for fall armyworm (Spodoptera frugiperda JE Smith) management: Providing low-cost, smallholder friendly solutions to an invasive pest. *Journal of Environmental Management*.

Rogers, E. M., (1983). *Diffusion of Innovations.* New York: The Free Press.

Ruzzante, S., Ricardo, L., & Amy, B. (2021). Adoption of agricultural technology in the developing world: A meta-analysis of the empirical literature. *World Development*(146). doi:athttps://doi.org/10.1016/j.worlddev.2021.

Saliou, N., Mawufe, K. A., Emily, K., Berita, M., El, F., Daisy, S., . . . Sevgan, S. (2021). Bioecology of fall armyworm Spodoptera frugiperda (J. E. Smith), its management and potential patterns of seasonal spread in Africa. *PLOS*.

Serrenko, A.,(2013). Meta-analysis of scientometric research of knowledge management: discovering the identity of the discipline. *Journal of Knowledge Managemnet*, 773- 812.

Shem, S., & Maxwell, A. P. (2019). Exploring tacit knowledge transfer and innovation capabilities within the buyer–supplier collaboration: a literature review. *Cogent Business & Management*. doi:10.1080/23311975.2019.1683130

Stevens, R., Millage, J., & Clark, S. (2010). Waves of Knowledge Management: The Flow between Explicit and Tacit Knowledge". *American Journal of Economics and Business Administration*, 129-135.

Tambo, J. A., Aliamo, C., Davis, T., Mugambi, I., Romney, D., Onyango, D. O., . . . Byantwale, S. T. (2019). The impact of ICT-enabledextension campaign on farmers' knowledge and management of fall armyworm in Uganda. *PLoS ONE*, *14*(8). doi:https://doi.org/10.1371/journal.pone.0220844

Tambo, J. A., Day, R. K., Lamontagne-Godwin, J., Silvestri, S., Beseh, P. K., Oppong-Mensah, B., . . . Matimelo, M. (2020). Tackling fall armyworm (Spodoptera frugiperda) outbreak in Africa: an analysis of farmers' control actions. *International journal of Pest managemnt*, *66*, 298 -310. doi:10.1080/09670874.2019.1646942

Tata, J. S., & McNamara, P. E. (2018). Impact of ICT on agricultural extension services delivery: evidence from the Catholic Relief Services SMART skills and Farmbook project in Kenya. *Journal of agricultural extension and education*, *24*(1), 89-110. doi:https://doi.org/10.1080/1389224X.2017.1387160

Tsedeke, A., Stephen, M., Hugo, D. G., & Mosisa, W. R. (2015). A Quarterly Bulletin of the Drought Tolerant Maize for Africa Project. *4*. Nairobi: CIMMYT. doi:10.1007/s12571-015-0488-z

Wanyama, R. M. (2016). *Agricultural Information sources and their Effect on farn Productivity in Kenya.* Nairobi,Kenya: Tegemeo Institute of Agricultural Policy and Development.

APPENDICES

Appendix 1: HH Questionnaire

Knowledge Management of FAW control practices in Makueni County

Introduction

Fall Armyworm (FAW) has become a major pest affecting maize production in Kenya since 2016. The Ministry of Agriculture, Livestock and Fisheries has developed methods and practices to control FAW infestation through research and development sector. This study seeks to assess the knowledge management structure and effectiveness of control practices on Fall Armyworm (FAW) management among smallholder maize farmers in Kilungu, Makueni County, Kenya. The aims of this study are:

1. To determine the knowledge sources of FAW control practices in Kilungu, Makueni County.
2. To evaluate knowledge exchange methods of FAW control practices in Kilungu, Makueni County.
3. To determine the most effective FAW control practices in Kilungu, Makueni County.

The interview takes a maximum of 60 minutes. All the information provided is used for the intended research only; confidentiality of information provided is guaranteed.

