THE INFLUENCE OF AGRICULTURAL EXTENSION ON INSECT FARMING FOR FOOD AND FEEDS ON SMALLHOLDER FARMS IN LAKE VICTORIA BASIN, KENYA

BY

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DEDICATION

This thesis is dedicated to my late mother Mrs. Joyce Adera Otieno who played both mother and father figure roles in my upbringing, and supporting my education, my wife Lucy Atieno, my sons Dennis, Brian and Naboth for their patience and moral support throughout my studies.

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Finally, and more importantly I wish to thank intermediary respondents who provided information on qualitative data and my fellow course mates for their input in the entire exercise.

To all I say GOD BLESS YOU!

DECLARATION AND APPROVAL

DECLARATION

I declare that this thesis is my original work and it has not been submitted in this form or any other for the award of a degree, diploma or certificate in this or any other University.

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Signature ………………………... **Date: ………………….**

APPROVAL

This work has been submitted for examination with our approval as Jaramogi Oginga Odinga University of Science and Technology supervisors.

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ABSTRACT

The study investigated the effects of agricultural extension on edible insect farming for food and feeds nutritional security among smallholder farmers in the Lake Basin Region, Kenya. The Kenyan Lake Victoria Basin presents challenges in providing sustainable food and feed sources for smallholder farmers. Insect farming has emerged as a promising solution due to its nutritional benefits and eco-friendly nature. However, there's a notable lack of comprehensive understanding regarding the influence of agricultural extension services on the adoption and success of insect farming in this specific region. Research in this area has not thoroughly investigated the direct impact of agricultural extension services on the promotion and enhancement of insect farming among smallholder farmers. Specifically, the study aimed at determining the influence of agricultural extension on the production of insects as food and feeds, assessed the determinants of adoption of insect farming as a source of nutritious foods and examine the role of agricultural extensions towards value addition of insects among smallholder farmers in the Lake Victoria Basin, Kenya. In so doing, the study probed relevant questions to establish the role of agricultural extension in the promotion of insects for food, sought to identify factors determining adoption of insect farming and the role of agricultural extension in the value addition of insects among food and feed industry players. The study adopted a descriptive survey design since it allows for collection of large amounts of data from the target population. Both primary and secondary data was collected from the respondents which included small holder farmers, extension service providers and stakeholders in the insect food farming and value addition sectors. A sample size of 210 respondents from a population of 443 were interviewed using questionnaires. Additional data was obtained from intermediary respondents through the use of interview guides. The data collected was analysed quantitatively using standard statistical packages to extract various information on critical aspects namely household characteristics, insect food and feed technology within households, status of food and nutritional security, status of livelihoods and challenges to improvement of food and feed nutritional security and general livelihoods. Regression analysis was run to estimate the relationships between value addition as the dependent variable and mechanization of the insect farms, rearing methods, pest and disease management, breeding technologies, marketing, consumption and other forms of utilization, credit acquisition and management and finally climate change and its effects. The study revealed that an increase in agricultural extension services correlates with a substantial rise in the promotion of insect farming, statistical findings also showcased the substantial impact of agricultural extension services on the adoption rate of insect farming, emphasizing the necessity of these services in enhancing adoption.

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LIST OF ABBREVIATIONS AND ACRONYMS

AES	Agricultural Extension Services
AEZ	Agro Ecological Zones
AIDS	Acquired Immuno Deficiency Syndrome
ANOVA	Analysis of variances
FAO	Food and Agriculture Organization
FFSM	Farmer Field School Model
GMOs	Genetically Modified Organisms
HIV	Human Immune Virus
IV	Instrumental Variable
JOOUST	Jaramogi Oginga Odinga University of Science and technology
KALRO	Kenya Agricultural and Livestock Research Organization
KEPHIS	Kenya Plant Health Inspectorate Service
KPIs	Key Performance Indicators
PEM	Participatory Extension Model
PEM	Protein Energy Malnutrition
SDG	Sustainable Development Goals
TTM	Technology Transfer Model

CHAPTER ONE

INTRODUCTION

1.1 Background Information

1.0.1. Insect Farming for Food and Feeds and Extension Services.

Insect farming is one of the areas that has gained significant interest in the recent years particularly in as far as eradicating poverty is concerned (Matthew et al., 2019). The rearing of insects for both feed and food purposes plays a crucial role in the dual objectives of ensuring food security and promoting sustainable living. Forecasting into 2030, the practice of insect farming for food and feed was anticipated to contribute significantly to the attainment of the Sustainable Development Goals (SDG) as outlined by the Department of Economic and Social Affairs in 2016 (DESA, 2016). This contribution is particularly relevant to several specific SDGs, including SDG 2, which seeks to achieve food security, eliminate hunger, enhance nutrition, and promote sustainable agriculture. Furthermore, it aligns with SDG 12, aiming to establish sustainable consumption and production patterns, as well as SDG 13, which addresses issues such as land degradation, forest management, desertification, biodiversity loss, and the urgent need to address climate change and its consequences. Additionally, the impact of insect farming for food and feed resonates with SDG 15, which focuses on ensuring the sustainable management and utilization of terrestrial ecosystems (Hengeveld et al., 2018). The imperative arising from these SDGs underscores the responsibility of all stakeholders involved to employ every available means to safeguard both food and national security, thereby giving rise to the emergence and growing significance of insect farming in this context.

According to Folaranmi (2012), a significant number of people lack access to healthy food because they are living below the international poverty line, which causes undernourishment, particularly protein-energy malnutrition (PEM), throughout Latin America, Asia, and Africa. In addition, trends foresee a continuous rise in population to 9 billion by 2050, which would raise the demand for food and feed from existing agro-ecosystems and put even more strain on the environment (FAO, 2017). Genetic selection, intensive agricultural practices, and most recently, the creation of genetically modified organisms (GMOs) have all improved food production systems (Belluco et al. 2013). Despite these improvements, alternative food sources — particularly protein sources are still required for a secure future food system. In

several low-income African and Asian countries, edible insects already have high market values that are occasionally comparable to or even higher than those of traditional livestock. Therefore, insects are a commodity with a market (McGill, 2016). Utilizing insects for food and nutrition is consistent with the sustainable diet context for food and nutritional security (Kelemu et al. 2015; Van Huis et al. 2013). Eaten insect species range from ants to beetle larvae consumed by tribes as part of their subsistence meals in Africa and Australia to the popular fried locusts and beetles consumed in Thailand. Despite the fact that some small insects are a major source of food and nutritional security, very little, if any, has been done towards farming them.
The fact that one third of the World's population eats insects, a practice that it is not only related to poverty, has resulted into interests within Europe and North America to come up with related industries (Dossey, Morales-Ramos, & Rojas, 2016). Edible insects can be obtained in three ways, namely, wild harvesting, semi-domestication (habitat manipulation to increase population), and farming, which ranges from single small cage to large factory (Yen, 2015). Insects can be reared on land that is unusable for other activities and in side streams or waste that provide sufficient nutrients. Insect farming uses very little water, because of both low water needs for feed production and many insect species do not need to drink water because the moisture in their feed provides enough. This means that farming insects should not only be easy but also highly beneficial. The dissemination of new information and technology to farmers and other end users is greatly aided through advisory services, community outreach, and extension programs.

The national governments and international development organizations have funded and executed a wide range of extension models and initiatives during the past 6 decades (Devaux et al., 2018). These programs' makeup has varied from country to country. These programs are still developing (Jayne et al., 2019). Many of these projects have been effective and had a significant influence on improving rural populations' livelihoods and agricultural output. The mopane worm has an animal trade value of more than $85 million alone in Southern Africa. The caterpillars' habitat encompasses around 384,000 km2 of forest in Angola, Botswana, Mozambique, Namibia, South Africa, Zambia, and Zimbabwe, where the mopane woodlands are endemic (Ndlovu et al., 2021). In Southern Africa, an estimated 9.5 billion mopane caterpillars are harvested each year. While Raheem et al. (2019)

recorded 23 edible species from the Bas-Congo, a western province of the Democratic Republic of Congo, Ebenebe et al. (2020) discovered 38 distinct species of caterpillar across the Democratic Republic of the Congo, Zambia, and Zimbabwe. There are, evidences, albeit, few that support the feasibility of rearing edible insects for food and nutritional security.

As a result, only a few attempts have been made to quantify the rates of return on adoption and sustainability in an agricultural context, particularly using an instrumental method. Cawley and Meyerhoefer (2012) used instruments in their investigation of the impact of obesity on medical expenses and concluded that earlier estimates severely underestimated the costs by 418% on average, compared to the IV method. Similarly, Danso-Abbeam et al. (2018) found that after instrumental variables were controlled for the four estimate biases, education had a greater influence on income. In an agricultural context, Nakano et al. (2018) revealed a 15% stronger positive relationship between extension and crop production value while also addressing endogeneity through fixed effects and observable ability. According to Mohanty et al (2020), agricultural extension has undergone a significant transformation as a result of the failure of public extension systems that were deemed outdated in the context of the information technology revolution, decentralization, and globalization. In many developing countries, extension systems are undergoing a paradigm change toward more farmer-focused approaches based on rural innovation that place an emphasis on the value of mutual learning that is interactive, integrative, and interdisciplinary across formal and informal knowledge systems (El Bilali, 2019). The extension system foresees a shift from technology-driven to market-driven extension in the present, where smallholder farmers would place an emphasis on the commercialization of insect farming for food and feed (Obiero et al., 2019).

Farmers’ ability to voice their desires for agricultural innovation has been aided by the decentralization of agricultural extension services in Kenya from the national to local governments (Kigatiira, Mberia & Wangula, 2018). However, Kenya's extension services, which are driven by community-based Common Interest Groups, have a lot to be desired. It would be challenging and impossible for the farmers to completely understand their true needs unless they had access to sufficient and high-quality information, which also means being able to find information and/or knowledge, analyse it, and apply it for future innovative knowledge creation. This is because most existing extension systems have largely targeted large scale or purely commercial farmers. (Town &Tranter, 2013). The role of extension in the development of insect food and feed technology as an alternative source of protein cannot be ignored. The nature of farming is evolving on a global scale. Agriculture is evolving from a production-driven industry to one that is market-driven. To keep the growers informed about the technologies available for increasing productivity and income from farming, effective use of other extension methods, including group/mass contact methods, need-based training programs, demonstrations of proven technologies with active participation from farmers, and more are required. It is therefore important to review the application of various innovative extension approaches for purposes of generating knowledge on its influence on edible insect farming for food and feed nutritional security among small holder farmers.

1.0.2. Insect Farming in Kenyan Lake Basin Region

Notably, the Lake Victoria Basin of Kenya is located along the Kenyan Equator between the latitudes of 0°20´N-3°S and longitudes 31°39´E–34°53´W with an average elevation of 1134 meters above sea level. Lake Victoria basin is the areas neighbouring the lake in the Kenyan side. The basin experiences mean annual evaporation rates of 1100mm-2400 mm, making the water balance of the lake to be primarily characterized by precipitation and evaporation. The area has witnessed reasonable degree of depletion of resources from within the lake and its surrounding environs, which is against the spirit of sustainability as provided for by the UN in the SDG's. Seeking alternative sources of protein is deemed appropriate through use of insect farming technology which will go a long way in reducing the pressure on the lake and its resources (Devaux et al., 2018). The Lake Victoria Basin in Kenya faces significant challenges in ensuring sustainable food and feed sources for smallholder farmers. In recent years, the exploration of insect farming for food and feed has gained significant attention globally due to its potential as a sustainable and nutritious source of protein. Agricultural extension services, traditionally aimed at providing knowledge and resources to improve agricultural practices, play a crucial role in introducing and disseminating innovative techniques among small-scale farmers (Hengeveld et al., 2018). However, there exists a notable gap in understanding the direct impact of agricultural extension services on the production and utilization of insects for food and feed among small-scale farmers in this region. While agricultural extension services are available, their specific role in supporting and enhancing insect farming remains largely unexplored.

One critical area where research gaps exist is the extent of the influence of agricultural extension services on insect farming. Understanding the depth of this impact is crucial to leverage the full potential of these services in supporting and promoting insect farming among smallholder farmers in the Lake Victoria Basin (Manyara, 2018). Furthermore, little research delves into the role of agricultural extension services in the value addition and processing techniques for insects used as food and feed. Enhancing the value of insects through processing and transformation is vital, and the educative role of extension services in these techniques remained under-researched (Belluco et al. 2013). Another area of concern was lack of comprehensive understanding of the factors that drove or inhibited the adoption of insect farming as a source of nutritious food and feed among smallholder farmers in the region. Investigating these determinants is crucial in designing effective strategies to encourage the adoption of insect farming (McGill, 2016). In addition, while there is a growing interest in insect farming, studies focusing on the specific context of the Lake Victoria Basin are scarce. Therefore, this study aims to fill these gaps in literature by examining the direct influence of agricultural extension services on insect farming for food and feed production in this particular region. Understanding the influence and potential of agricultural extension services in the context of insect farming is pivotal for creating tailored interventions and policies to promote sustainable and nutritious food and feed sources among smallholder farmers in the Kenyan Lake Victoria Basin. This research endeavours to provide valuable insights into the role of agricultural extension in fostering insect farming as viable.

1.2. Statement of the Problem

The Kenyan Lake Victoria Basin presents challenges in providing sustainable food and feed sources for smallholder farmers. Insect farming has emerged as a promising solution due to its nutritional benefits and eco-friendly nature. However, there’s a notable lack of comprehensive understanding regarding the influence of agricultural extension services on the adoption and success of insect farming in this specific region (Siddiqui and Mirani, 2012). Research in this area has not thoroughly investigated the direct impact of agricultural extension services on the promotion and enhancement of insect farming among smallholder farmers (Nogueira, 2019).

Understanding the depth and nature of this impact is crucial to effectively leverage these services for promoting insect farming in the Lake Victoria Basin.

Of the many studies carried out on agricultural extension, the main concern has been the academic structure of the extension education (Azadi *et. al*., 2019), and the organizational structure of the extension agencies (Nogueira, 2019). Some of the studies have also covered private extension services (Riaz, 2014; Mengal *et al*., 2012; Siddiqui and Mirani, 2012). There is however no explicit study has been undertaken to find out the extent of accessibility to extension services on edible insects by farmers find the extension services useful in the farming of insects as food or feed (Riaz, 2014). While the actual impact of extension services is determined by the level of use of knowledge and technology resulting from farmers' perceptions of the usefulness of the services, no study has yet been conducted to establish such usage and its determinants (Siddiqui & Mirani, 2012). The study aimed at providing empirical evidence on the effects of agricultural extension on insect framing for food and feeds. Moreover, the role of agricultural extension in adding value to insect products for food and feed purposes has received limited attention (Mengal *et. al*., 2012). There's a significant gap in understanding how extension services facilitate the processing and transformation of insects into viable food and feed products for smallholder farmers in this region.

Another critical gap in knowledge lies in understanding the determinants influencing the adoption or reluctance to adopt insect farming among smallholder farmers in the Kenyan Lake Victoria Basin. Without a comprehensive understanding of these factors, it is challenging to develop strategies that would encourage widespread adoption of insect farming practices (Azadi *et. al*., 2019). Additionally, while insect farming has gained global attention, there was a lack of specific research focusing on the Lake Victoria Basin. The unique socio-economic, cultural, and environmental characteristics of this region necessitated a targeted investigation to comprehend how agricultural extension services could effectively support and promote insect farming among smallholder farmers (Nogueira, 2019). The collective absence of comprehensive research in these areas underscores the critical gap in knowledge regarding the influence of agricultural extension services on insect farming for food and feed production among smallholder farmers in the Kenyan Lake Victoria Basin. Bridging these gaps would be essential for designing tailored and effective strategies that could maximize the potential of agricultural extension services in promoting sustainable and nutritious food and feed sources for the region's smallholder farmers.

1.3. General Objective

The general objective of this study was to assess the effects of agricultural extension on edible insect farming for food and feed nutritional security among smallholder farmers.

1.3.1. Specific Objectives

1. To determine the effects of agricultural extension on the promotion of insects as food and feeds among small-scale farmers.
2. To investigate the role of agricultural extension towards value addition of insects for food and feeds among small-scale farmers.
3. To assess the determinants of adoption of insect farming as source of nutritious food and feeds among small holder farmers.

1.4. Research Questions

The study adopted the following research questions:

1. What is the role of agricultural extension in the promotion of insects for food and feeds among small-holder farmers?
2. What is the role of agricultural extension in the value addition of insects among food and feed industry players?
3. What factors determine adoption of insect farming for food and feed among small holder farmers?

1.5. Significance of the Study

The study is expected to generate crucial knowledge and information to various stakeholders and players in the agricultural sector. Key among them is the county government and by extension the National Government Ministry of Agriculture. Several Ministries and organizations concerned with promotion of new technologies would also benefit from the study. The fore mentioned government departments would use the findings to scale up the rate of adoption of various technologies. Learning and research institutions from Kenya and beyond would also benefit from the findings of the study as the research topic (Food and nutrition security) is among the most current contemporary issues. The institutions would benefit by using the findings to advance knowledge and training on use of innovative extension approaches. The general public is also expected to benefit on new methods of fostering and improving extension service delivery would be discovered or the existing ones strengthened. In particular, there is need for gaining more insight in developing and improving the framework for information flow back and forth, establishing and strengthening partnerships, collaborations and more so put emphasis on realizing the desired level of satisfaction and enhanced rate of adoption of the insect food and feed technology. Above all, the study is expected to add to the existing body of knowledge in innovative approaches in extension service delivery as a measure towards enhanced rate of technology adoption, refinement and sustainability

1.6. Scope of the Study

The study focused on the use of different extension approaches in the development and adoption of the value chains in the insect food and feed technology and its role in the rate of technology uptake. The study was expected to take a review of extension methodologies of sampled insect food value chains development in the last 5 years and the impact the aspect of innovation has had in their adoption by small holder farmers. In particular, the study focused on reviewing the existing extension approaches, the use of more farmer participatory innovative approaches and the use of multimedia to enhance effectiveness extension on spurring technology uptake. Various stake holders and institutions (state and non-state) were contacted for information on the meant to help examine the variables. The area of study included the counties of Busia, Siaya, Kisumu, Homabay and Migori. The institutions also included Universities carrying out research on insect farming and extension service providers both within and without government.

1.7. Limitations of the Study

The anticipated limitations of the study include:

1. Unavailability of reports and /or busy respondents. In these cases, the researcher made prior arrangements such as flexible time schedules to accommodate highly busy respondents.
2. Exceptional circumstances, such as harsh weather and geographical terrain. In the event of an emergency, reliable transportation plans were arranged, as well as networking with the local security apparatus.

3. Unexpected financial constraints due to the need for intensified search for respondents in the area lacking well developed official structures. Recruitment of key volunteer agents and informers was done to mitigate this risk.

1.8. Assumptions of the Study

The study adopted the following assumptions;

1. That the respondents were to be honest and that they were to provide accurate information to the research questions presented.
2. That the data on rate of adoption and extension approaches was provided by the relevant institutions would be genuine and credible.

1.9. Definition of Key Terms

Agricultural Extension: Agricultural extension is also referred to as agricultural advisory services. In practice, extension involves teaching farmers — for this study, smallholders in poor nations – agronomic practices and skills that will help them enhance their productivity, food security, and livelihoods. This includes two key components: the transmission of practical information, such as superior seeds, soil quality, equipment, water management, crop protection, agricultural techniques, and livestock, and the execution of this knowledge on the farm. Syngenta Foundation for Sustainable Agriculture (2019)

Food security: Food Security is "adequate access to food for all people at all times for an active, healthy life" (Bjerregaard *et al*., 2021)

Extension services: Agricultural extension services refers to giving smallholder farmers information, methods and services to improve their output, food security and income (Kassem, Alotaibi, Muddassir, & Herab, 2021).

Insect farming: Means rearing of edible insects, especially where Insects are cultivated in captivity, and each rearing step is controlled (e.g., living conditions, diet, and food quality) (Madau *et al*., 2020)

Nutrition security: Nutrition security encompasses food security, which encompasses nutrient content. A nutrient is a constituent that meets the various needs of the body for its physical and healthy

	functioning, making nutrition security the ultimate goal food security (Ingram, 2020).
Small holder farmer:	Smallholder farmers are generally those cultivating less than 2ha of land, relying mainly on family labour, with limited capital (natural, physical, social, financial, and human), low-input-technology, and having limited access to markets (Kamara *et al*., 2019)
Value addition:	A Value addition is the introduction of new features or economic value to a product or service by a company or venture before offering to the customer. (Nagy *et al*., 2018)
Adoption:	This refers to the process of accepting, integrating and using emerging methods, techniques and practices in the agricultural society. Moreso emerging technological innovations that tend to improve production, provide efficiency of services within the agricultural sector (Rehman, Jingdong, Khatoon, Hussain, & Iqbal, 2016).

CHAPTER TWO

LITERATURE REVIEW

2.0. Introduction

The chapter reviews literature pertinent to the research objectives. A number of published works are reviewed in order to understand the past research in the subject matter and enriching understanding of the research objectives, refining methodology and assisting in the interpretation and understanding of the data collected. This chapter provides an overview of agricultural extension and its application on the edible insect farming among the small holder farmers and the key dimension in technology adaptation efforts mainly focused on past researches already undertaken and their relevance to this particular study. The study purposefully reviewed relevant studies on the influence of extension on edible insect farming in order to identify gaps (gaps in scientific knowledge and also in policy implementation strategies) that are addressed by this study.

2.1. Theoretical Framework

Two theories, the adoption and diffusion theories and the farmer participation framework, served as this study's theoretical framework. Adoption and diffusion theory will be the major theory of the study

2.1.0. Adoption and Diffusion Theory

According to Gregor and Jones (1999), diffusion theory examines the process by which innovations are adopted over time or how they are disseminated through time among members of a social system via specific channels (Apperson and Wikstrom, 1997). It was conceived when the social sciences first emerged in Europe in the early 20th century, it was initially focused on people as decision-makers; but, by the early 1960s, research on organizations as units of adoption and also embracing fields like political sciences (Apperson and Wikstrom, 1997). However, it wasn't until the middle of the 1960s that diffusion theory was applied to the study of consumer behavior. Diffusion theory has its roots in rural sociology, geography, medical psychology, cultural anthropology, and industrial economics (Gatignon and Robertson, 1985).

Diffusion of innovations is a theory that seeks to explain how, why, and at what rate new ideas and technology spread. The theory was popularized by Everett Rogers in his book Diffusion of Innovations, first published in 1962. Rogers argues that diffusion is the process by which an innovation is communicated over time among the participants in a social system. The origins of the diffusion of innovations theory are varied and span multiple disciplines.

Rogers proposes that five main elements influence the spread of a new idea: the innovation itself, adopters, communication channels, time, and a social system. This process relies heavily on social capital. The innovation must be widely adopted in order to self-sustain. Within the rate of adoption, there is a point at which an innovation reaches critical mass. In 1989, management consultants working at the consulting firm Regis Mckenna Inc. theorized that this point lies at the boundary between the early adopters and the early majority. This gap between niche appeal and mass (self-sustained) adoption was originally labeled "the marketing chasm"

The categories of adopters are innovators, early adopters, early majority, late majority, and laggards. Diffusion manifests itself in different ways and is highly subject to the type of adopters and innovation-decision process. The criterion for the adopter categorization is innovativeness, defined as the degree to which an individual adopts a new idea.

Figure1: Degrees to which an individual adopts a new idea.

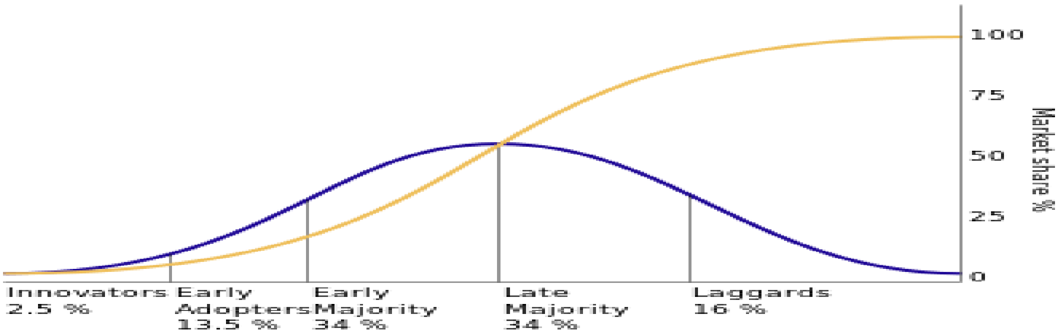


Figure 1: *Degree of Adoption to New Ideas*

Innovation, communication channels, time, and the social system are the four core components of diffusion theory, as initially applied by Rogers to the study of consumer behaviour (Mahajan et al, 1990). To forecast first-purchase sales of new items, diffusion models analyse the evolution of a life cycle curve (Mahajan et al, 1990). Interpersonal and mass media are both used as communication mediums. While interpersonal comjunication affect the speed and type of the diffusion process over time, external communications affect early innovators or adopters (Mahajan et al, 1990).

As a result, the focus of diffusion is on interpersonal communications within social systems over time as it relates to the dissemination of innovations (Gatignon & Robertson, 1985), and it highlights that the social system's norms and beliefs must be addressed in any diffusion process of innovation (Gregor and Jones, 1999). Since not all prospective adopters in a social system accept a new product at the same time, adopters can be categorised based on when they adopt the product. These categories are important because they can aid in the targeting of new prospects for a new product, the development of marketing strategies to penetrate the various adopter categories, and the prediction of a new product's continued acceptance or rejection (Mahajan et al, 1990). Rogers' approach of classifying adopters consisted of distributing the categories on a bell-shaped curve using basic statistical parameters of normal distribution. As a result, he found five adopter categories: innovators, who account for 2.5% of the schema; early adopters, who account for 13.5% of the category; early majority, who account for 34%; late majority, who account for another 34%; and laggards, who account for 16% of the classification (Mahajan, Muller and Srivastava, 1990). In the agricultural sector, the government provides farmers with better farming techniques, experience, enhanced skills, and loans for farm inputs in order to promote food security in the country through extension services, field exhibits, agricultural fairs, and credit facilities.

The study is anchored on the diffusion theory. Proposed and developed by Roling (1988), diffusion theory posits that agricultural extension mission is to increase agricultural production as well as productivity through the idea of transferring knowledge and information. Diffusion theory also provides that agricultural extension services are aimed at offering technical and economic pieces of advice, which would go a long way in improving production and productivity. Nonetheless, it should be noted that agricultural extension as a professional practice continues to change. Despite the fact that diffusion theory is limited in scope, that is, the theory looks at agricultural extension as activities aimed at increasing production that may result into unsustainable practices, it is an effective foundation and premise for examining how the use of agricultural extension would promote farming of edible insects. There have been extensions of the diffusion theory to include ecological modernization and the de-modernization theories. These theories still emanate from the diffusion theory. Therefore, the study other than explaining and using the ecological modernization and de-modernization theories focused mainly on the diffusion theory to explain how agricultural extension services could be used to diffuse knowledge, information, technical, and economic advice that would promote farming of edible insects around the Lake Victoria Basin Region.

2.1.1. Farmer Participatory Framework

Farrington and Martin (1987) coined the term Farmer Participatory Framework (FPF) after traditional top-down, prescriptive approaches to agricultural research and extension were heavily criticized for low uptake of agricultural technologies and frequently, the development of technologies that are inappropriate to farmer needs and socioeconomic and agro-ecological environments. Researchers are switching to farmer participatory research methods as a result of rising discontent with this "technology transfer" strategy. The foundation of the Farmer Participatory Framework is the idea that farmers are independent researchers who have first-hand knowledge of the conditions in their region (Chambers *et al*., 1989). In the context of development, a participatory framework is a process in which a group or community identifies a challenge or subject of interest, assesses what is known about it, conducts research on it, analyzes the information gathered, make conclusions, and implements solutions (Selener 1997). The center of decision-making in this concept is implicitly within the group or community concerned. Approaches to participatory research have been developed and utilized in four primary areas: (1) community development, (2) action research, with the most notable being: iteration or repeated cycling of reflection and action; the breakdown of subject-object polarity; the rejection of passive knowledge banking in favour of active knowledge acquisition and generation through participation in research and analysis, and application of the results; and external actors facilitating the development of critical consciousness. This research sought to ascertain how farmers in Kenya's Lake Victoria basin received training and assistance from extension officers and other agricultural extension personnel in order to improve their food security. According to the theory, the amount of engagement of farmers at each step of implementation will determine the rate of technological diffusion. Farmers' failure to participate meant that the problem of food insecurity in Kenya's Lake Victoria basin would endure.

2.2. Theoretical Concepts under investigation

2.2.1. Concept and Models of Agricultural Extension

Ever since its emergence in the classical period, agricultural extension has attracted interests among scholars and practitioners alike (Feller, 2019). Notably, agricultural extension, a cornerstone of the agricultural sector, encompasses a myriad of concepts and models critical for disseminating knowledge, fostering technological advancements, and supporting farmers in adopting innovative practices (Koutsouris, 2018). The primary objective of agricultural extension services is to bridge the gap between scientific knowledge, research findings, and practical applications in farming, thereby improving agricultural productivity, sustainability, and the livelihoods of farmers (McFall & McKelvey, 1989). Another important aspect to note is that the concept of agricultural extension revolves around the transfer of information, skills, and technologies from research institutions, agricultural experts, or extension workers to the farming community (Altal *et al,* 2015). It acts as a conduit, facilitating the delivery and adoption of improved farming practices, technologies, and methods, ultimately aiding in the development and advancement of agriculture.

For a better understanding of agricultural extension, several models exist within agricultural extension, each offering unique approaches to disseminating information and supporting farmers in their endeavours (Taylor & Bhasme, 2018). These models vary in their methods of delivery, level of farmer participation, and the nature of information conveyed. One of the commonly used models is the Technology Transfer Model (TTM) (Koutsouris, 2018). As one of the prominent approaches in agricultural extension, TTM is a model primarily focuses on the dissemination of technical information and innovations directly to farmers (Taylor & Bhasme, 2018). It involves various methods such as workshops, training sessions, demonstrations, and information sharing through extension workers. The emphasis is on imparting specific technological practices and innovative approaches to the farming community (Feller, 2019). Another model that also offers a better understanding of the concept of agricultural extension is the Farmer Field School Model (FFSM). In contrast to the TTM, the FFSM takes a participatory and experiential learning approach (Simpson & Owens, 2002; Anandajayasekeram *et al*, 2007). This model emphasizes learning by doing, with farmers engaging in problem-solving and learning from their own field experiences (Bajwa *et al*, 2010; Feder *et al*, 2004). It is typically conducted in a group setting, allowing farmers to experiment and apply sustainable agricultural practices in their fields.

Another model that is also useful in the implementation and exercising of agricultural extension is that of Participatory Extension Model (PEM). The PEM involves farmers as active participants in the decision-making process (Bernet *et al*, 1999; Kaur & Kaur, 2018). This model values local knowledge, traditions, and practices, incorporating them into the extension services (Murray, 2000). It emphasizes a collaborative and participatory approach to development, allowing farmers to contribute their insights and expertise (Belay, 2003; Bernet *et al.*, 2001; and Gandhi *et al*, 2007). Another significant model is the Training and Visit System (TVS), which involves regular visits by extension agents to farmers' fields (Benor & Cleaver, 1989). This model focuses on providing personalized guidance, training, and troubleshooting on a one-to-one basis. Extension agents visit farms regularly, offering direct assistance and support tailored to the individual needs of each farmer (Jalvi, 1981). Notably, the choice of a specific model often depends on several factors, including the needs of the local farming community, available resources, the technological level of the community, the region's agricultural landscape, and the desired level of farmer engagement in the extension process.

Modern agricultural extension has evolved to address not only the technical aspects but also broader socio-economic considerations (Benson & Jafry, 2013). It emphasizes empowering farmers, enabling them to become active decision-makers in their farming practices. This shift involves capacity building, enabling farmers to make informed choices, adapt practices, and make decisions that suit their specific contexts (Birkhaeuser *et al*, 1991). This evolution in agricultural extension services includes considerations of market dynamics, sustainable agricultural practices, environmental conservation, and the promotion of responsible farming methods (Belay, 2003). Extension services are now more comprehensive and holistic, aiming to address not just technical improvements but also social, economic, and environmental aspects of agriculture (Adefalu *et al.*, 2023). The diversity in extension concepts and models reflects the evolving nature of agriculture and the need for adaptable, context-specific approaches to support farmers in their pursuit of improved productivity, profitability, and sustainability (Zivkovic *et al.*, 2009). It is imperative to tailor extension services to suit the diverse needs and circumstances of different farming communities and regions, ensuring that they contribute effectively to the sustainable development of agriculture.

Moreover, the agricultural extension landscape is continually evolving, influenced by technological advancements, changing market dynamics, and environmental considerations (Altalb *et al.*, 2015). Emerging technologies and digital tools have the potential to revolutionize extension services, making information more accessible and improving the outreach to a larger number of farmers (Belay & Abebaw, 2004). Mobile applications, online resources, and digital platforms are increasingly becoming integral parts of modern agricultural extension services, facilitating knowledge sharing and enhancing communication between farmers and experts (Rezaei-Moghaddam & Karami, 2008). The role of extension services is not confined solely to the transfer of information; it extends to the facilitation of training, guidance on best practices, and support for farmers (Khodamoradi & Abedi, 2011). These services aim to improve the overall farming practices, increase crop yield, enhance livestock management, and promote sustainable farming methods. Sustainability has become a pivotal focus in the contemporary agricultural extension paradigm (Zivkovic *et al*, 2009). As agriculture grapples with the challenges posed by climate change, soil degradation, and the need for resource efficiency, extension services play a crucial role in disseminating knowledge and techniques that promote sustainable and environmentally friendly farming practices (Adefalu *et al.*, 2023). Farmers are encouraged to adopt practices that not only enhance productivity but also conserve natural resources, reduce environmental impact, and ensure long-term agricultural viability.

Critically, the concept and models of agricultural extension serve as the bridge between the ever-evolving scientific advancements in agriculture and their practical application on the ground. These models continue to adapt and transform, aiming to address the current challenges faced by the agricultural sector and respond effectively to the dynamic needs of farmers. In conclusion, agricultural extension remains a fundamental pillar in the agricultural landscape, playing a pivotal role in facilitating the transfer of knowledge, technology, and best practices to the farming community. The diverse models and evolving concepts of agricultural extension services aim to support farmers in adopting improved and sustainable farming practices, fostering increased productivity, better livelihoods, and a more resilient agricultural sector.

2.2.2. Concept and Indicators of Food and Nutritional Security

Food and nutritional security are a cornerstone of societal welfare, encompassing various dimensions essential for individuals to access adequate, safe, and nutritious food (Lele *et al*, 2016). This concept revolves around ensuring consistent access to food that meets dietary needs, fostering the ability of individuals and communities to lead healthy and productive lives (Gross *et al*, 2000). Availability, the first dimension of food and nutritional security, ensures there are adequate food supplies available, whether produced locally or obtained through trade or aid, to fulfil dietary needs (Weingärtner, 2009). This aspect is crucial to sustaining populations and preventing hunger and malnutrition. It involves assessing the quantity of food available in a particular region and understanding its sources, whether it be through local production, trade, or food aid programs (Haddad *et al*, 1994). Availability of food resources stands as a fundamental pillar in ensuring the sustenance and well-being of communities. This dimension of food and nutritional security is essential in safeguarding against hunger and malnutrition, vital to fostering thriving and healthy populations (Pinstrup-Andersen, 2009). It involves an intricate assessment of the quantity, sources, and distribution of food supplies within a particular region.

Local production is a cornerstone of food availability, acting as a primary source for many communities (Gustafson *et al*, 2016). The assessment of food availability involves evaluating local agricultural productivity, understanding the types of crops grown, livestock reared, and fisheries cultivated within a region (Arnés *et al*, 2019). This assessment can provide insights into the adequacy of local food production in meeting the dietary needs of the population. Additionally, it evaluates the sustainability of agricultural practices and the diversity of food sources, crucial for ensuring a balanced and nutritious diet (Coates, 2013). Moreover, understanding trade dynamics contributes significantly to food availability. Trade, whether between regions or across borders, supplements local production by ensuring a diverse range of food products reaches communities (Berry *et al*, 2015). Assessing the volume and variety of food imports and exports provides insights into the capacity of a region to access food resources beyond what is locally produced (Pritchard, 2016). This dimension is particularly crucial in regions with limitations in local food production due to factors such as climate, land constraints, or other environmental conditions (Simelane & Worth, 2020). Food aid programs play a significant role in supplementing local production and trade to ensure food availability, especially in regions facing food shortages due to various crises, such as natural disasters, conflicts, or economic instability (Gross, 2002). The assessment of food aid programs involves understanding the types and volumes of aid received, the efficiency of distribution, and the coverage of populations in need (Carletto *et al*, 2013). This dimension is critical in times of crisis when immediate and sustained access to food is essential to prevent hunger and malnutrition.

Assessing the quantity and sources of available food in a region allows policymakers, humanitarian organizations, and governments to understand the vulnerabilities and strengths of the food system (Radhakrishna & Reddy, 2004). It aids in identifying areas that require support, be it in enhancing local agricultural production, improving trade relationships, or providing assistance in times of crises (Zurek *et al*, 2018). Moreover, it assists in designing policies and interventions aimed at promoting sustainable food production and ensuring consistent and adequate access to food resources for all individuals within a region (Kalkuhl *et al*, 2013). The dimension of availability in food and nutritional security revolves around understanding the sources, diversity, and quantity of food supplies within a region. It encompasses local production, trade dynamics, and food aid programs, vital in ensuring sustained access to food resources, thereby preventing hunger and malnutrition (Ardakani *et al.*, 2017). Understanding the nuances of food availability assists in crafting effective strategies to bolster local production, enhance trade relationships, and ensure prompt and efficient aid delivery in times of need.

Access, the second dimension, focuses on the economic and physical ability of individuals to acquire food (El Bilali *et al*, 2019). Economic access considers factors such as income levels, poverty rates, and food prices, determining whether individuals or communities have the resources necessary to acquire sufficient food (Béné *et al*, 2016). Physical access evaluates the availability and proximity of food outlets and markets, ensuring that individuals have access to these sources. Utilization is the third critical dimension, which emphasizes the quality, safety, and adequacy of food intake, ensuring proper nutrition (Ardakani *et al*, 2017). Utilization involves ensuring that the food consumed meets nutritional requirements, considering dietary diversity, nutrient content, and food safety. It's not only about having access to food but also consuming a balanced, nutritious diet. Stability is the fourth dimension, ensuring consistent access to food over time, preventing shocks or disruptions that could threaten food security (Kalkuhl *et al*, 2013). Stability measures the resilience of food systems against potential risks, ensuring a consistent food supply even in times of crises, such as natural disasters, economic downturns, or conflicts.