1. Do you consent to help us with this research study?

☐ Yes

☐ No

DATE: ______________________________

Respondent's characteristics

2. Name: __________________________
3. Questionnaire ID: ___________________
4. Telephone number: ___________________
5. Age: ____________________________
6. Gender

Mark only one oval.

- ☐ Male
- ☐ Female
- ☐ Prefer not to say

7. Education level/Number of years in school

Mark only one oval.

- ☐ Primary education

- ☐ Lower Secondary education
- ☐ Secondary school education
- ☐ Technical and Vocational College
- ☐ University
- ☐ Others (years in school)

8. Occupation
   - ☐ Formal employment
   - ☐ Non formal employment
   - ☐ Farmer
   - ☐ Business
   - ☐ Formal employment and farmer
   - ☐ Non formal employment and farmer
   - ☐ Other
9. What is your primary source of income?

Mark only one oval.
   - ☐ Maize Production
   - ☐ Mixed farming
   - ☐ Dairy Production
   - ☐ Formal employment
   - ☐ Informal employment
   - ☐ Other:
10. What is your income from the following:

S/NO	**Enterprise**	**Approximate Income**
1	Maize farming	
2	Dairy farming	
3	Green gram farming	
	Other	

11. Total area under crop production: ____________________(Acres)
12. Land tenure/ownership
   - ☐ Ancestral land
   - ☐ Acquired land
   - ☐ Leased land
   - ☐ Other
13. What are the major crops grown on the farm?
   - ☐ Cereals
   - ☐ Pulses
   - ☐ Vegetables
   - ☐ Fruits
   - ☐ Others
14. Area under maize production: _______________________

15. How much do you spend on the following per season:

S/NO	Activity	Amount spent
1	Land preparation e.g., slashing, ploughing, ridging.	
2	Seed/variety purchase	
3	Planting	
4	Weeding	
5	Pest control e.g., purchase of pesticide and spraying	
6	Harvesting	
7	Post - harvest e.g., shelling, sorting or grading	

16. Maize quantity harvested: ______________________________
17. Unit (s) used: ____________________________________

Objective 1: To determine the knowledge sources of FAW control practices in Kilungu, Makueni County

18. When do you plant maize on your farm? How many times do you plant maize in a year?
- ☐ All year round
- ☐ Long season
- ☐ Short season
- ☐ Other

19. Where do you get the following information on maize production?

	Fellow farmers	**Extension officers**	**Traditional experts**	**Radio**	**Mass communication**	**Workshops/seminars**	**TV**	**Internet e.g., websites**	**Other**
Planting season									
Planting time									
Seed selection									
Soil testing									
Organic manure preparation									
Pest identification									

Pest control									
FAW control pracs									

20. Do you know of any pests that affect maize production?
    - ☐ Yes
    - ☐ No
21. If yes, which one? (Pictorials of each of the listed pests)
    - ☐ FAW
    - ☐ Maize stalk borers
    - ☐ Maize leafhoppers
    - ☐ Maize aphids
    - ☐ African bollworms
    - ☐ Cutworms
    - ☐ Other
22. At what stage do they (FAW) attack? (Pictorials of maize growth stages): Edit stages
    - ☐ Emergence
    - ☐ 1st leaf
    - ☐ 2nd leaf
    - ☐ Nth leaf
    - ☐ Tassel
    - ☐ Silk
    - ☐ Seed stage
    - ☐ Physiological maturity
23. What proportion of your maize crop was destroyed by FAW attack?
    - ☐ All of it
    - ☐ Half of it
    - ☐ Quarter of it
    - ☐ None of it
24. Did you apply any control practices?

    Mark only one oval.
    - ☐ Yes
    - ☐ No
25. If yes, which method did you use?