Indicators are significant tools used to assess and measure food and nutritional security across these dimensions (Carletto *et al*, 2013). These indicators help policymakers and organizations identify areas that need improvement and implement strategies to ensure adequate and sustainable access to nutritious food for all individuals and communities (Simelane & Worth, 2020). The significance of food and nutritional security cannot be overstated. Insufficient access to nutritious food can result in malnutrition, impacting health, development, and overall well-being. Vulnerable populations, such as children and pregnant women, are especially at risk (Gross *et al*, 2000). Moreover, food insecurity can lead to economic and social instability, hindering human development and productivity. The COVID-19 pandemic has accentuated the vulnerabilities in global food systems (Simelane & Worth, 2020). Disruptions in supply chains and economic downturns have severely affected food access, particularly in vulnerable communities and among low-income populations (El Bilali *et al*, 2019). Addressing food insecurity demands robust policy measures and interventions. Strategies to enhance agricultural productivity, improve market access, and ensure equitable distribution of food resources are imperative.

Innovative solutions leveraging technology and modern agricultural practices play a significant role in addressing food insecurity (Ardakani *et al*, 2017). Precision agriculture, climate-resilient crops, efficient irrigation systems, and digital technologies can enhance food production and access to information in the agricultural sector (Zurek *et al*, 2018). Societies must aim to achieve food and nutritional security, aligning with sustainable development goals such as zero hunger and good health and well-being (Simelane & Worth, 2020). By addressing food insecurity, communities can make substantial strides toward ending poverty, promoting economic growth, and fostering a healthier, more resilient future (Arnés *et al*, 2019). In conclusion, food and nutritional security, encompassing the dimensions of availability, access, utilization, and stability, are crucial for ensuring a sustainable and equitable food system. Effective policy measures, collaborative efforts, innovative solutions, and a comprehensive approach are pivotal in addressing the multifaceted challenges of food insecurity and in fostering a healthier and more resilient future for all individuals and communities.

2.2.3. Insect Farming/Production Systems

Insect farming or production system has, in the recent past, experienced significant growth across the globe (Wu *et al*, 2023). Generally, insect farming or production systems represent an emerging and innovative approach to addressing various global challenges, including food security, environmental sustainability, and economic development (Alemu *et al*, 2023). In recent years, the interest in insect farming has grown significantly, primarily due to its potential as a sustainable and efficient source of food and feed (Specht *et al*, 2019). Insects, such as crickets, mealworms, and black soldier flies, are rich in protein, essential amino acids, and various micronutrients (Chaalala *et al*, 2018). As such, they offer a promising solution to global food insecurity, especially in regions where traditional protein sources are scarce (Grabowski *et al*, 2022). One of the primary advantages of insect farming is its high efficiency in resource utilization. Insects, compared to traditional livestock like cattle, require substantially fewer resources in terms of feed, water, and space (Matandirotya *et al*, 2022). For instance, crickets need significantly less feed to produce the same amount of protein as cattle or pigs. Moreover, they can thrive on organic waste, presenting an opportunity for sustainable waste management and converting organic by-products into valuable protein sources.

The methodologies of insect farming and production systems vary but generally involve controlled environments for breeding, rearing, and processing insects (Corrado *et al*, 2019). Common methods include the use of climate-controlled environments to regulate temperature, humidity, and lighting, ensuring optimal conditions for insect growth (Gamborg *et al*, 2018). Additionally, specific diets or feed are provided to the insects to maximize their growth and nutritional content. Insect farming and production systems utilize various methodologies that are adaptable and dependent on the species being farmed, the intended purpose (food, feed, or other applications), and the scale of the operation (Kusch-Brandt, 2020). These systems involve controlled and managed environments specifically tailored to the needs of the insects being reared (Delgado *et al*, 2022). Temperature, humidity, and lighting play pivotal roles in creating ideal conditions for the growth and development of insects. In controlled environments, precise regulation of these factors is essential. For instance, maintaining specific temperature ranges is crucial for the successful breeding and growth of insects. Different species have varied temperature requirements; therefore, climate-controlled environments can be adjusted to suit these diverse needs (Halloran *et al*, 2018). Additionally, regulating humidity is necessary as excessively dry or moist conditions can impact insect development negatively. Maintaining optimal humidity levels ensures a healthy and suitable environment for rearing.

Lighting is another critical factor. Some insects have specific photoperiod requirements for breeding, feeding, or growth (Halloran *et al*, 2018). Mimicking natural light cycles in a controlled environment can help regulate the insects' developmental stages and reproductive patterns (Shah *et al*, 2022). For instance, specific lighting conditions can trigger mating behaviour or stimulate feeding in certain species, enhancing their growth and reproductive rates. The diets or feed provided to insects are carefully formulated to meet their nutritional needs (Brader, 1982). Different species of insects have specific dietary requirements that affect their growth and nutritional content. In some cases, insects are fed organic waste materials, such as agricultural by-products or kitchen scraps, converting what might otherwise be waste into valuable sources of nutrients (Llagostera *et al*, 2019). Formulating balanced and nutritious diets can result in insects with higher protein content and optimal health, making them more beneficial for consumption or use in animal feed (Naik *et al*, 2012).

Additionally, to ensure optimal growth and health, the rearing process might involve various stages, from the initial egg or larvae phase to the adult stage (Weinreis *et al*, 2023). The management of each developmental stage is essential. For instance, providing optimal conditions during the larvae stage can significantly impact the quality and quantity of the resulting insects (Baiano, 2020). Different techniques such as optimal substrate conditions or feeding regimes might be applied at specific life stages to enhance growth and nutritional value (Wu *et al*, 2023). In larger commercial insect production systems, technology plays a significant role. Automated systems, sensors, and advanced machinery are utilized to maintain environmental conditions, monitor growth rates, and optimize processes for mass production (Alemu *et al*, 2023). These technologies allow for precise control and efficient management, reducing manual labour and ensuring consistency in insect quality and quantity. Moreover, the processing of insects also involves specific techniques tailored to the intended use of the insects (Naik *et al*, 2012). Processes such as dehydration, grinding, or extraction of specific components are applied to prepare insects for human consumption or animal feed (Specht *et al*, 2019). These processing methods ensure that the final insect products meet safety standards and are palatable or suitable for the intended application.

In essence, the methodologies in insect farming and production systems revolve around creating and managing controlled environments that cater to the specific needs of the insects being farmed (Llagostera *et al*, 2019). The manipulation of environmental conditions, feed formulation, and technological innovations are all geared towards optimizing growth, nutritional content, and the quality of the final insect products (Wu *et al*, 2023). This intricate process ensures that insects are cultivated sustainably, efficiently, and with the highest nutritional and commercial value possible (Grabowski *et al*, 2022). Insect production systems encompass both small-scale, localized farming setups and larger commercial operations. Small-scale systems often utilize simple setups, such as containers or small enclosures, making them accessible to local communities (Alemu *et al*, 2023). These systems are beneficial in providing a decentralized means of producing protein-rich food and feed, particularly in areas where conventional agriculture is limited (Kusch-Brandt, 2020). On the other hand, larger commercial operations utilize advanced technology and automated systems to mass-produce insects for food and feed (Delgado *et al.*, 2022). These systems require significant capital investment and specialized knowledge but have the potential to cater to larger market demands and contribute to the mainstream food and feed industry.

The utilization of insects as a source of food and feed has gained traction due to the versatile applications of insect-derived products (Chaalala *et al*, 2018). In addition to direct consumption as whole insects or in processed forms, insect-derived protein can be used in animal feed, aquaculture, and even in pet food (Specht *et al.*, 2019). The versatility of insect-derived products offers a broad range of applications and markets, contributing to agricultural and industrial diversification. However, several challenges exist in the widespread adoption of insect farming and production systems (Shah *et al*, 2022). Regulatory frameworks and societal perceptions surrounding the consumption of insects in many culture, present hurdles to their integration into mainstream diets (Kusch-Brandt, 2020). Moreover, there are concerns about the scalability and cost-effectiveness of large-scale insect production systems, as well as the ethical considerations of rearing and harvesting insects. Nonetheless, ongoing research and development in the field of insect farming are addressing these challenges (Halloran *et al*, 2018). Efforts are being made to explore the nutritional benefits of insect-based foods, develop efficient and cost-effective rearing techniques, and create more appealing insect-based food products. As these advancements continue, there's a growing realization of the potential of insects in contributing to sustainable food systems (Alemu *et al*, 2023). In conclusion, insect farming and production systems offered a promising solution to various global food and nutritional security challenges. Their efficient resource utilization, nutritional value, and versatile applications make them an attractive prospect for addressing food security and sustainability concerns. Despite existing challenges, ongoing research and developments signify a growing acceptance and understanding of the potential of insects in contributing to sustainable and diverse food and feed systems.

2.2.4. Insect Farming Value Chains and Value Addition

Within insect farming, there are aspects of value chains in addition to value addition (Berggren *et al*, 2019). Notably, the realm of insect value chains and value addition encompasses a diverse and evolving sector that explores the multifaceted utilization of insects for various purposes, including food, feed, pharmaceuticals, and industrial applications (Roffeis *et al*, 2017). It involves a spectrum of processes and activities, from insect rearing, processing, and distribution to the creation of innovative products. Insect value chains are interconnected systems that involve the development and transformation of insects into various value-added products (Reim *et al*, 2019). These chains typically include multiple stages, from initial rearing and cultivation to the final delivery of processed insect-based goods to consumers or other industries (Chia *et al*, 2019). They encompass activities such as sourcing or farming insects, processing and refining them, and ultimately distributing or applying them in different sectors.

There are several stages or steps linked to insect value chain (Odongo *et al*, 2018). The first step in the insect value chain is the rearing and cultivation of insects, which involves creating controlled environments to breed and raise insects in a manner that optimizes their growth and development (Tanga *et al*, 2021). Varied insects are reared using different methodologies, such as black soldier flies, mealworms, or crickets, each with specific environmental and dietary requirements (Donkor *et al*, 2023). The rearing process aims to produce a high-quality insect product by managing factors like temperature, humidity, and diet to meet the desired nutritional composition or the characteristics essential for the intended application (Riccaboni *et al*, 2021). The second step is the harvesting and processing in which, once insects reach the desired stage of development, they are harvested and processed (Macombe *et al*, 2019). Harvesting techniques depend on the species and the intended use. Insects may be collected live, in their larval stage, or harvested as adults, depending on the specific requirements of the product being produced (Kinyuru & Ndung'u, 2020). The processing stage involves various techniques, including drying, grinding, or extraction of specific components such as proteins, lipids, or chitin (Madau *et al*, 2020). Processing can result in insect-based ingredients or finished products suitable for human consumption, animal feed, or other applications.

The value addition stage involves refining insect-based products for different applications (Veldkamp *et al*, 2022). Insect proteins, for example, might undergo additional processes, such as purification or extraction of specific protein fractions, to improve their functionality or purity (Ameixa *et al*, 2020). Value addition can also include developing innovative products, such as insect-based snacks, protein powders, or pet food, which cater to diverse markets and consumer preferences (Riccaboni *et al*, 2021). Moreover, research into utilizing insects in pharmaceuticals, bioplastics, and other industrial applications contributes to the value addition in the insect sector (Donkor *et al*, 2023). Value addition in the context of insect farming and production involves enhancing the quality, functionality, and market appeal of insect-based products through various processes and innovations (Tanga *et al*, 2021). It aims to transform raw insect materials into more refined, processed, and diverse end products with increased nutritional value, functionality, and marketability.

Value addition begins with the processing and refinement of insects to create different product forms suitable for various applications (Odongo *et al*, 2018). Insects undergo a range of treatments such as cleaning, drying, grinding, and extraction. For instance, mealworms might be processed into powders, oils, or protein concentrates, while crickets might be ground into flour or used to extract oils or proteins (Chia *et al*, 2019). The goal is to refine insects into ingredients that can be incorporated into different food or feed products. A critical aspect of value addition is extracting specific nutrients or components from insects (Roffeis *et al*, 2017). This might involve isolating proteins, fats, chitin, or other bioactive compounds with unique nutritional or functional properties. For example, insect proteins can be processed to isolate specific amino acids, while insect fats can be extracted and processed to create oils rich in essential fatty acids. These isolated compounds can be used in various applications, such as fortifying food products or producing specialty ingredients for pharmaceutical or industrial use (Berggren *et al*, 2019). In addition, value addition involves using refined insect materials as ingredients to develop innovative and diverse end products. This includes creating new food items like energy bars, pasta, or snacks that contain insect protein or incorporating insect-based ingredients in pet foods (Ameixa *et al*, 2020). In pharmaceuticals, insect-derived compounds might be used in the development of supplements or medicines due to their potential health benefits.

It is also important to note that value addition in insect farming also focuses on enhancing the functionality of insect-based ingredients (Riccaboni *et al*, 2021). This might involve modifying insect proteins to improve their solubility, emulsifying properties, or gelling capacity, making them more adaptable for various food and industrial applications (Berggren *et al*, 2019). Additionally, modifying insect-based ingredients to remove any potential off-flavours or undesirable attributes contributes to enhancing their acceptability in different end products (Chia *et al*, 2019). With respect to insect faming, value addition strategies often target sustainability by utilizing insects in a manner that reduces waste and environmental impact. Insects can be used to upcycle organic waste into valuable protein sources, which in turn reduces the environmental burden of waste disposal (Macombe *et al*, 2019). Moreover, by utilizing insects as feed for animals, it contributes to a more sustainable and circular agricultural system, reducing reliance on traditional feed sources.

Value addition in the context of insect-based products aims to create consumer-friendly, marketable products. Innovations focus on creating visually appealing, palatable, and nutritious insect-based food items that align with evolving consumer preferences (Kinyuru & Ndung'u, 2020). Moreover, through marketing and education efforts, the aim is to gradually shift societal perceptions and overcome cultural barriers to foster wider acceptance of insect-based products (Riccaboni *et al,* 2021). Value addition in the insect sector is an ongoing process that continually explores ways to refine insect-based materials, develop new products, and improve existing ones (Tanga *et al*, 2021). It addresses the challenges associated with consumer acceptance, scalability, and the development of consistent, quality insect-based products suitable for diverse applications and markets (Veldkamp *et al*, 2022). As research and innovation continue, the potential for value addition in insect farming remains vast, promising diversified applications and a sustainable, resource-efficient alternative for various industries and consumers (Roffeis *et al*, 2017).

There are several benefits and significances of engaging in insect farming value addition. First, insect value chains and value addition provide a sustainable and efficient source of protein and nutrients, contributing to addressing global food security challenges (Tanga *et al,* 2021). Insects require fewer resources compared to traditional livestock, making them an environmentally friendly alternative. They can upcycle organic waste and are resilient in adverse environmental conditions, making them adaptable to various production systems and locations (Roffeis *et al*, 2017). The utilization of insects in value addition fosters economic growth by creating new markets and opportunities. The development of innovative insect-based products caters to evolving consumer demands for sustainable and nutritious alternatives (Chia *et al*, 2019). Additionally, it encourages entrepreneurship, supporting small-scale insect farming and processing enterprises, and contributes to the development of rural economies.

Despite the potential benefits, several challenges hinder the widespread adoption of insect value chains. Regulatory frameworks and consumer perceptions surrounding insect consumption vary across regions, impacting market acceptance (Macombe *et al*, 2019). The lack of standardized production methods, quality control, and research and development hampers the scalability and consistency of insect-based products (Madau *et al,* 2020). Addressing these challenges requires collaborative efforts from policymakers, researchers, and industry players to promote and regulate the industry's growth. The future of insect value chains and value addition looks promising (Ameixa *et al,* 2020). Ongoing research and development aim to address existing challenges and capitalize on the potential of insects in various applications (Riccaboni *et al*, 2021). Advances in processing technologies, genetic improvements in insect strains, and increased consumer acceptance of insect-based products bode well for the industry's future growth.

In conclusion, insect value chains and value addition constitute a dynamic and evolving sector that holds substantial promise. They offer a sustainable, resource-efficient, and versatile solution to various global challenges, including food security and environmental sustainability. The utilization of insects in diverse sectors, from food to pharmaceuticals and beyond, presents an opportunity for innovative and impactful contributions to diverse industries, economies, and global sustainability efforts. The development of robust insect value chains is a critical step in harnessing the potential of insects and realizing their multifaceted benefits for a sustainable and prosperous future.

2.2.5. Performance and Performance Indicators in Insect Farming

Studies on insect farming have established increased interests in the same (Ruckli et al, 2021; Stuart et al, 2018). Notably, insect farming, as a burgeoning industry, relies on effective performance evaluation to measure and enhance productivity, sustainability, and overall success (Madau et al, 2020). Evaluating the performance of insect farming involves understanding and analysing various parameters, often captured through performance indicators. However, for purposes of understanding how the industry is burgeoning, there are performance evaluation indicators and metrics used (Prandini et al, 2015). The evaluation of performance in insect farming is crucial for assessing the efficiency, sustainability, and quality of the entire production process. This assessment helps identify areas for improvement, guide decision-making, and ultimately enhance productivity (Liland et al, 2021). The multifaceted nature of insect farming necessitates a comprehensive evaluation that includes various performance indicators.

As a result, there are several Key Performance Indicators (KPIs) in insect faming, which are used across the globe to evaluate the performance (Sorjonen et al, 2022).

Among the KPIs commonly used are the growth and development Rates. Growth and development rates are essential for monitoring the growth rates of insects within farms. Monitoring the growth rates of insects from larvae to adult stage is crucial (Danieli et al, 2015). This indicator measures the time it takes for insects to reach maturity, aiding in managing production cycles and optimizing resource use. There has also been the use of Feed Conversion Ratio (FCR) for purposes of measuring the efficiency of feed conversion into insect biomass (Okello et al, 2021). It calculates the amount of feed needed to produce a unit of insect biomass, providing insights into resource utilization and cost-effectiveness (Allegretti et al, 2018). Mortality rate is also used for tracking mortality rates is essential in assessing the health and success of rearing. Lower mortality rates indicate better health management and a more efficient rearing process (Modahl & Brekke, 2022). There is also the use of reproduction rate, which is an indicator that focuses on the ability of insects to reproduce. It measures the number of eggs produced per female or the success rate of breeding programs, influencing the overall sustainability of the farming process.

Farmers can also use the nutritional composition indicator for purposes of analysing the nutritional content of insects produced, such as protein, fat, or essential amino acids, helps ensure the quality and suitability of the final product for different applications, such as food or feed (Benfekih et al, 2018). The use of resource use efficiency indicator has been identified essential in the evaluation of the utilization of resources, including space, feed, and water, against the output of insect biomass, provides insights into the sustainability and efficiency of the farming system (Okello et al, 2021). In addition, there is also the use of environmental impact indicator, which helps in the assessment of the environmental footprint of insect farming, such as greenhouse gas emissions, waste management, and land use, is crucial in determining the sustainability and eco-friendliness of the process (Alfiko et al, 2022). The other commonly used KPIs in the insect farming is economic viability indicator. The economic viability indicate helps in the monitoring the costs involved in rearing and processing insects against the revenue generated helps assess the economic viability and profitability of insect farming operations (Modahl & Brekke, 2022). The aforementioned KPIs have become essential in allowing farmers understand the progress of insect farming. They can also be adopted in the case of Kenyan Lake Basin Region.

Performance evaluation of insect farming for food and feed remains an essential concept in the agricultural practices among smallholders (Okello et al, 2021). The evaluation of performance indicators in insect farming is crucial for several reasons. It allows farmers and stakeholders to make informed decisions, optimize production, and improve farming practices (Danieli et al, 2015). By identifying areas needing improvement, such as optimizing feeding regimes or managing environmental conditions, it leads to increased efficiency, reduced costs, and enhanced product quality. Moreover, performance evaluation is critical in promoting sustainable practices (Liland et al, 2021). It helps in managing resources effectively, reducing waste, and minimizing environmental impacts. Identifying and implementing sustainable practices contribute to the overall positive image and long-term success of insect farming (Allegretti et al, 2018). The idea behind the performance evaluation is to allow for smallholder farmers understand whether or not they are making progress when it comes to breeding insects for feed and food. Farming insects is considered as a project; hence, the need to ensure that the set project objectives are adequately attained.

Even though farming insects benefit significantly from performance evaluation, there are possible challenges and future developments (Stuart et al, 2018). Challenges in performance evaluation in insect farming include standardizing methodologies for measurements, adapting to different insect species, and integrating advanced technologies for data collection and analysis (Prandini et al, 2015). Overcoming these challenges requires collaborative efforts among researchers, farmers, and industry stakeholders to establish standardized protocols and leverage technological advancements for data collection and analysis (Sorjonen et al, 2022). The future of performance evaluation in insect farming lies in advanced data collection methods, precision farming technologies, and the development of comprehensive databases for benchmarking (Okello et al, 2021). Improved data analytics and artificial intelligence applications may revolutionize the way performance indicators are measured and analysed, leading to more accurate and detailed assessments (Modahl & Brekke, 2022). In conclusion, the evaluation of performance indicators in insect farming is indispensable for achieving efficient, sustainable, and successful operations. By continuously monitoring and analysing key parameters, farmers can optimize their processes, enhance product quality, and contribute to the overall sustainability of insect farming. As technology and methodologies advance, the precision and depth of performance evaluation in insect farming are expected to significantly improve, fostering a more resilient and thriving insect farming industry.

2.3. Agricultural Extensions and Insect Farming for Food and Feeds

Poorer sections of society and small-scale farmers, who are heavily dependent on global food supply and who suffer the most during times of conflict, exhibit nutritional deficiencies, particularly in protein (Dicke, 2018). Due to their nutritious composition, accessibility, simple and inexpensive rearing techniques, and ability to be reared on organic residual streams by producing bio-fertilizer, insects may be gathered, reared, and processed to help combat food insecurity and promote peace process. For these reasons, the development of the production of these sustainable proteins has the potential to enhance the social stability and living conditions of smallholder farmers as well as vulnerable groups, such as women and the landless, in both urban and rural areas of developing countries, which would be a significant step toward their social and economic integration (Van Huis *et al* 2013; Osman & Yosuf, 2020 & Barragan-Fonseca, 2020). Therefore, insects may result in a local circular economy and help to foster and uphold inclusive and peaceful communities, lowering the likelihood of riots and other forms of violence. However, ensuring the accessibility of food is a shared duty, thus it's critical that many stakeholders become involved. To develop the insect-derived food and feed sector, particularly in developing countries, governments and other institutions, including universities and private companies, should participate in national and international capacity building and networking projects, as well as be effective in informing and training local farmers.

Maternal and child undernutrition are major global problems with serious implications for health, human development, and economic output. Undernutrition kills over 3.1 million children each year, accounting for almost 45% of all child mortality (Black *et al* 2013) Maternal and child undernutrition have considerable short- and long-term implications, such as adverse pregnancy outcomes, reduced child survival, diminished cognitive and educational performance, and an increased risk of chronic illnesses in adulthood (Bhutta *et al*, 2013) The economic implications of undernutrition are significant, impacting the most vulnerable people in low- and middle-income countries (LMICs) (Black *et al*, 2008 & Horton and Steckel, 2013) Individuals' economic productivity losses due to undernutrition are estimated to be more than 10% of lifetime earnings, while national economies' losses are projected to be roughly 2-3% of GDP (Townsend *et al*., 2013).

Women's groups in the nutrition-sensitive agricultural extension intervention (AGRI) arm watched and discussed two NSA films each month for 32 months. Following each video viewing, all pregnant women and mothers with children aged 0 to 23 months (primary beneficiaries of the trial) received follow-up visits. The purpose of these follow-up visits was to see if participants could recall the important themes in the videos or have implemented the key practices, to reinforce the concepts displayed in the videos, and to urge participants to attend future sessions. The visits also served to improve the connection between participants and community frontline workers, as well as to refer visibly unwell or malnourished children to community workers or other health practitioners. The video dissemination meetings and home visits were led by Community surveillance program (CSPs). Women's groups in the nutrition-sensitive agricultural extension and nutrition-specific behaviour-change intervention (AGRI-NUT) arm watched and discussed two videos each month, one on NSA themes and one on nutrition-specific topics, complemented by the above-mentioned follow-up visits.

Just like many other developing economies, the Kenya Lake Victoria Basin continues to suffer from food and nutritional insecurity. The region experienced inadequate food and nutrition despite neighbouring one of the world's largest fresh water lakes. A lot of focus and emphasis has been on large scale farming. In addition, the farming revolved around the ordinary. The farmers were unwilling to try extraordinary engagements such as the idea of edible insect farming. Considering the fact that majority of farmers in the region did small-scale farming, continued focus on large scale farming would not only leave the majority who were small-scale farmers out but also lead to further deterioration of the conditions of food and nutrition security. It was time for the region to thought outside the box and adopted the extraordinary strategies while involving the masses. One of the possible reasons for low involvement in extraordinary farming practices, despite evidence confirming the sustainability and feasibility of edible insect farming on small scale farming, could be the idea of inadequate and inefficient agricultural extension systems. It would be imperative to investigate how the agricultural extension systems can be used for the benefits of small-scale farmers in Kenya Victoria basis while at the same time achieving SDGs on food and nutritional security.

The United Nations Sustainable Development Goals (SDGs), which include seventeen important themes for action by all countries, seek to be ambitious and, ideally, address challenges such as peace and prosperity for people and the planet today and in the future. Edible insects were identified as a potential solution to one of today's primary challenges: increasing food production while lowering the environmental impact. The "insect concept" was linked to the single SDGs in this review to illustrate its potential. Similarly, an indirect relationship between insect farming and various SDGs has been observed (Moruzzo, Mancini, & Guidi, 2021). Large and small-scale insect farming will undoubtedly lead to an overall increase in agricultural production. Particularly in nations with a lengthy tradition of entomophagy and the rearing of insects, like Asia, South America, and Africa, an increased and widespread awareness of the potential of insects will also influence political and marketing decisions, enhancing livelihood, economic development, and social integration. “The Thai example” serves as a concrete illustration of the insects’ potential. Even while using insects as food has traditionally been in the country, in recent decades it has only been made better by switching from gathering insects in the wild to rearing them in a closed environment. It was effectively propelled by a strong market demand that was backed up by academic research and private sector innovation (from processing to selling). With more than 20,000 family farms rearing insects for food and feed, a new production sector was skilfully built to ensure new incomes and employment for Thai people (Hanboonsong *et al*., 2013).

The sustainable use of marine resources – that is, the conservation and sustainable exploitation of the oceans, seas, and marine resources – could also be facilitated by insect farming. Although aquatic insects are not currently farmed for food, by partially or completely replacing fishmeal and fish oil in livestock feed, insects might help reduce overfishing. In fact, a significant section of the aquaculture industry today relies on feed containing these two substances as proteins or fats, which has a significant negative impact on the environment. Despite evidence on the increasing edible insect farming, the concept was yet to be adopted in most parts of the globe particularly those suffering from food and nutritional insecurity. Kenyan Lake Victoria Basin is one such region that continues to experience food and nutritional insecurity even though it surrounds one of the largest fresh water lakes in the world. The focus around this region has been to engage in ordinary farming, which, in most cases, is large scale. Even though there is evidence of how edible insect farming on both small- and large-scale can benefit the community, small-scale farmers are still sceptical about implementing the same. This means that agricultural extension systems are not being effective in offering the needed information to the farmers. Therefore, a study examining the effects that agricultural extension systems can make towards edible insect farming among small-scale farmers would promote the uptake of the farming system as well as assist towards achieving SDGs on food and nutritional security.

There is along collection and use of insect as food among many ethnic groups in Kenya (Pambo *et al*., 2016). In western part of Kenya, eating insects is mostly practiced among many communities. Edible insects are commonly utilized as part of the diet, where they are used as a side dish, snack or ingredient in making and preparation of other food products. To communities depending on the wild harvesting, collection and consumption of these edible insects occurs at certain months of the year due their seasonality (Pambo, 2018). Most of these communities were depending on wild harvesting but attempts are being made to train and empower farmers on mass rearing of some of the edible insects to ensure continuous supply and consumption (Pambo, 2018).

Along the Kenyan Lake Victoria Basin there are several edible insects like crickets, termites, locusts, grasshoppers and edible lake flies (Ayieko et al, 2012). Harvesting of these edible insects occurs during the wet periods normally around the homestead, they are usually eaten as a whole while fresh or fried (Pambo, 2018) Edible insects can also be dried and grinded into powder for various uses, for instance women from western Kenya use the powder in preparation of baby porridge which is fundamental in early child development due to its excellent nutritive value (Pambo, 2018). These edible insects have also been nearly used as an ingredient in pilot production of different insect base products like wheat burns, muffins, crackers, cricket biscuits, sausages, meat loaf, and cricket flour burns (Ayieko *et al*, 2012, Pambo, 2018, Alemu *et al*, 2017, and Weru *et al* 2021). On this study there is little information concerning how culture could have led to acceptance or rejection of insects as food.

In order to determine if consumers are willing to incorporate edible insects and seaweed in their diets, questions of acceptability have been investigated (Verbeke, 2015). Different new approaches to food production sometimes face technical challenges, which may account for why certain innovations remain at the prototype stage (Specht *et al*., 2016). However, technological viability is not the only factor that determines whether an innovation will succeed. Additionally, essential to the innovation's dissemination are social acceptance and benefits perceptions. Consumers could reject approaches that go against their traditional perceptions of agriculture. Local government officials may resist the innovation’s deployment if they don't comprehend it (Specht *et al*., 2015), the findings also show trends with regard to the various approaches and their individual contributions to the various sustainability dimensions. The findings highlight the significant societal benefits of techniques like rooftop greenhouses and vertical farming. In light of the approach "yuck factor," the large number of social potentials for insect production somewhat surprised us (Yen, 2015). Algae production showed few social potentials, maybe because there were few options for designing underwater food production in a way that was interactive. Possible impediments include a lack of understanding of the new techniques, uncertainty about their advantages, concerns about health risks, an absence of familiarity with the food products, and moral concerns about animal welfare. We conclude that adaptation of the unsuitable regulatory framework, which discourages investors, is an important first step to foster dissemination of the urban food production approaches. To be better understood by farmers and society at large, issues concerning the ethics, acceptability, health, safety, and cultural values of edible insects necessitate a more organized approach such as extension services. If implemented, extension services (ES) will play a role in promoting edible insects (Ebenebe *et al*., 2020).

There are three ways to get edible insects by harvesting them from the wild (Chia *et al*., 2022); semi-domestication (manipulating their habitat to boost output); and farming, which can take the form of anything from a small-scale operation to a huge factory (Yen, 2015). According to Yen (2015) when solely taking into account the consumption of edible insects by humans (entomophagy), wild harvesting makes up roughly 92% of the total, whereas semi-domesticated insects make up about 6%. As a result, just 2% of edible insects is farmed. However, due to seasonal and geographical variations, insects might not always be present in the wild all year round. Therefore, with the aid of environmentally friendly insect breeding, farming, and processing technologies, industrial-scale insect production can reduce the cost of selling edible insects while also easing supply-side constraints. Notably, farming is currently the most effective approach to produce insects that are meant for use as food and feed and it has the potential to develop a brand-new economic sector with standardized practices on an industrial scale (Van Huis 2015). In addition, farming insects on a small to medium-scale might help provide nutrient-dense food in a timely manner and with minimal technology use (Raheen *et al*l, 2019). Due to the limited investment costs (per unit of generated protein), the relatively straightforward management (requiring little formal training), the quick production cycle, and the high feed conversion efficiency (with a low environmental impact if reared on side stream substrates), this type of farming does really offer faster investment and high financial returns. Increased employment and the advancement of local technologies might have a favourable impact on low-income communities (Chia, Tanga, Van loom & Dicke, 2019). Furthermore, this practice is a common source of income and serves an important societal role in countries where edible insects are traditionally harvested (van Huis & Oonincx, 2017).

Increasing planetary health requires sustainable techniques of feeding the world's population, which is increasing quickly. Additionally, these new productions (like those involving insects) should also participate in reducing existing environmental harm and transition to greener forms of production. Particularly, eating edible insects has the potential to support several SDGs by providing multiple advantages to both humans and the environment. Success depends on close cooperation between all stakeholders, including the government, business community, and academia. To fully profit from the advantages of edible insects in the future, knowledge-sharing networks must be established, multidisciplinary research must be funded, and sustainable policies must be developed. Along with market strategies, legislative frameworks and cultural barriers also play a part in the global health and nutritional condition, but we must seize this opportunity to actively and indirectly contribute to several SDGs. The SDG interdependencies can also serve as a blueprint for how research can give direction for policy action by translating them into requirements for policymaking.

Minimal value addition, a lack of standardization and inappropriate market information were the defining characteristics of the marketing of edible insects. It was discovered that edible insects have significant commercial potential, with year-round demand frequently exceeding supply and consistently higher unit pricing than similar items like beef, pork, and poultry. Thus, the marketing of edible insects offers populations in the Lake Victoria Basin a means of livelihood. To make this a reality, solutions for enhancing the value of edible insects must be explored. Standardizing their packaging, weighing, and pricing is also necessary (C.A. Okia *et al*, 2017).

Latin America is now the second-largest market in the world for edible insects and has a long tradition of entomophagy. When compared to Europe and North America, the number of start-ups producing edible insects is still incredibly low. Using the systemic competitiveness method, (C.A. Okia *et al*, 2017) investigates the potential for farming and processing edible insects in Latin America in order to identify the major opportunities and limitations for the sector's growth in the area. First, despite the tradition of entomophagy, the meta level looks diffuse since there are no obvious regional or national strategies towards the development of an insect-based food industry, and because the bulk of the urbanized population harbours prejudice towards insects. However, the potential for recovering traditional knowledge is enormous. Although there is an opportunity associated to the revised Novel Food Regulation (Regulation (EU) No. 2015/2283) that may facilitate exports to the European market, the macro level is characterized by a lack of local and international regulation on food safety, production, and commercialization.

At the middle level, despite an increase in financing and investment for insect-based start-ups globally, there aren't many research and training institutions in the region. The main opportunity is to generate innovative products based on the traditionally-known organoleptic and functional characteristics of insects. The main constraints identified at the micro level are the high prices of edible insects due to an existing disrupted supply chain and the lack of technology to mass produce insects. Undoubtedly, more has to be done for Latin America to take the lead globally, including strengthening the local framework for growing edible insects and encouraging entrepreneurship. All stakeholders participating in the many systemic levels, including: entrepreneurs, research institutions, government, and society should coordinate these efforts (Bermúdez-Serrano *et al*., 2020). Of these stakeholders, agricultural extension officers are considered close to farmers. They have a direct link with the farmers; hence, have a touch on the problems affecting them. Through their contribution, regions are likely to reap the benefits of value addition for the insect farming. However, this is not the case especially in the Kenya Lake Victoria Basin. There seems to be low involvement of agricultural extension officers, who have the ability and resources to help in transforming farming in the region and achieve SDGs on food and nutritional security. Therefore, it is imperative to conduct an investigation on the effects of agricultural extension system in relation to edible insect farming, which would then inform the activity around the Kenyan Lake Victoria Basin.

Given its role in agriculture, agricultural extension has remained an area of interest especially with respect to promoting edible insect farming for food and feed nutritional security among smallholder farmers. One of the aspects that has become of particular interest is the effects of agricultural extension on the production of insects as food and feeds among small scale-farmers. Even though there is some empirical evidence on such contribution, it is considered inadequate. In their study within the Central African region, Kelemu *et al*. (2015) reviewed entomophagy as practiced within the African context. The review of the study leaned on the idea of food and nutritional security especially with respect to offering an inventory of different species of insects that can be used for enhancing food security. According to the findings, Kelemu *et al*. (2015) noted that in as much as there are numerous insects that can be used as food, there is little contribution made; hence, the call for research for development. Even though the study has offered a basis of understanding use of insects as foods, it failed to acknowledge and appreciate the role of agricultural extension services. This forms the basis of evaluating how agricultural extension can be used to improve food and nutritional security from the idea of insect farming.

In another study, Khan *et al*. (2014) examined the push-pull technology and its role in improving insect farming especially among smallholders. The study aimed at creating an understanding on how the novel cropping systems linked to the International Centre of Insect Physiology and Ecology has been an effective approach towards improving mixed farming among smallholders. Mixed cropping in this case is about crop and insect farming. According to the findings, Khan *et al*. (2014) noted that through the technology, there has been improved mixed cropping among smallholders in Africa. The technology is considered appropriate in effectively addressing major production constraints alongside increasing food security. In this study, Khan *et al*. (2014) admit that with proper strategic management, it is possible for Africa to ensure food and nutritional security. However, the company leaned on the push-pull technology, while ignoring some of its pillars. One of the pillars of the push-pull technology is the use of agricultural extension services. Having agricultural extension services can be considered as either a push or a pull factor when it comes to the idea of mixed cropping. With the assumption that agricultural extension services are part of the push-pull technology, it can be established that Khan *et al*. (2014) implicitly indicated their roles in such mixed cropping. Nonetheless, it would be imperative to have an explicit investigation into how agricultural extension services can be used to promote insect farming; hence, forming the basis of the present study.

Ibitoye *et al*. (2021) conducted a study to investigate role of extension services in the commercialization and utilization of insect resources. The study was conducted in Nigeria. According to the study, extension services were considered effective in fostering agricultural developments in the past. In addition, they also indicated that extension services have been used extensively across the country to enhance insect production and utilization. Using six geopolitical zones in Nigeria, the study noted increased consumption of insects. However, the study noted that while there are numerous insects consumed in Nigeria, majority are wild, which raised the concern as to how extension services can be used to enhance production of such insects to promote food security. Based on the findings, Ibitoye *et al*. (2021) noted that through extension services, Nigeria has experienced increased farming of edible insect; a move that has since created additional food and nutritional security. They confirmed that, if adopted, extension services can promote farming of edible insects. Picking from such recommendations, the present study seeks to examine how adoption of extension services can be used to promote edible insect farming around the Lake Victoria Basin region in Kenya.