    Check all that apply.
    - ☐ Hand picking
    - ☐ Plant rogueing
    - ☐ Use of pesticides
    - ☐ Use of resistant varieties
    - ☐ Use of botanical plants e.g., marigold, tithonia, neem, aloe Vera.
    - ☐ Sand or soil
    - ☐ Use of detergents e.g., OMO
    - ☐ Push pull technology
    - ☐ Crop rotation

- ☐ Intercropping
- ☐ IPM
- ☐ Traps
- ☐ Use of pheromones', FAW predators
- ☐ Other:

26. How did you get to know about these control practices?

Check all that apply.

- ☐ Fellow farmers
- ☐ Extension programs
- ☐ Mass communication campaigns
- ☐ Workshops
- ☐ Farmer associations
- ☐ Traditional healers
- ☐ Radio
- ☐ TV
- ☐ Printed materials e.g., newspaper, books, manuals, brochures.
- ☐ Pictures
- ☐ Videos
- ☐ Voice recording
- ☐ Text Messages
- ☐ Internet e.g., websites, mobile applications.
- ☐ Other

27. Did you pay for the information?

Mark only one oval.

- ☐ Yes
- ☐ No

28. How?

- ☐ Training fee
- ☐ Consultation fee
- ☐ Other

29. Which method did you use to ensure you did not lose it or forget? How do you retain this information?

Check all that apply.

- ☐ Mental memory
- ☐ Pictures
- ☐ Asking questions
- ☐ Note taking
- ☐ Video recording
- ☐ Voice recording
- ☐ Other

Objective 2: To evaluate knowledge exchange methods of FAW control practices in Kilungu, Makueni County

30. How willing are you to exchange knowledge on FAW control practices with fellow farmers or anyone

Mark only one oval.

- ☐ Not willing
- ☐ Somewhat willing
- ☐ Willing
- ☐ Moderately willing
- ☐ Very willing

31. How often do you exchange knowledge on FAW control practices?

Mark only one oval.

- ☐ Not very often
- ☐ Not often
- ☐ Often
- ☐ Very often
- ☐ All the time/ as needed

32. How do you do it?

Check all that apply.

- ☐ Communities of practice
- ☐ Story telling
- ☐ Farmer field schools
- ☐ Mass communication campaigns
- ☐ *Barazas*
- ☐ Workshops
- ☐ Seminars
- ☐ Group meetings e.g., farmer group, church group.
- ☐ Internet e.g., websites, mobile applications.
- ☐ Other

33. Which platform do you use to exchange information on FAW control practices with fellow farmers, family members, agric-extension officers, researchers e.t.c.

Check all that apply

- ☐ Radio
- ☐ Television
- ☐ Text messages
- ☐ Videos
- ☐ Print media
- ☐ Internet e.g., email, websites, mobile applications
- ☐ Other

34. How willing are you to use online tools e.g., websites, mobile applications, USSD to exchange knowledge on FAW management?

- ☐ Not willing
- ☐ Somewhat willing
- ☐ Willing
- ☐ Moderately willing
- ☐ Very willing

35. On a scale of 1-5, which online tool would you prefer to use as a knowledge exchange platform?

	Unlikely	Least likely	likely	Moderately likely	Most likely
Websites e.g., NAFIS,					
USSD e.g., iCow					
Mobile applications e.g., YouTube, iCow, iFarmer, KALRO apps					

36. On a scale of 1-5, what kind of knowledge on FAW are you likely to exchange using online tools?

	Unlikely	Least likely	likely	Moderately likely	Most likely
FAW identification					
FAW infestation e.g., stage of attack, pre-disposing factors e.t.c.					
FAW destruction level					
FAW control practices					
Effectiveness of FAW control practices					
FAW pesticide resistance and tolerance					
Maize varieties resistant/tolerant to FAW					

37. Have you experienced or witnessed a change of the knowledge on FAW control practices?

Mark only one oval.