2.5. Conceptual Framework

Given the above aspects, the following conceptual framework highlights the relationship between the variables to be studied:

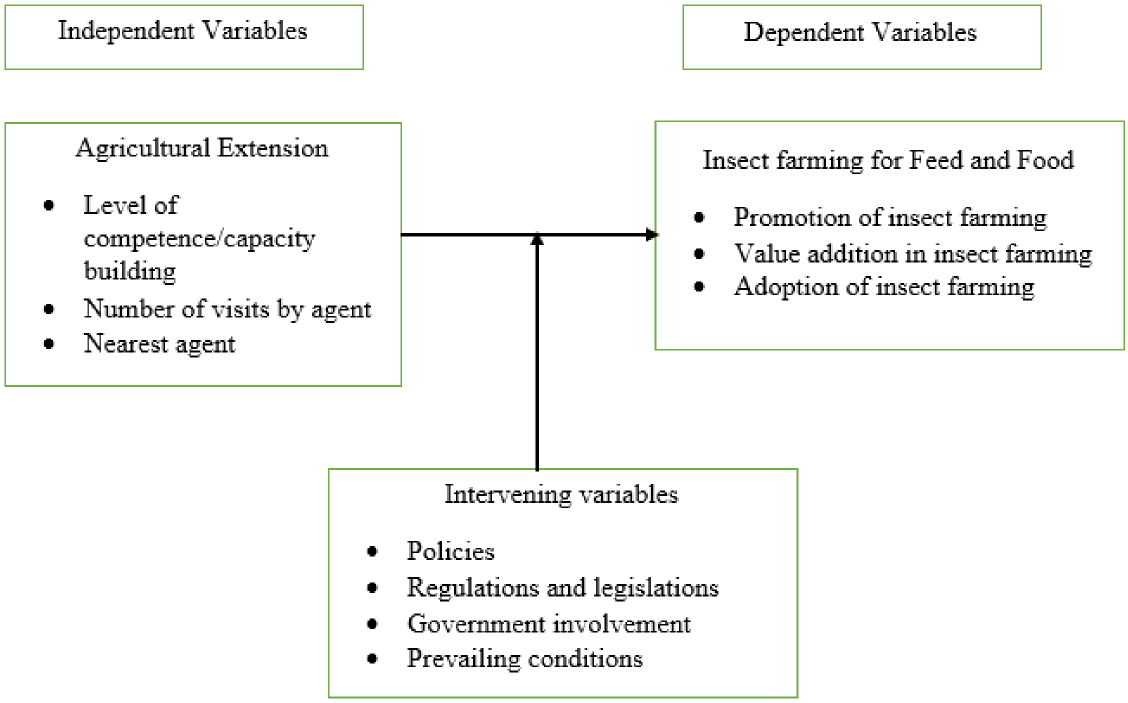


Figure 2: *Conceptual Framework*

According to the conceptual framework, the focus of the study was to examine the relationship between agricultural extension systems to insect farming and food and nutrition security. The study intended to measure agricultural extension system through innovative extension approaches, socio-economic factors, and value addition. Food and nutrition security were to be measured using nutrition value, availability, and accessibility of foods. Nonetheless, there were intervening variables of policies, funding mechanisms, and training. For the study, the assumption was that the intervening variables were constant for the duration of the study, that is, the intervening variables were not to change during the study period.

The conceptual framework proposed aims to explore the multifaceted landscape of insect farming for food and feed, emphasizing the pivotal role of agricultural extension and considering influential intervening variables that shape the overall context. The dependent variable is insect farming for feed and food. In this study, insect farming, the focal point of the study, comprises various essential components. First, the promotion of insect farming constitutes concerted efforts to educate, raise awareness, and encourage the adoption of insect farming practices. This encompasses awareness campaigns, educational programs, and marketing strategies aimed at highlighting the benefits and opportunities inherent in insect farming for food and feed. The goal is to drive interest and active participation in insect farming. Additionally, value creation in insect farming involves strategies aimed at enhancing the quality, diversity, and market viability of insect-based food and feed products. This includes innovative processing techniques, diversification of products, and improved nutritional content to add value to the range of insect-derived food and feed products available in the market. Lastly, the adoption of insect farming signifies the practical application and acceptance of insect farming practices by farmers, stakeholders, and consumers. This encompasses the actual implementation of insect farming methods, the integration of insect-based products into markets, and the acceptance and consumption of insect-based food products by consumers.

The independent variable of the study was agricultural extension. Notably, the agricultural extension, as the independent variable, encompasses level of competency, number of visits, and the nearest age. The level of competency represents the expertise, knowledge, and effectiveness of extension personnel in communicating and guiding stakeholders regarding insect farming. This variable focuses on the capability and proficiency of these individuals in imparting accurate and practical guidance to the community. The frequency of visits by extension agents signifies the consistency of engagement and support provided by agricultural extension agents to individuals or communities involved in insect farming. The frequency of interaction and support from these agents is crucial in facilitating guidance and sharing valuable knowledge regarding insect farming practices. The nearest agent variable considers the accessibility of agricultural extension services to the farmers or communities engaged in insect farming. This proximal aspect directly impacts the availability of support and guidance for effective insect farming practices.

Other than the dependent and independent variables, there are also intervening variables. The intervening variables that might significantly influence the relationship between agricultural extension and insect farming include policies, regulations, legislations, government support, and prevailing socio-economic conditions. Policies and regulations established by governing bodies concerning insect farming practices. Legislation encompassing specific laws and regulations directly related to insect farming. Government support through initiatives, financial aid, and programs designed to either support or regulate insect farming activities. Prevailing conditions such as economic, environmental, or social factors that impact the feasibility and success of insect farming practices. This comprehensive framework offers a holistic perspective on the factors and variables interwoven within the domain of insect farming for food and feed. It underscores the pivotal role of agricultural extension and the broader external factors that shape insect farming practices and outcomes.

CHAPTER THREE

RESEARCH METHODOLOGY

3.0. Introduction

This chapter identified the specific strategies and procedures that were used by the researcher in data collection and analysis. This chapter focused on providing information regarding the study area, research designs, target population, methods of data collection, sample population, validity of the instruments, and data analysis.

3.1. Conceptualisation of the Variables

In this study, the main variables included insect farming for feed and food (dependent variable) and agricultural extension services (independent variable). The study defined insect faming for feed and food as means rearing of edible insects, especially where Insects are cultivated in captivity, and each rearing step is controlled (e.g., living conditions, diet, and food quality) (Madau *et al*., 2020). In this study, promotion, value addition, and adoption were used to measure insect farming for feed and food. Promotion generally refers to the creation of awareness. For value addition, the study conceptualised it as the introduction of new features or economic value to a product or service by a company or venture before offering to the customer (Nagy *et al*., 2018). The study further conceptualised adoption as the process of accepting, integrating and using emerging methods, techniques and practices in the agricultural society. Morever, emerging technological innovations that tend to improve production, provide efficiency of services within the agricultural sector (Rehman, Jingdong, Khatoon, Hussain, & Iqbal, 2016).

The other variable was agricultural extension. In terms of conceptualisation, the study defined agricultural extension as agricultural advisory services. In practice, extension involves teaching farmers — for us, smallholders in poor nations – agronomic practices and skills that will help them enhance their productivity, food security, and livelihoods. This includes two key components: the transmission of practical information, such as superior seeds, soil quality, equipment, water management, crop protection, agricultural techniques, and livestock, and the execution of this knowledge on the farm (Syngenta Foundation for Sustainable Agriculture, 2019). The agricultural extension was measured by the level of capacity, frequency of visits, and the nearness to agricultural extension agents. The aforementioned conceptualisation formed the basis of developing items, which were used to measure the constructs.

The following table provides a summary of how the variables were conceptualised.

Table 1: *Conceptualization of the Variables*

Variable	Aspect	Explanation
Insect farming for feed and food	Promotion of Insect Farming	This facet involves initiatives, awareness programs, and educational campaigns aimed at encouraging and advocating for the adoption of insect farming for food and feed. Strategies that promote the advantages, nutritional benefits, and economic viability of insect farming fall under this aspect.
	Value Creation in Insect Farming	This dimension pertains to actions and methodologies focused on enhancing the value and utility of insect farming for food and feed. It includes innovation in processing, diversification of insect-based products, and improving the nutritional quality of the final products.
	Adoption of Insect Farming	The adoption aspect signifies the actual integration and acceptance of insect farming practices by stakeholders, including farmers, communities, and consumers. This variable measures the degree to which insect farming practices are being implemented and embraced.
Agricultural extension	Level of Competency	This component assesses the proficiency, expertise, and knowledge of the agricultural extension personnel in providing guidance and support related to insect farming for food and feed. It encompasses the ability to effectively communicate, educate, and guide stakeholders on insect farming practices.
	Frequency of Interaction	This facet measures the regularity and consistency of engagements between agricultural extension agents and stakeholders involved in insect farming. It reflects the frequency of guidance, support, and information-sharing provided to the community.
	Proximity to Services	The nearest agent variable emphasizes the accessibility and proximity of agricultural extension services to individuals or communities engaged in insect farming. It focuses on the availability and ease of access to guidance and support from extension agents.

Notably, conceptualizing these variables involves understanding the core components, dimensions, and attributes associated with insect farming for feed and food as well as agricultural extension services. The characterization and definition of these variables are crucial for subsequent analysis, as they form the foundation for examining the relationships, influence, and impact of agricultural extension services on insect farming for food and feed among smallholder farmers within the Lake Victoria Basin in Kenya.

3.2. Study Area

The study area is the Lake Victoria Basin in Kenya, which covers fourteen counties of which five counties were purposively selected due to resource constraints, the selected counties were Busia, Siaya, Kisumu, Homabay, and Migori. The Lake Victoria Basin in Kenya is an area of remarkable ecological significance, situated along the equator and spanning approximately between latitudes 0°20´N-3°S and longitudes 31°39´E–34°53´W. With an average elevation of 1134 meters above sea level, it hosts Lake Victoria, the second-largest freshwater body globally, shared among Kenya, Uganda, and Tanzania. In Kenya, the Lake Victoria Basin, the area surrounding the lake, is crucial for its ecological and socio-economic importance. Lake Victoria itself serves as a critical component of the region's hydrology, receiving substantial rainfall and experiencing evaporation rates ranging from 1100mm to 2400mm annually. The water balance of the lake predominantly relies on precipitation and evaporation, influencing the region's climatic conditions and ecosystems.

The catchment area of Lake Victoria spans about 195,000 km2, extending across multiple countries, including Kenya, Uganda, Tanzania, Rwanda, and Burundi. In Kenya, the Lake Victoria Basin covers approximately 43,000 km2, constituting nearly 22% of the lake's total catchment area. This geographic context underscores the significance of the basin's influence on the surrounding ecosystems, livelihoods, and regional stability. For the purpose of the conducted study, research was specifically concentrated in five administrative counties directly bordering the Kenyan side of Lake Victoria: Busia, Siaya, Kisumu, Homabay, and Migori, as indicated in Appendix 1. These counties, forming regional administrative units within Kenya, belong to the Western region and serve as an ideal location for the comprehensive assessment of food and nutritional security. The criteria used to select the five counties for this study were not explicitly specified. However, typically, selection criteria in research may include proximity to the study's focus area, prevalence of the subject under investigation (insect farming for food and feed), diversity in agricultural practices, and accessibility of resources or participants.

The selection of these counties is particularly strategic due to their immediate proximity to Lake Victoria, shaping their socio-economic and ecological dynamics. These counties hold immense potential for evaluating and understanding food security issues within the context of the lake's influence on agricultural practices, nutritional patterns, and the overall well-being of the communities residing in these areas. By concentrating on these counties, the study leverages their unique geographic and socio-economic characteristics, making them a representative and pertinent focus area for assessing food and nutritional security. The findings obtained from this study within the Kenyan Lake Victoria Basin yield insights that are not only regionally relevant but also contribute significantly to the broader discourse on food security, agriculture, and environmental sustainability.

The failure to record and describe the insect species commonly kept by the farmers in this chapter could be due to oversight due to lack of emphasis on this particular aspect within the research design. However, a comprehensive study about insect farming for food and feed would ideally involve the identification, documentation, and description of the specific insect species reared by the farmers. This information would be crucial for a detailed understanding of the farming practices and their potential impact on food and feed production in the Lake Victoria Basin.

3.3. Research Design

Research design is the arrangement of conditions for collection and analysis of data in a manner that aims to combine relevance to the research purpose with economy in procedure (Kothari 2014). Descriptive survey is an observational research design that focuses on determining the status of a defined population, phenomenon, situation or condition being studied (Kothari 2002). The design helps to gather a large amount of data from a given population in order to determine its status with respect to one or more variables (Mugenda & Mugenda, 2003). The research design adopted for this study is a descriptive survey, selected to comprehensively explore and understand the current status, practices, and perceptions related to insect farming for food and feed within the Lake Victoria Basin in Kenya. The descriptive survey design focuses on capturing and summarizing essential information about the variables under investigation.

There were three main objectives that informed the selection of descriptive survey design adopted in this study. First, the survey offered a basis for gathering comprehensive information regarding the current methods, practices, and levels of engagement in insect farming for food and feed within the Lake Victoria Basin. In addition, the survey offered an opportunity to explore the perceptions, attitudes, and beliefs held by stakeholders involved in or impacted by insect farming in the region. The other rationale behind preferring the descriptive research design to other designs was to help in the evaluation of the influence and effectiveness of agricultural extension services on the promotion and adoption of insect farming practices in the study area. The design was appropriate for this study since the study sought to assess status of edible insect farming among a large number of small holder farmers, extension services and different actors in the edible insect food and feed value chains and the challenges bedeviling the sector in Siaya County of Kenya.

3.4. Sampling and Sample Size

Sampling refers to selection of a section of individuals from a population so as to estimate the features of the entire population (Singh & Masuku, 2014). As observed, the importance of sampling are; makes data collection process faster and lowers the cost. Sampling is broadly used to gather data about a particular population. The study population consists of individuals engaged in or affected by insect farming for food and feed within the Lake Victoria Basin in Kenya. This includes farmers, agricultural extension personnel, local community members, and other relevant stakeholders. The sampling technique employed is a stratified random sampling method to ensure a representative and diverse selection of respondents from different demographic and professional backgrounds. To establish how to engage the stratified random sampling, the first step was to determine the preferred sample size using the following formula;

$$n = \frac{N}{1 + N(e)^2}$$

Considering the total identified population of N farmers, the study considered the above formular to determine the sample size proportion to use; where n refers to the sample size and N is the population size and e is the level of precision. A 95% confidence level and P = 0.5 are assumed for equation (Singh & Masuku, 2014). Substituting the formula elements with projected total population to attain the sample size, the study obtained the following results; where N was 443.

To select the 443 participants, the study employed a stratified random sampling technique to ensure a representative and diverse selection of respondents. Stratification was based on specific criteria such as geographic location, occupation, and level of involvement in insect farming. The first step in the sampling was to identify the strata. The researcher divided the population into distinct strata based on occupation (farmers, extension workers, community members, and experts), geographic location (counties), and level of involvement in insect farming. The second stage was to conduct random selection, where, within each stratum, a random selection method was used to select participants. This ensured that every individual in the population had an equal chance of being chosen for the survey.

The inclusion criterion identified was one where individuals eligible for participation met specific inclusion criteria related to their involvement or impact in the domain of insect farming for food and feed within the Lake Victoria Basin. The sampling strategy aimed to include a diverse range of perspectives, experiences, and practices related to insect farming. It ensured that the selected participants could offer comprehensive insights into the subject, thereby enhancing the richness and validity of the survey findings.

Table 2: *Distribution of the sample size per county*

COUNTIES	**N**	**n**
Busia	80	38
Siaya	128	61
Kisumu	89	42
Homabay	75	35
Migori	71	34
TOTAL	443	210

3.5. Methods of Data Collection

The study collected primary data. The primary data included the respondents' demographics, insect farming conditions and their interaction with extension services in the last 5 years. A total of 210 farmers were interviewed in this study using semi-structured questionnaires with open and closed ended questions. Areas where insect farming is propagated were identified with the help of partners and stakeholders in the insect farming research domain. The design of the questionnaire was such that it captured all the aspects under investigation. In other words, the questionnaire was structured into sections, designed to capture diverse information related to insect farming for food and feed and the role of agricultural extension in promoting and supporting these practices among small-holder farmers.

Section A of the question was on socio-economic profile of the respondent. This section aimed to collect demographic information and socio-economic characteristics of respondents involved in insect farming. It included details on gender, age, civil status, land size, religious affiliation, education level, employment status, and monthly income. Section B of the questionnaire was on the role of agricultural extension in insect farming promotion. This section gauged the role of agricultural extension in promoting insect farming, assessing the access and impact of extension services in providing information on insect farming. In the third section, the questionnaire sought to measure the respondents' perceived competency in handling various aspects related to insect farming, including mechanization, rearing methods, value addition, pest and disease management, breeding technologies, marketing, climate change effects, and credit management. In addition, the section measured the frequency of visits and proximity to extension services.

There was a section on the influence of agricultural extension on adoption rate of insect farming. In this section, the questionnaire was designed to help the study establish the influence of agricultural extension on the adoption rate of insect farming among small-holder farmers. The section included questions on reasons for adoption, duration of involvement in insect farming, adoption drivers, and the influence of extension on adoption. The questionnaire also contained extension and upscaling of insect farming section, which gathered data to evaluate the role of extension in upscaling the adoption and sustainability of insect farming by assessing the contributions made in training, marketing, processing, governance, and referral services. The last section on the role of agricultural extension in value addition of insects for food and feeds assisted in gathering data on the influence of agricultural extension on value addition activities related to insect farming. It included questions about processing, storage, by-product utilization, auxiliary ventures, microfinance availability, marketing, and consumer acceptance.

Additional data on the other hand was collected through interviews and focus group discussions with relevant institutions and how they have been promoted through extension support, existing and potential value chains and their effect in promoting food and feed nutritional security among small holder farmers. Type of insects and the stages of technology transfers and level of yields and diffusion or spread were examined. In particular, KALRO, KEPHIS, JOOUST and other institutions engaged in the development and promotion of edible insect farming for food and nutritional security were contacted. Other participants were selected through the help of the local administrative agencies and institutions. Precaution was taken to ensure gender rule compliance and general principles of social inclusivity. A check list of questions was prepared to guide the discussions. This multi-faceted approach to data collection ensured a comprehensive gathering of information, covering a wide spectrum of perspectives, experiences, and insights related to insect farming practices and the influence of agricultural extension services in the Kenyan Lake Victoria Basin.

3.6. Pilot Study

A pilot study among farmers not included in the study was done to improve both validity and reliability of the instruments in Kisumu county. Validity determines whether the research truly measures that which it was intended to measure (Hulley, 2007) while reliability denotes that the same research instrument yields similar results each time it is applied (Kerlinger & Lee, 2000). The Pilot study helped to strengthen reliability and validity as well as the general suitability of the instrument. Besides the piloting site helped in training of the research assistants and enumerators. To validate the data, cobo collect validation instruments were used in the study when digitizing the data collection form; this ensured that where an integer, float, string, date were so validly collected. The following explain how reliability and validity of the instruments were attained through pilot study.

3.6.1. Reliability of the Instrument

Reliability refers to the consistency and stability of measurements or instruments used in research. The pilot study aimed to assess the reliability of the questionnaire by testing its consistency in producing similar results when administered to a small subset of the target population. In other words, reliability can be defined as consistency of one’s measurements or the degree to which an instrument measures the same way each time; if the measurement is used under the same condition with same subject (Trochim, 2006). A measure is considered reliable if the person’s scores on the same test given twice is similar. Reliability of research instruments were run using SPSS and revealed a level of 75% which is within the recommended level.

In this context, the pilot study sought to verify that the questionnaire consistently measured the intended factors or variables related to insect farming practices. This involved examining whether responses obtained from participants were stable and would likely be reproducible when the full-scale study was conducted. Any inconsistencies or ambiguities in responses during the pilot study could signal potential issues with the reliability of the questionnaire, prompting necessary adjustments or clarifications before the main study.

In the study on insect farming within the Lake Victoria Basin, the pilot study assessed questionnaire reliability by examining response consistency among a smaller subset of participants. It aimed to ensure uniformity in responses regarding insect farming practices and the impact of agricultural extension. Observations of inconsistencies or variations in participant responses guided refinements to the questionnaire, enhancing its clarity and reliability before its full-scale deployment in the main study. The pilot study served to strengthen the questionnaire's ability to yield consistent and dependable responses from a larger sample in the main study.

3.6.2. Validity of the Instrument

According to Gay (2009), validity refers to the extent to which research instruments measure what it is designed to measure. It implies how best the measuring instrument used in the research fulfills the purpose of the study. There are different types of validity available for researchers to use; criterion validity, construct validity, content validity and statistical conclusion validity. This study used content validity which is the extent to which a measuring instrument provide adequate coverage of topic of study by ensuring all respondents understood the items in the questionnaire thus avoiding errors and misunderstanding of results (Kathara, 2014). Specifically to validate the data, cobo collect validation instruments were used in the study when digitizing the data collection form; this ensured that where an integer, float, string, date were so validly collected.

In the context of studying insect farming for food and feed in the Lake Victoria Basin, the pilot study was integral in determining the validity of the research instrument, primarily the semi-structured questionnaire used in the main study. For the face validity, the researcher administered the questionnaire to a subset of the target population involved in insect farming. The researcher then observed participants' reactions and collected feedback to evaluate the apparent relevance and clarity of the questions. Specific attention was paid to ensuring that the questions seemed relevant, clear, and comprehensible to the participants, directly addressing issues related to insect farming and agricultural extension within the region.

In respect to content validity, through the pilot study, researcher assessed the content validity of the questionnaire by analyzing the responses gathered. The researcher checked if the questions covered the entire spectrum of information related to insect farming and agricultural extension. This involved confirming that the questionnaire comprehensively captured participants' experiences, opinions, and practices associated with insect farming for food and feed within the Lake Victoria Basin. Additionally, feedback and observations from the pilot study were crucial in identifying any discrepancies or inadequacies in the questionnaire. If participants found certain questions confusing or if there were aspects missing in the survey related to insect farming practices or extension services, researchers used this input to refine the questionnaire. Specific questions were clarified, rephrased, or added to ensure a more comprehensive and accurate representation of the subject matter.

By addressing participant feedback and refining the questionnaire based on the pilot study's findings, researchers strengthened the validity of the instrument. Adjustments made to improve the clarity, relevance, and coverage of the questionnaire allowed for a more accurate and comprehensive assessment of participants' views, experiences, and practices in insect farming and the role of agricultural extension in the Lake Victoria Basin. The pilot study's role in assessing the face and content validity of the questionnaire was essential in ensuring that the questions accurately captured the intended information regarding insect farming and agricultural extension. The refinements made based on the pilot study's observations contributed to the questionnaire's enhanced validity in measuring the desired aspects in the subsequent main study.

3.7. Data Analysis

The collected data from the survey was taken through systematic analysis based on the data type. Quantitative data obtained through the structured questionnaire was processed using statistical software for descriptive statistical analysis. This analysis will involve summarizing, organizing, and presenting the data to reveal patterns, frequencies, and correlations among variables. Qualitative data from interviews and focus group discussions were thematically analyzed to extract key themes, opinions, and narratives regarding insect farming and the role of agricultural extension services. For all the 3 objectives, answers provided were coded and analyzed using IBM SPSS Version 26 statistics, frequency counts and percentages to describe the personal and demographic profiles of the respondents and summarizes responses to questions regarding their awareness of the insect farming technology. For all the questions, percentages were calculated using the total number of respondents who responded to the questions. Cross tabulations were used to determine the relationship between categorical variables. These included perception on the benefits, farmers' participation in the insect farming and their level of exposure to the insect farming information and advisory. The following is a summary of the data analysis matrix adopted;

Table 3: *Data Analysis Matrix*

Research Objective	**Research Question**	**Data Analysis**
To determine the effects of agricultural extension on the promotion of insects as food and feeds among small-scale farmers in the Kenyan Lake Victoria Basin.	What is the role of agricultural extension in the promotion of insects for food and feeds among small-holder farmers in the Kenyan Lake Victoria Basin?	Descriptive statistics (mean, standard deviation, and cross-tabulations) Correlation matrix Regression analysis
To investigate the role of agricultural extension towards value addition of insects for food and feeds among small-scale farmers in the Kenyan Lake Victoria Basin	What is the role of agricultural extension in the value addition of insects among food and feed industry players in the Kenyan Lake Victoria Basin?	Descriptive statistics (mean, standard deviation, and cross-tabulations) Correlation matrix Regression analysis
To assess the determinants of adoption of insect farming as source of nutritious food and feeds among small holder farmers in the Kenyan Lake Victoria Basin.	What factors determine adoption of insect farming for food and feed among small holder farmers in the Kenyan Lake Victoria Basin?	Descriptive statistics (mean, standard deviation, and cross-tabulations) Correlation matrix Regression analysis

Notably, the results of the data analysis were presented in tables and charts.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.0. Introduction

This chapter presents information on background of the respondents, frequency counts, percentages and graphical presentation of 210 respondents to describe the personal and demographic profiles of the respondents regarding their awareness of the insect farming technology.

4.1. General Information

Age, gender, marital status, land size, religious affiliation, highest level of education, employment status, estimated monthly income and the number of dependents were among the general questions the respondents were asked to answer. The findings are presented below.

4.1.1. Composition of the Participants by Gender

The first concern was the composition of the participants by gender. The questionnaire asked the participants to indicate their genders. The results of the responses from the participants are summarised in the following figure:

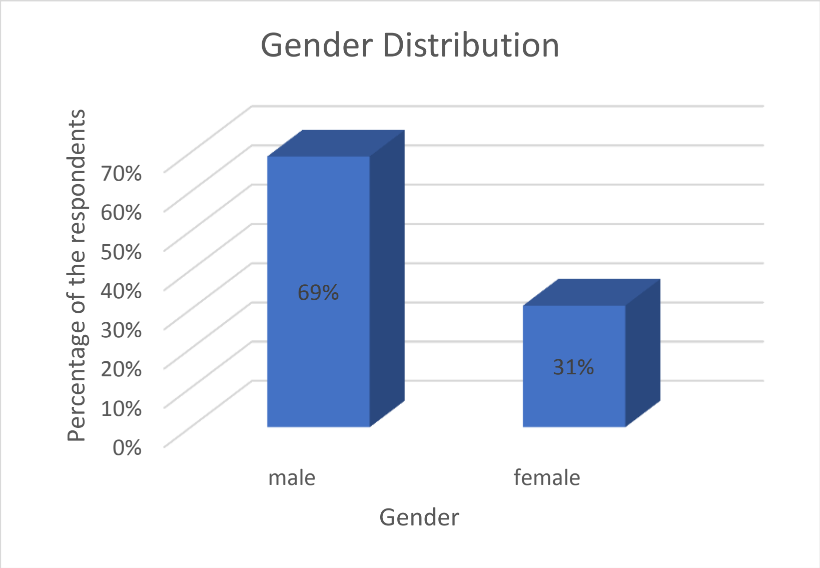


Figure 3: *Distribution of Respondents by Gender*

Based on the findings, the study results show that 69% of the respondents were male and only 31% were female. This means that men are more interested in insect farming than women. It was ensured that gender rule compliance and general principles of social inclusivity is considered in the report

4.1.2. Composition of Participants by Age

The next focus was the composition of the participants by age. Participants were asked to state their ages. The results of their responses are summarised in the following figure:

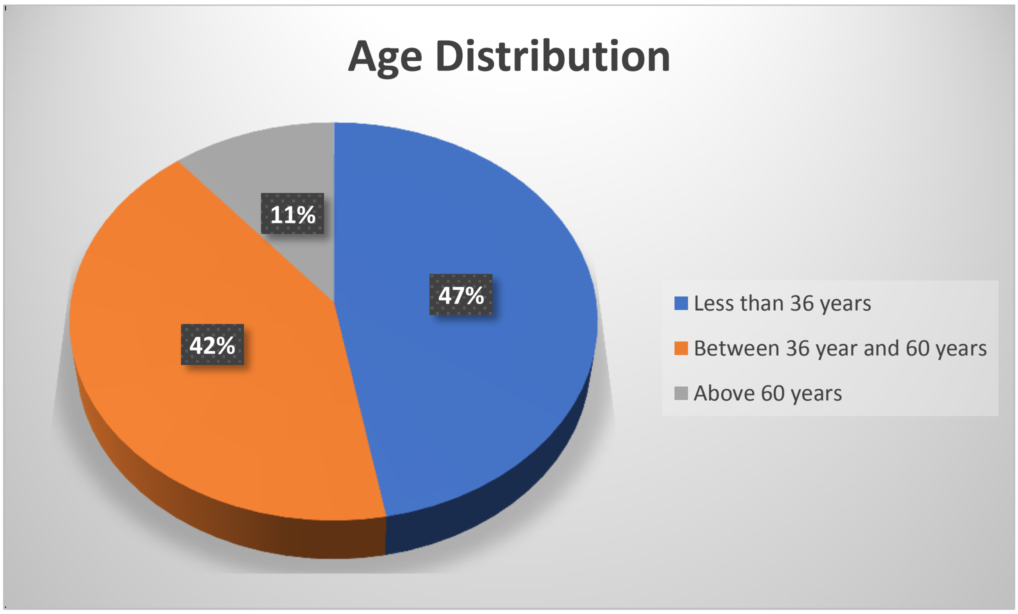


Figure 4: *Distribution of the Respondents by Age*

As to what age the respondents belonged, the findings in Figure 4 revealed that majority of the respondents were less than 36 years of age with 47% while those aged between 36 years to 60 years 42% and only 11% of the respondents were aged above 60 years. This could be attributed to the fact that most youths have gone to work in urban centers leaving the elderly to do the farming which according to Obamiro *et al* (2003) is one of the causes of food insecurity

4.1.3. Education Level

The study was also interested in finding out the composition of the participants based on their levels of education. When asked to indicate their levels of education, the responses obtained from the participants are summarised below:

Table 4: *Level of Education of the Respondents*

		Value	Count	Percent
Valid Values	1	Primary	57	27.1%
	2	Secondary	114	54.3%
	3	Postsecondary	39	18.6%

The study findings in Table 1 shows that majority of the respondents have secondary education with 54.3%, 27.1% have primary education with only 18.6% of the farmers with post-secondary education. The results mean that most farmers had secondary education level and below which may be attributed to lack of proper knowledge in insect farming as an effect of agricultural extension to insect farming for food and nutritional security. Figure 5 gives the distribution of the respondents by the level of education in a simple bar chart.

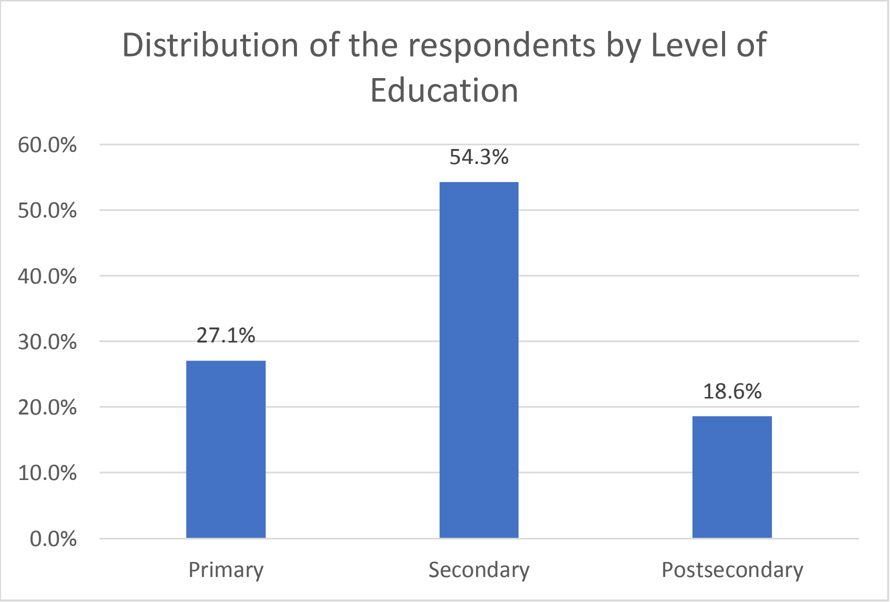


Figure 5: *Distribution of the respondents by Level of Education*

4.1.4. Employment

There was also a need to determine the composition of the participants based on their employment statuses. The research asked participants to indicate their employment statuses. This was useful to determine whether participants were full-time farmers or those who engaged in farming as part-time activity. The results obtained from the responses are summarised below:

Table 5: *Employment status of the Respondents*

		Value	Count	Percent
Valid Values	1	Farming	185	88.1%
	2	Salaried Employment	25	11.9%
	3	Others	0	0.0%

The study findings in Table 5 shows that 11.9% of the respondents were employed while 88.1% were relying on farming. The study findings therefore meant that the main occupation in the region is small scale farming.

4.1.5 Marital Status

The study was also interested in finding out the marital statuses of the participants. However, for a better understanding, there was need to determine the marital statuses by gender. As a result, a cross-tabulation analysis was conducted. The results are summarised below:

Table 6: *Cross tabulation of Marital Status and Gender of the Respondents*

		Gender of the respondent		Total	
		Male	Female		Percent
Civil status of the respondent	Married	136	47	183	87.1%
	Single	3	2	5	2.4%
	Widow/Widower	6	16	22	10.5%
Total		145	65	210	100%

The study established that majority of the respondents (87.1%) were married, 10.5% were widowed while only 2.4% of the respondents were single. This means that small scale farming is dominated by people who have families. Figure 6 gives a distribution of the respondents by marital status on chart figure as a percentage of the total respondents given in three categories i.e. married, single and widow/widower.

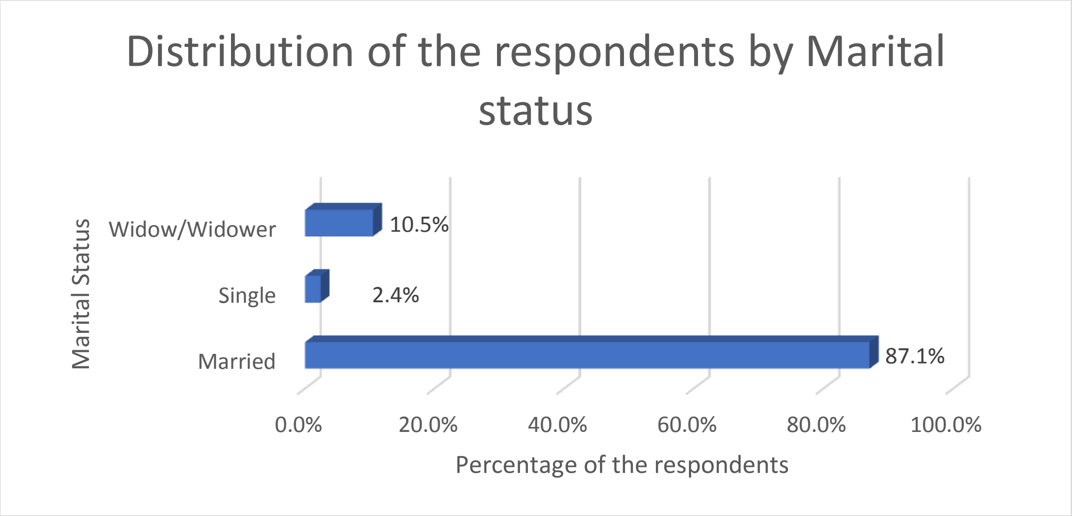


Figure 6: *Distribution of the Respondents by Marital Status*

4.1.6 Number of dependents

Given the fact that the study was interested in how insect farming can be used to improve on food and feed security, there was a need to determine the level of dependency among the participants. Participants were asked to state their dependents. The responses obtained are summarised in the following table:

Table 7: *Cross tabulation of number of dependents against the civil status*

Number of dependents		Civil status of the respondent Married	Single	Widow/Widower	Total	Percent
Number of dependents	0-4 Dependents	80	5	11	96	45.7%
	5-9 Dependents	97	0	11	108	51.4%
	10 + dependents	6	0	0	6	2.9%

The results in Table 7 established that 45.7% of the families had between 0 and four dependents, 51.4% had between five and nine dependents and 2.9% had more than nine dependents. This shows that more than 54% of the respondents have more than 4 dependents which may explain the food security situation in Kenyan Lake Victoria Basin as argued by Paddy (2003) that food requirements increase in relation to the number of persons in a household (dependents). This means that the families were large and therefore needed increased food requirements (Paddy, 2003).

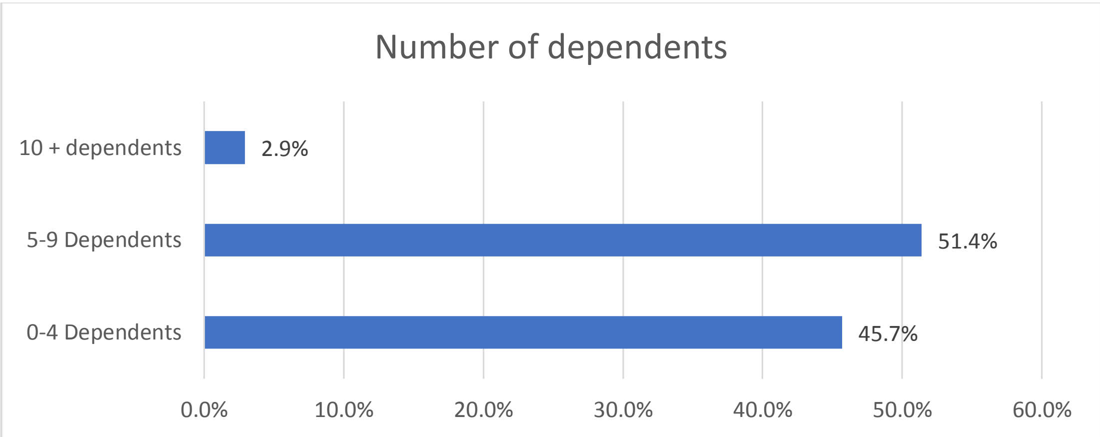


Figure 7: *Distribution of the respondents by number of dependents*

4.1.8 Land size

For purposes of having an insight into how extensive the farming of insect maybe, there as a need to examine the land size. The assumption was that with large land size, it was not necessary to engage in insect farming since there was enough space for traditional farming practices for both crops and livestock. Moreover, the present study focused mainly on small-scale farmers. The idea behind finding out the land size was to determine whether indeed the participants were small-scale farmers. The results are summarised below:

Table 8: *Land size of the Respondents*

		Value	Count	Percent
Valid Values	1	Less than 6 Ha	195	92.9%
	2	Between 6 –to- 10 Ha	10	4.8%
	3	Above 10 Ha	5	2.4%

The respondents were asked to state the acreage of their land and 92.9 % of the respondents indicated that they had less than six acres while 4.8% had between 6 to 10 acres of land. Only 2.4% of the respondents had more than 10 acres. These findings may be used to explain the food security situation in Kenyan Lake Victoria Basin as the findings agree with the views of Preibisch *et al* (2002), Njuki *et al* (2004) and Doka and Monimart (2004) who noted that land was one of the determinants of food security in small scale farming since more than 95% of the respondents had less than 10 acres of land.