- ☐ Yes
- ☐ No

38. How did this happen?

Check all that apply

- ☐ Transformation e.g., from text to video, video to pictures, or vice versa
- ☐ Publication of Indigenous Knowledge
- ☐ Misinterpretation
- ☐ Translation

39. Which of these practices would you advise a fellow maize farmer to use?

Mark only one oval

	Unlikely	Least likely	likely	Moderately likely	Most likely
Hand picking					
Rogueing					
Pesticides					
Resistant varieties					
Botanical plants					
Sand/soil					
OMO					
Push pull					
Crop rotation					
Intercropping					
IPM					
Traps					
Pheromones or predators					

Appendix 2: Key informants' /Focus group discussion questionnaire

Knowledge Management of FAW control practices in Makueni County

Introduction

Fall armyworm (FAW) has become a major pest affecting maize production in Kenya since 2016. The Ministry of Agriculture, Livestock and Fisheries has developed methods and practices to control FAW infestation through research and development sector. This study seeks to assess the knowledge management structure and effectiveness of control practices on Fall Armyworm (FAW) management among smallholder maize farmers in Kilungu, Makueni County, Kenya.

The aims of this study are:

1. To determine the knowledge sources of FAW control practices in Kilungu, Makueni County.
2. To evaluate knowledge exchange methods of FAW control practices in Kilungu, Makueni County.
3. To determine the most effective FAW control practices in Kilungu, Makueni County.

This discussion takes a maximum of 40 minutes. All the information provided is used for the intended research only; confidentiality of information provided is guaranteed.

1. Do you consent to help us with this research study?

☐ Yes

☐ No

DATE: ______________________________

Participants' characteristics

2. Name: ___________________________
3. Questionnaire ID: ____________________
4. Name of Institution: ____
5. Role in FAW management in Kilungu, Makueni County
    - ☐ Agrochemical supplier
    - ☐ Ward Agricultural officer
    - ☐ Sub county Agricultural officer
    - ☐ NGO/Faith Based Organization/ CBO
    - ☐ Livestock officer

FAW infestation and control practices

6. Is FAW a major crop pest in maize production in Kilungu?
    - ☐ Yes
    - ☐ No
7. What is the destruction level?
    - ☐ >19 %
    - ☐ 20-39 %

- ☐ 40 -59 %
- ☐ 60 – 79 %
- ☐ 80- 100 %

8. Do you have a database for maize farmers affected by FAW?
   - ☐ Yes
   - ☐ No
9. Number of farmers were affected by FAW infestation in the last cropping season: ________________
10. Approximate losses due to FAW infestation per acre: ___________________________________
11. What are the categories used to classify FAW control practices?
   - ☐ Organic
   - ☐ Inorganic/ Industrial chemicals
   - ☐ Cultural
   - ☐ Physical
   - ☐ Biological
   - ☐ Botanical
   - ☐ Other
12. What are the control practices under each category?

Organic	Inorganic	Cultural	Physical	Biological	Botanical

13. Which control practices are effective?

____

____

____

<u>Chemical control of FAW infestation</u>

14. What percentage of farmers use agrochemicals to control FAW infestation?
   - ☐ >19 %
   - ☐ 20-39 %
   - ☐ 40 -59 %
   - ☐ 60 – 79 %
   - ☐ 80- 100 %

15. Which pesticides are used to control FAW infestations?

____

____

____

____

16. Which pesticide is mostly purchased?

____

Knowledge management of FAW control practices

17. Are farmers aware of FAW control practices?
    - ☐ Yes
    - ☐ No

18. Which methods are used to disseminate this information to farmers?
    - ☐ Extension programs
    - ☐ Mass communication campaigns
    - ☐ Workshops
    - ☐ Farmer associations trainings
    - ☐ Farmer field schools
    - ☐ Communities of practice
    - ☐ Storytelling
    - ☐ *Barazas*
    - ☐ Internet e.g., websites, mobile applications.
    - ☐ Other

19. What is the effectiveness of these methods?

	Not effective	Least effective	Effective	Moderately effective	Most effective
Extension programs					
Mass communication campaigns					
Workshops					
Farmer association trainings					
Farmer field schools					
Communities of practice					
Story telling					
Barazas					
Internet e.g.					
Other					