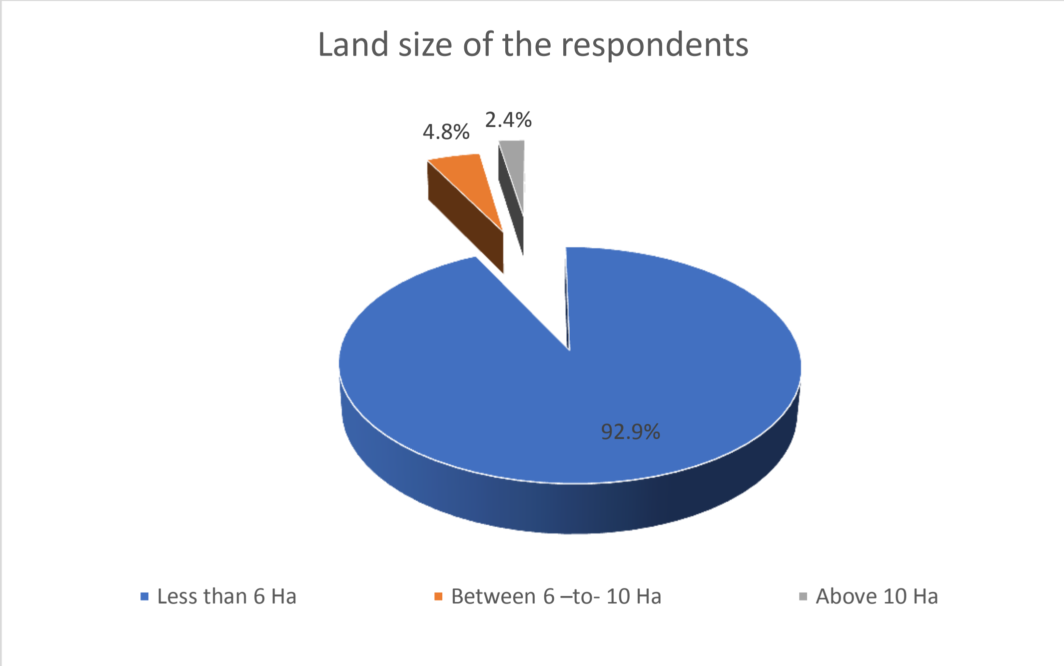


Figure 8: *Land size of the respondents*

4.1.9 Estimated monthly income and Religious affiliation

There was also a need to establish estimated monthly incomes and religious affiliations of the participants. The assumption was that small-scale farmers tend to be more religious and with relatively low levels of incomes. When asked to state their estimated monthly incomes and religious affiliations, the results obtained are summarised in the following figures:

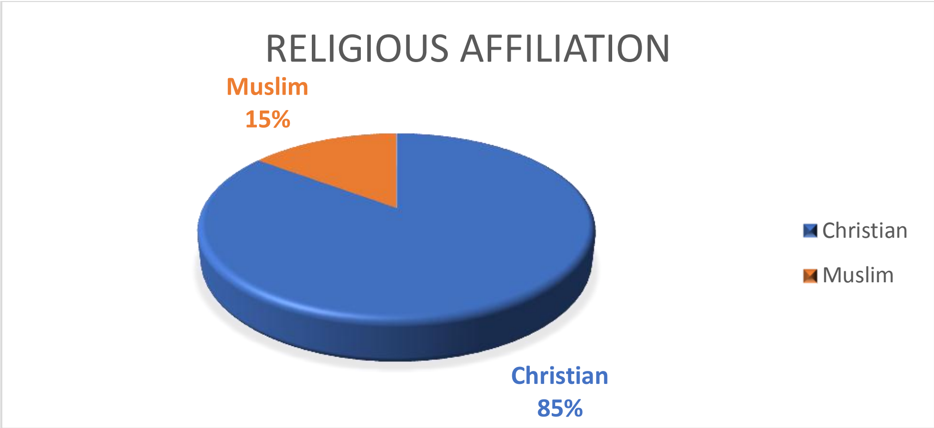


Figure 9: *Religious Affiliation*

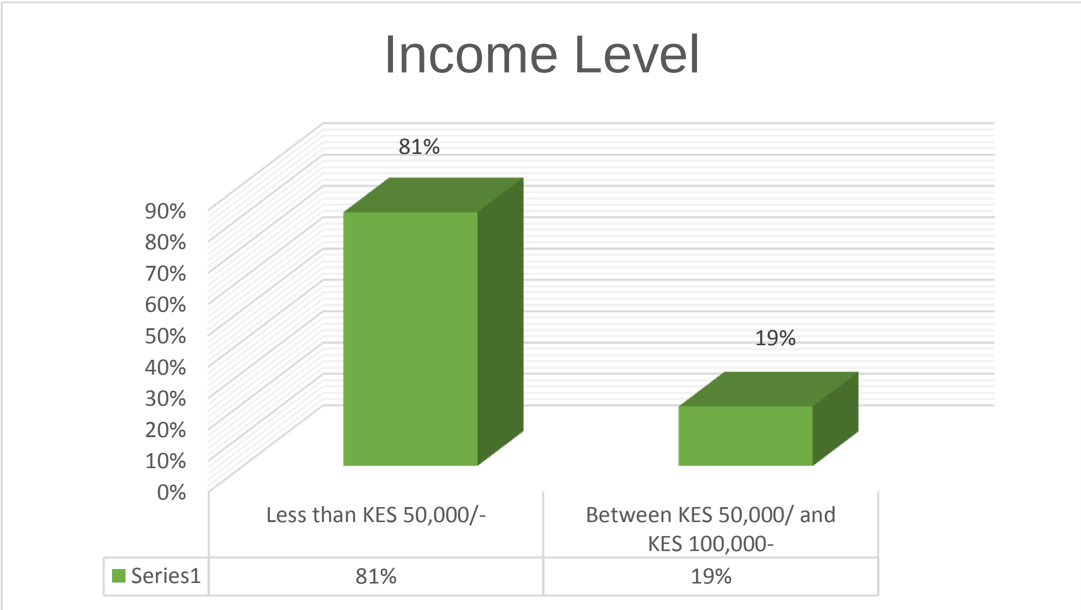


Figure 10: *Estimated monthly income*

Based on the findings, the study established that most of the respondents (81%) had monthly income of less than Ksh. 50,000 with only 19% having an estimated monthly income above Ksh. 50,000. Most of the respondents from the region were confirmed to be Christians at 85% with only 15% being non-Christians.

4.2. Assumptions of Regression Analysis

In achieving the study objectives, regression analysis was used. The rationale behind selecting regression analysis stemmed from its capability to enable the study in forecasting the dependent variable based on changes in the independent variable, a feat not feasible through correlational analysis. Through the adoption of regression analysis, the study utilized the ordinary least squares (OLS) approach, which was contingent upon several underlying assumptions:

i) Linearity in how the factors impacted on the insect farming for food and feed

ii) The anticipated mean error being zero for the estimated regression model.

iii) Homoscedasticity assumptions, signifying a constant variance in the error term.

iv) The assumption of error independence; absence of autocorrelation and multicollinearity.

v) The errors following a normal distribution.

The objective was to attain Best Linear Unbiased Estimators (BLUE) outcomes. Consequently, it became imperative to investigate whether the mentioned assumptions were adhered to or violated.

The choice to utilize regression analysis over correlation was driven by the distinct advantage it offered, permitting the study to not just examine relationships between variables, but to predict the dependent variable based on alterations in the independent variable. The ordinary least squares (OLS) approach was adopted due to its efficacy in minimizing the discrepancies between the observed and predicted values by adhering to certain prerequisites. These prerequisites included assumptions of linearity in how the factors influenced adoption of insect farming, the expected error's mean value being zero for the model, consistent variance in the error term (homoscedasticity), the independence of errors to avert autocorrelation and multicollinearity, and a normal distribution of errors.

Given the critical reliance on the integrity of these assumptions for accurate regression outcomes, an evaluation was necessary to ascertain compliance or breaches in these conditions. Consequently, this verification was essential to ensure the reliability and validity of the obtained results, allowing for a more accurate understanding and interpretation of the relationships between variables in the insect farming adoption by small holder farmers.

Commencing from the foundational presumptions of normality, linearity, and multicollinearity, this study engaged various diagnostic tools to evaluate these assumptions. Specifically, the examination employed normal probability-probability (P-P) plots, scatterplots of the residuals, and Variance Inflation Factor (VIF) assessments. The subsequent analysis involved statistical tests focusing on the normality of residuals, featuring the Shapiro-Wilk test and the Kolmogorov-Smirnov test, as displayed in Table 9.

Table 9: ***Tests of Normality***

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Unstandardized Residual	0.170	210	.547	0.927	210	.325

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

The idea was to use the Shapiro-Wilk given the size of the dataset falling below the threshold of 2,000. The obtained p-value from the Shapiro-Wilk test exceeding 0.05 implies that, at a 5% significance level, the study failed to reject the null hypothesis (H0), thereby concluding that the data likely conforms to a normal distribution.

To provide further validation for the assumption of normality, the study constructed a normal P-P plot.

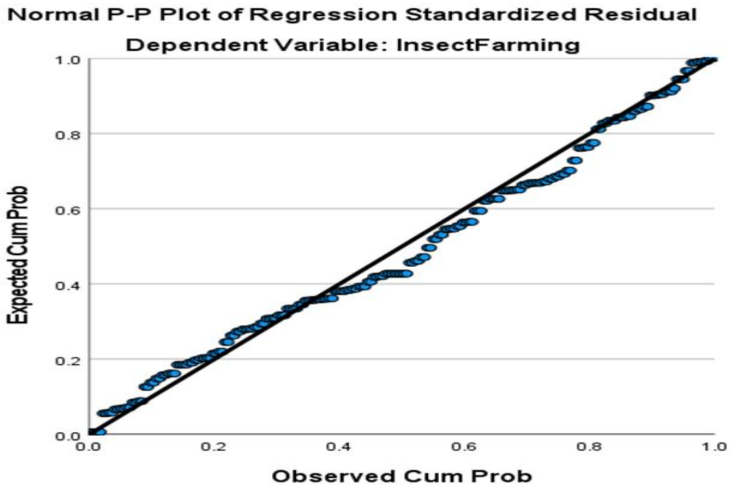


Figure 11: *Normal P-P Plot of regression standardized residuals*

The graphical representation was essential in determining whether the data was normally distributed given the residuals. According to the results, the graphical representation illustrates that, by and large, the residuals align closely with the expected normality line. While there exist sporadic deviations where certain residuals diverge from this anticipated trajectory, the predominant trend strongly suggests adherence to a distribution that aligns with normality. This observation bolsters the credibility of assuming normality within the dataset, despite occasional deviations from the anticipated pattern.

Moreover, the investigation delved into the descriptive statistics concerning both the residuals and the predicted values. These statistical analyses were conducted in alignment with the foundational assumption that the expected mean error amounts to zero. The results of these statistics are meticulously depicted in the accompanying table, providing a comprehensive visual representation of the findings.

Table 10: *Residual Statistics*

Residuals Statistics[a]					
	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	1.6796	3.3648	2.4146	0.39316	210
Residual	-1.51511	2.14494	0.0000	0.59455	210
Std. Predicted Value	-1.869	2.417	0.0000	1.000	210
Std. Residual	-2.542	3.599	0.0000	0.998	210
a. Dependent Variable: Insect Farming					

Table 10 above offers crucial insights into the residual values and their descriptive statistics in the context of the assumption that the expected mean error term is zero. These statistics offer a comprehensive understanding of the variations and properties of the residuals. The minimum and maximum values of the residuals indicate the range within which these errors fluctuate. The residual values range from -1.51511 to 2.14494, depicting the spread of deviations between predicted and actual values. In addition, the mean of the residuals is presented as 0.0000, while the standard deviation is 0.59455. A mean of zero suggests that, on average, the errors tend to balance out to zero, indicating that the model's predictions are, on average, correct. However, the standard deviation showcases the degree of dispersion or variability among these errors. In this case, the standard deviation suggests the spread or distance of the residuals from the mean.

In interpreting these statistics with respect to the assumption that the expected mean error term is zero, it is notable that the mean of the residuals is reported as 0.0000, implying that, on average, the errors balance out to zero. This suggests that the model, on average, is accurate in predicting the outcome. However, the standard deviation of 0.59455 indicates that the spread of these residuals from the mean is significant, suggesting variability in the accuracy of predictions. The standardized residuals also show the extent of deviations from the mean in terms of standard units. Although the mean being close to zero suggests that, on average, the model is unbiased, the variability indicated by the standard deviation signifies that the model's accuracy varies across observations. The dispersion in the residuals might prompt further investigation into the potential sources of variability and outliers, which could affect the model's predictive capability in specific instances.

Notably, through the utilization of ANOVA, specifically by regressing the squares of residuals against the independent variables, this investigation aimed to assess the possible breach of the homoscedasticity assumption. The obtained ANOVA results are presented as follows:

Table 11: *Analysis of Variance for testing Assumptions of Linear Regression*

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	32.307	1	32.307	90.958	<0.001[b]
	Residual	73.878	208	0.355		
	Total	106.185	209			
a. Dependent Variable: Insect Farming						
b. Predictors: (Constant), Agricultural Extension Services						

It is important to indicate that the ANOVA results play a significant role in assessing the assumption of homoscedasticity, a crucial aspect in regression analysis. In this context, the key elements for evaluating homoscedasticity include the comparison of the residual mean square from the regression model against the residual mean square from the error term.

Based on the ANOVA results in Table 11, there is a sum of squares of 32.307 with 1 degree of freedom (df), resulting in a mean square of 32.307. This pertains to the variability in the regression model due to the predictor variable (Agricultural Extension Services). However, the residual row indicates a sum of squares of 73.878 with 208 degrees of freedom, resulting in a mean square of 0.355. This particular aspect indicates the unexplained variability or errors in the model after accounting for the predictors.

In the context of evaluating homoscedasticity, attention is directed toward the comparison of mean squares. The assessment involves observing whether the variances of the residuals remain consistent across the different values of the independent variable (Agricultural Extension Services). If the assumption of homoscedasticity holds true, the variability in the residuals should remain constant across all levels or values of the predictors.

Here, the mean square from the residual row (0.355) reflects the variability that remains unexplained by the model. The relatively smaller value of the residual mean square compared to the regression mean square might suggest a degree of consistency in the variance of the residuals across the range of the predictor variable. This closer correspondence between the residual variances implies that the assumption of homoscedasticity could be upheld in this particular regression model.

Moreover, the high F-value of 90.958 and a statistically significant p-value (<0.001) suggest a strong relationship between the independent variable, which in this case is the Agricultural Extension Services, and the dependent variable, which is the Insect farming for food and feed. This robust relationship between the predictor and the outcome indicates the effectiveness of the model in explaining the variation in the dependent variable. Nevertheless, while the results suggest adherence to homoscedasticity, further diagnostic checks or residual plots could provide a more comprehensive assessment and verification of the assumption across different segments of the data.

The other assumptions were of autocorrelation and multicollinearity. In this study, Variance Inflation Factor (VIF) and Durbin-Watson tests were used in scrutinizing the potential breach of autocorrelation and multicollinearity assumptions. The VIF outcomes are presented below, serving as a diagnostic tool to assess the severity of multicollinearity. The VIF results are crucial in determining the level of multicollinearity within the model. High VIF values indicate heightened multicollinearity, which could affect the precision and reliability of the regression estimates. Meanwhile, low VIF values imply minimal multicollinearity, reinforcing the credibility of the regression model.

By assessing the Variance Inflation Factor, the study aimed to ascertain the extent of multicollinearity, a condition where independent variables in a regression model are highly correlated, thereby impacting the model's reliability in estimating the relationships between predictors and the target variable. The VIF values aid in detecting the correlation between predictors, with high VIF values indicating the potential presence of multicollinearity, which might necessitate corrective measures for more accurate regression analysis.

The utilization of Durbin-Watson statistics, on the other hand, aims to detect potential autocorrelation in the residuals of a regression analysis. Autocorrelation occurs when errors in a time series data or observations are correlated with each other, possibly leading to biased and less efficient regression estimates. The Durbin-Watson test helps identify the presence and severity of autocorrelation by examining the correlation of residuals at various lags.

In summary, the incorporation of VIF and Durbin-Watson tests serves as an essential step in diagnosing multicollinearity and autocorrelation issues, ensuring the reliability and validity of regression model results. The obtained outcomes provide crucial insights into the presence and magnitude of these issues, guiding further steps for remediation or adjustments to enhance the accuracy of the regression analysis. The results of the VIF are as follows;

Table 12: *VIF and Durbin-Watson Statistics*

Model		Collinearity Statistics		Durbin-Watson
		Tolerance	VIF	
1	(Constant)			1.304
	Agricultural Extension Services	1.000	1.000	

Additional collinearity diagnostic tests are provided as follows;

Table 13: *Additional collinearity diagnostic*

Collinearity Diagnostics[a]

Model	Dimension	Eigenvalue	Condition Index	Variance Proportions	
				(Constant)	Agricultural Extension Services
1	1	1.973	1.000	0.01	0.01
	2	0.027	8.551	0.99	0.99

a. Dependent Variable: Insect Farming

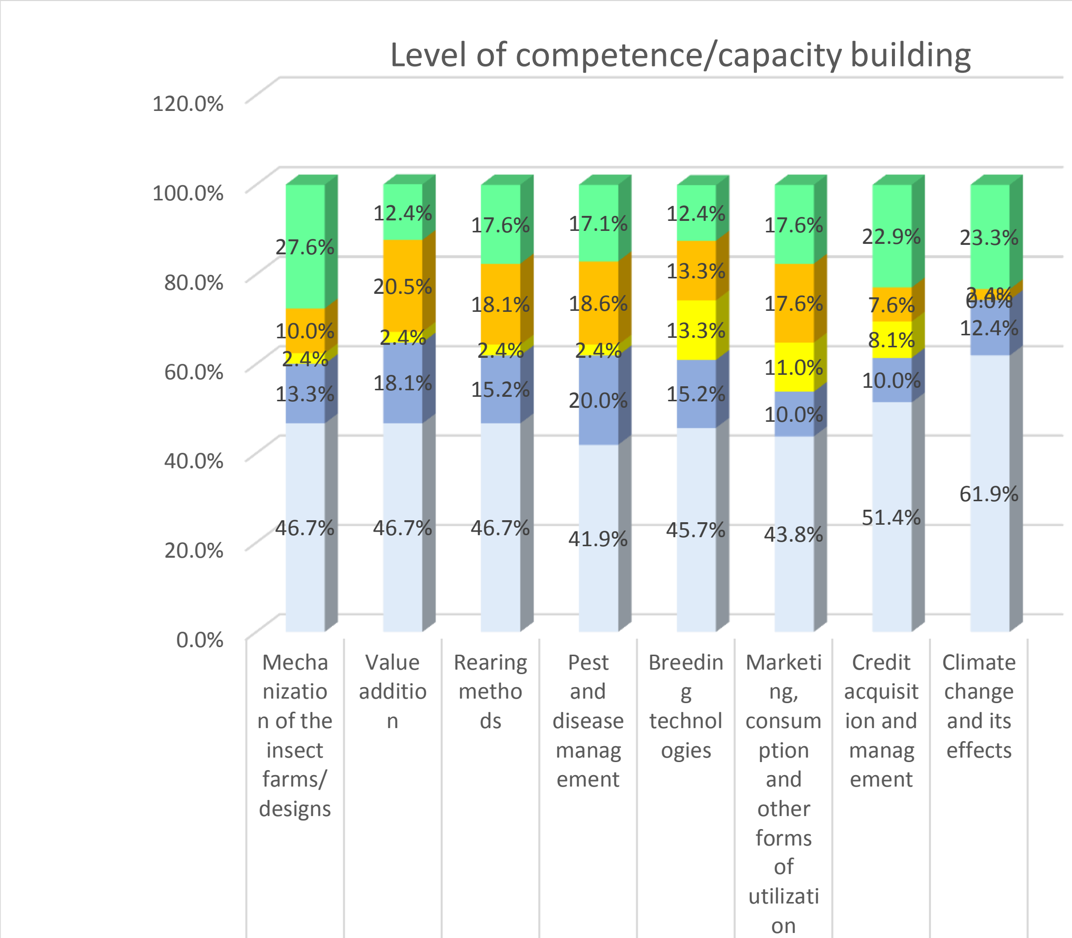
From the results, the Durbin-Watson test = 1.713. Rule of the thumb posits that values between 1.5 and 2.5 are considered normal with no multicollinearity. In addition, all the VIF values < 10. Given these findings, the study confirms that assumptions of multicollinearity and autocorrelation are not violated.

Since all the diagnostic tests performed indicate that all the assumptions of ordinary least squares were not violated, the study proceeded to establish how the independent variables affected the dependent variable as indicated in the sections that follow.