20. How often do you disseminate this information?
    - ☐ Not very often
    - ☐ Not often
    - ☐ Often
    - ☐ Very often

☐ All the time/ as needed

21. Which platforms are used to disseminate this information to farmers?
    - ☐ Radio
    - ☐ Television
    - ☐ Text messages
    - ☐ Videos
    - ☐ Print media
    - ☐ Internet e.g., email, websites, mobile applications
    - ☐ Other
22. What is the effectiveness of these platforms?

	Not effective	Least effective	Effective	Moderately effective	Most effective
Radio					
Television					
Text messages					
Videos					
Print media					
Internet e.g., email, websites, mobile applications					
Radio					
Television					
Text messages					
Other					

<u>Online tools for knowledge management on FAW management</u>

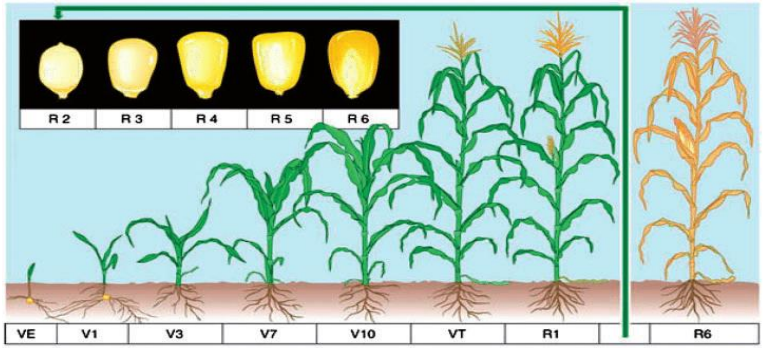
23. How willing are you to use online tools e.g., websites, mobile applications, USSD to exchange knowledge on FAW management?
    - ☐ Not willing
    - ☐ Somewhat willing
    - ☐ Willing
    - ☐ Moderately willing
    - ☐ Very willing
24. On a scale of 1-5, which online tool would you prefer to use as a knowledge exchange platform?

	Unlikely	Least likely	likely	Moderately likely	Most likely
Websites e.g., NAFIS,					
USSD e.g., icow					
Mobile applications e.g., YouTube, icow, ifarmer, KALRO apps					

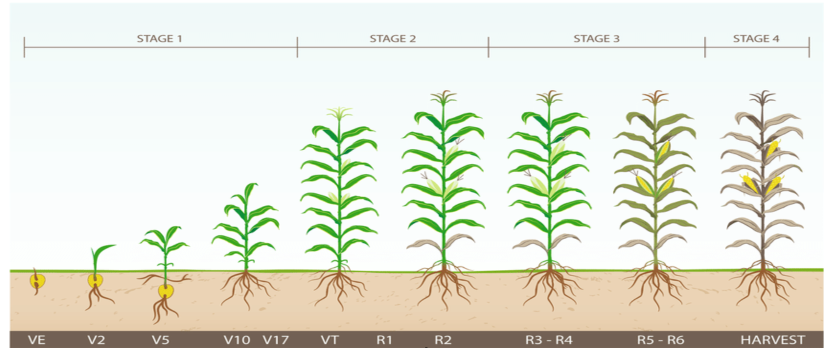
25. On a scale of 1-5, what kind of knowledge on FAW are you likely to exchange using online tools?

	Unlikely	Least likely	likely	Moderately likely	Most likely
FAW identification					
FAW infestation e.g., stage of attack, pre-disposing factors e.t.c.					
FAW destruction level					
FAW control practices					
Effectiveness of FAW control practices					
FAW pesticide resistance and tolerance					
Maize varieties resistant/tolerant to FAW					

Annex 3: Pictorials used during data collection



Maize growth stages



Maize growth stages