4.3. Agricultural Extension Services

The independent variable in this study was the agricultural extension services within the Kenya's Lake Victorian Basin. Prior to establishing how agricultural extension services would influence the insect farming for food and feed, there was a need to understand the level of agricultural extension services in the selected study site. Several questions were asked that assisted in measuring agricultural extension services. It was imperative to establish how to measure agricultural extension services, which then formed the basis of conducting additional inferential statistical analysis to determine its effects on the other aspects of insect farming for food and feed.

In measuring the level of agricultural extension services, the study asked the participants to state how far the small holder farmers agreed with the level of competence to handle mechanization of the insect farms/designs, rearing methods, value addition, pest and disease management, breeding technologies, marketing, consumption and other forms of utilization, credit acquisition and management and finally climate change and its effects. Figure 12 provides a summary of the responses among the small-scale farmers in the Kenyan Lake Victoria Basin.



	Mechanization of the insect farms/ designs	Value addition	Rearing methods	Pest and disease management	Breeding technologies	Marketing, consumption and other forms of utilization	Credit acquisition and management	Climate change and its effects
Strongly Agree	27.6%	12.4%	17.6%	17.1%	12.4%	17.6%	22.9%	23.3%
Agree	10.0%	20.5%	18.1%	18.6%	13.3%	17.6%	7.6%	2.4%
Undecided	2.4%	2.4%	2.4%	2.4%	13.3%	11.0%	8.1%	0.0%
Disagree	13.3%	18.1%	15.2%	20.0%	15.2%	10.0%	10.0%	12.4%
Strongly Disagree	46.7%	46.7%	46.7%	41.9%	45.7%	43.8%	51.4%	61.9%

Figure 12: *Level of competence/capacity building*

Notably, Fig. 12 offers an extensive overview of the capacities and perceived competencies of smallholder farmers in the Kenyan Lake Victoria Basin across various facets of insect farming. Firstly, a significant majority, precisely 62.4% of the respondents, did not either agree or strongly agree with their competence or capacity to handle the mechanization of insect farms and designs. Only 37.6% of smallholder farmers expressed acceptance that they possess the necessary skills to manage the mechanization aspect of insect farming. This discrepancy indicates a notable gap in the perceived capabilities of farmers in managing mechanized aspects of insect farming.

Similarly, when it comes to the competence in rearing methods, 61.9% of the respondents collectively disagreed with their proficiency, while merely 35.7%

supported their competence in these methods. This disparity underscores a widespread lack of confidence in handling the techniques related to rearing insects for farming purposes among the surveyed farmers. Concerning the management of pest and diseases, the statistics revealed that 61.9% of farmers admitted to feeling unable to manage pests and diseases effectively, while only 35.7% acknowledged their ability to handle these critical aspects of insect farming. This suggests a substantial gap in the farmers' knowledge and skill in combating pests and diseases in insect farming practices.

Moreover, in terms of breeding technologies, a notable 60.9% of farmers expressed their disagreement with their capacity to handle breeding technologies competently. Only 25.7% of respondents admitted to possessing the necessary skills to handle breeding technologies, emphasizing a significant need for improvement and education in this domain. The study also explored the farmers' perceived capacities in marketing, consumption, and other forms of utilization related to insect farming. Here, 53.8% of the respondents failed to agree on their competence in handling these aspects, while only 35.2% admitted their proficiency in managing marketing, processing, consumption, and other forms of utilization in the context of insect farming. In respect to the credit acquisition and management, a substantial 61.4% of the farmers disagreed with their capability in handling credit acquisition and management. Merely 30.5% admitted to being competent in this area, indicating a need for support and education in financial matters concerning insect farming.

Finally, the study assessed the capacity of farmers to handle the effects of climate change. A significant 74.3% either disagreed or did not strongly agree with their competence in managing the effects of climate change. Only 25.7% felt confident in their ability to handle the challenges posed by climate change in the context of insect farming. The obtained information collectively emphasizes widespread inadequacies and varying degrees of competence among smallholder farmers in the Kenyan Lake Victoria Basin in critical areas related to insect farming. The statistics underscore the urgent need for training, support, and capacity-building initiatives to enhance the farmers' skills and knowledge in these crucial aspects of insect farming for sustainable and successful agricultural practices.

The insights obtained from the data on agricultural extension services in the Kenyan Lake Victoria Basin can be contextualized within the framework of previous scholarly works and studies. These findings align with and validate the viewpoints expressed by various scholars in the field of agricultural extension services. Notably, Feller (2019) emphasizes the enduring significance of agricultural extension services, tracing their historical emergence and the continuous interest they have garnered among both scholars and practitioners since the classical period. This aligns with the enduring importance and attention dedicated to agricultural extension services over time. Similarly, Koutsouris (2018) highlights the pivotal role of agricultural extension in the agricultural sector, emphasizing its diverse concepts and models crucial for disseminating knowledge, fostering technological advancements, and aiding farmers in adopting innovative practices. These insights affirm the multifaceted nature and importance of agricultural extension in driving agricultural progress.

Moreover, the works of Altalb *et al*. (2015) and McFall and McKelvey (1989) underline the primary goal of agricultural extension services: to bridge the gap between scientific knowledge, research findings, and practical applications in farming. By doing so, these services aim to enhance agricultural productivity, sustainability, and the livelihoods of farmers. This resonates with the overarching purpose and objectives of agricultural extension services in improving agricultural practices and farmer well-being. From a different standpoint, Taylor and Bhasme (2018) present the idea that various models exist within agricultural extension, each offering distinct approaches to disseminating information and supporting farmers in their endeavours. This suggests the diverse array of methods available for extending information to farmers and facilitating their agricultural pursuits.

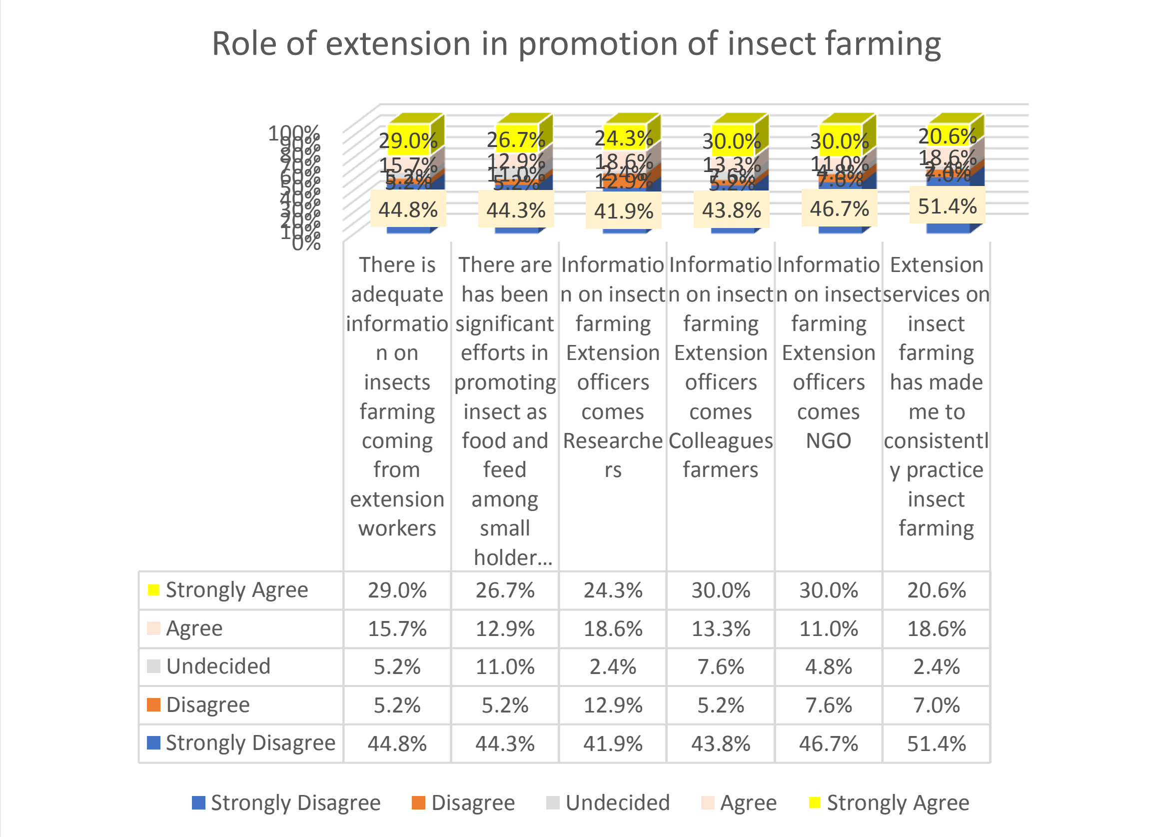
Collectively, these scholarly perspectives suggest that agricultural extension services have seen an upsurge in various regions in recent times, adopting diverse models and methodologies. These insights align with the observations drawn from the participants' responses regarding agricultural extension services in the Kenyan Lake Victoria Basin, indicating the diversity and evolving nature of these services in different regions. The convergence of these scholarly viewpoints with the responses obtained from participants further supports the understanding of the evolving landscape of agricultural extension services in the specific context of the Kenyan Lake Victoria Basin.

4.5. Agricultural Extension Services and Promotion of Insects Farming

The first objective of the study was ***to determine the effects of agricultural extension on the promotion of insects as food and feeds among small-scale farmers in the Kenyan Lake Victoria Basin***. This objective was meant to establish the role of agricultural extension in promoting insect farming. The indicators were the extent to which the respondents agreed with the statements on access to information on insect farming and the level of competence/capacity building. The objective was attained through a combination of descriptive and inferential statistics as explained in the earlier chapter. The objective was attained by finding answers to the question ***"what is the role of agricultural extension in the promotion of insects for food and feeds among small-holder farmers in the Kenyan Lake Victoria Basin?"*** While the descriptive statistical analysis assisted in understanding how the promotion level of insect farming for food and feed was measured in the research, the inferential statistical analysis was useful for determining how agricultural extension services affected the promotion.

4.5.1. Descriptive statistics on Promotion level of Insect Farming

In order to achieve the first objective, there was a need to understand the promotional level of insect farming for food and feed in Kenyan Lake Victoria Basin. The idea was to measure the promotion level using different items developed from the previous studies. The study used 5-point Likert scale to ask participants state their levels of agreement and disagreement with the statements on the promotion levels of insect farming for food and feed in the Kenyan Lake Victoria Basin. Figure 13 gives the percentage summary and bar graph from the variable statements.



	There is adequate information on insects farming coming from extension workers	There are has been significant efforts in promoting insect as food and feed among small holder...	Information on insect farming Extension officers comes Researchers	Information on insect farming Extension officers comes Colleagues farmers	Information on insect farming Extension officers comes NGO	Extension services on insect farming has made me to consistently practice insect farming
Strongly Agree	29.0%	26.7%	24.3%	30.0%	30.0%	20.6%
Agree	15.7%	12.9%	18.6%	13.3%	11.0%	18.6%
Undecided	5.2%	11.0%	2.4%	7.6%	4.8%	2.4%
Disagree	5.2%	5.2%	12.9%	5.2%	7.6%	7.0%
Strongly Disagree	44.8%	44.3%	41.9%	43.8%	46.7%	51.4%

Figure 13: *Role of extension in promotion of insect farming*

The study findings reveal intriguing statistics that shed light on the perceptions and opinions of smallholder farmers in the Kenyan Lake Victoria Basin concerning agricultural extension services in respect to the different aspects associated with the insect farming for feed and food.

First and foremost, the study established that precisely 50% of the respondents jointly disagreed and strongly disagreed with the notion that there is adequate information on insect farming coming from extension workers. Only 44.7% of the respondents supported the statement that extension workers provide sufficient information on insect farming. In a similar vein, a significant 49.5% of smallholder farmers differed with the assertion that there have been noteworthy efforts in promoting insects as food and feed in the region, whereas only 39.6% agreed with this statement. These statistics offer valuable insights into the effects of agricultural extension services to insect farming practices in the Kenyan Lake Victoria Basin.

Moreover, the study revealed that 54.8% of smallholder farmers did not support the idea that information on insect farming comes from researchers, while only 42.9% of respondents supported this statement. As for the origin of information from fellow farmers, 49% of the respondents expressed disagreement, while 43.3% endorsed the claim. These statistics underline the variations in the sources of information and the degree of trust that smallholder farmers have in different information providers. Furthermore, the study unveiled that a majority, specifically 54.3% of the respondents, disagreed that information on insect farming originates from non-governmental organizations (NGOs), whereas only 41% collectively agreed that NGO-provided information plays a role in insect farming practices within the Kenyan Lake Victoria Basin. These figures provide valuable insights into the perceived involvement of NGOs in promoting insect farming and the extent to which farmers trust information from this source.

When it comes to the impact of extension services on insect farming practices, 54.8% of the respondents cumulatively disagreed and strongly disagreed with the notion that extension services have made them consistently engage in insect farming. In contrast, only 39.2% of farmers jointly agreed and strongly agreed that extension services have positively influenced their consistency in insect farming practices. These figures demonstrate the varying degrees of influence that extension services exert on farmers in the region. Additionally, the study delved into the farmers' self-assessment of their competence in various aspects related to insect farming, encompassing mechanization, rearing methods, value addition, pest and disease management, breeding technologies, marketing, consumption, credit acquisition, and management, as well as climate change and its effects. The specific percentages for these competencies are illustrated in Figure 8, offering a detailed overview of the diverse landscape of attitudes and competence levels among the farmers in the Kenyan Lake Victoria Basin.

These statistics signify a multitude of implications. The disparities in information sources and the perceived impact of extension services suggest potential areas for improvement in knowledge dissemination and support systems. The variations in competence levels could point towards the need for targeted training and education in various facets of insect farming. Furthermore, these figures could emphasize the necessity for enhanced collaboration between extension services, researchers, NGOs, and the farming community to bolster information sharing and support for insect farming initiatives. In essence, these statistics provide a nuanced and comprehensive understanding of the challenges and opportunities for the development of insect farming as a sustainable practice among smallholder farmers in the Kenyan Lake Victoria Basin.

The obtained findings corroborate previous findings on the aspects of insect farming for food and feed around the world particularly with respect to promotion. In their submissions, Wu, *et. al.* (2023) noted the recent significant growth of insect farming or production systems globally. This surge in interest is primarily due to the potential of these systems in addressing various global challenges, such as food security, environmental sustainability, and economic development, as emphasized by Alemu, *et. al.* (2023). Additionally, Specht, *et. al.* (2019) highlight the growing interest in insect farming owing to its potential as a sustainable and efficient source of food and feed. Insects like crickets, mealworms, and black soldier flies, detailed by Chaalala, *et. al.* (2018), are rich in protein, essential amino acids, and various micronutrients, presenting a promising solution to global food insecurity, particularly in regions where traditional protein sources are scarce. From a different perspective, Gabowski, *et. al.* (2022) underscore one of the primary advantages of insect farming - its high efficiency in resource utilization.

Insects, as detailed by Matandirotya, *et. al.* (2022), require significantly fewer resources such as feed, water, and space, compared to traditional livestock like cattle. For example, crickets need substantially less feed to produce the same amount of protein as cattle or pigs and can thrive on organic waste, a point highlighted by Matandirotya, *et. al.* (2022). The findings of the present study in collaboration with previous studies confirm that indeed there seems to be increased promotion of insect farming for food and feed. Indisputably, the aforementioned studies as well as the present study confirms the increased promotion of insect farming for food and feed not only in the Kenyan Lake Victoria Basin but also across the globe. The present study was interested in agricultural extension services; hence, the concern was whether agricultural extension services had something to do with the increasing promotion of insect farming for food and feed. The section that follows provide an inferential statistical analysis to determine whether agricultural extensions services had a significant influence in the promotion of insect farming for food and feed in the Kenyan Lake Victoria Basin.

4.5.2. Agricultural Extension Services (AES) and Promotion of Insect Farming

Having confirmed that there is increased promotion of insect farming for feed and food in the Kenyan Lake Victoria Basin on one hand and increased adoption of agricultural extension services on the other hand, there was a need to establish whether the latter informed the former. To achieve this, the study conducted a regression analysis. The results of the regression analysis are summarised in the following tables:

Table 14: *Model Summary: Agricultural Extension Services and Promotion of Insect Farming*

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.457[a]	.209	.205	.77370
a. Predictors: (Constant), Agricultural Extension Services				

The first step was to confirm the goodness of fit of the model using R-squared. The r value in the model is 0.457, signifying the correlation coefficient, which measures the strength and direction of the relationship between the predictor variable (Agricultural Extension Services) and the outcome variable (Promotion of Insect Farming for Food and Feed). A value of 0.457 suggests a moderate positive correlation between these variables.

The 'R Square' value, at 0.209, indicates the coefficient of determination, expressing the proportion of variance in the dependent variable (outcome) that is predictable from the independent variable (Agricultural Extension Services). In this case, approximately 20.9% of the variance in the promotion of insect farming for food and feed in the Kenyan Lake Victoria Basin can be explained by changes in the agricultural extension services. On the other hand, the adjusted r-square of 0.205 is similar to r-square but takes into account the number of predictors in the model and adjusts the value accordingly. It is slightly lower than the R Square, suggesting that the model may not be substantially improved by adding more predictors.

The standard error of estimate (0.77370) provides an estimate of the variability or error in the predictions made by the model. It reflects the average distance that the observed values fall from the regression line, indicating the accuracy of the model's predictions. In interpretation, the r and r-square values indicate that agricultural extension services explain approximately 21% of the variance in the promotion of insect farming for food and feed in the Kenyan Lake Victoria Basin. While the correlation is moderate, it suggests that other factors beyond agricultural extension services may also influence the outcome variable. The adjusted r-square being slightly lower than the r-square indicates that additional predictors might not significantly improve the model's explanatory power. Overall, this analysis suggests a moderate relationship between agricultural extension services and the promotion of insect farming for food and feed in the Kenyan Lake Victoria Basin, but it may be beneficial to consider other variables or factors to better explain the variance observed in the outcome.

Having established that the model was a good fit using r-squared, there was a need to confirm the same using the ANOVA. The following is a result of the ANOVA obtained from the findings.

Table 15: *ANOVA for Agricultural Extension Services and Promotion of Insect Farming*

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	32.810	1	32.810	54.810	<.001[b]
	Residual	124.510	208	.599		
	Total	157.320	209			

a. Dependent Variable: Promotion of Insect Farming

b. Predictors: (Constant), Agricultural Extension Services

The results of the ANOVA help in further exploration of how the model provides a good prediction of the relationship between the predictor variable (agricultural extension services) and the dependent variable (promotion of insect farming for food and feed in the Kenyan Lake Victoria Basin). The regression model indicates that the predictor variable, agricultural extension services, has a significant impact on the promotion of insect farming for food and feed in the Kenyan Lake Victoria Basin, as demonstrated by the low p-value ($p < .001$). The F-statistic, at 54.810, indicates a strong relationship between the predictor and the dependent variable.

The regression row of the table 15 reveals several information. First, it reveals that the sum of squares of 32.810 represents the amount of variance in the dependent variable (promotion of insect farming for food and feed in the Kenyan Lake Victoria Basin) explained by the predictor variable (agricultural extension services). The df (degrees of freedom) for the regression is 1, indicating the number of predictors in the model. The mean square is also 32.810, calculated by dividing the Sum of Squares by its degrees of freedom, which represents that the average variance attributed to the model is approximately 32.81%. The residual further indicates that 124.510 is the amount of variance in the dependent variable that the model fails to explain.

From the findings, it can be noted that the regression model with the agricultural extension services as a predictor significantly explains the variance in the promotion of insect farming for food and feed in the Kenyan Lake Victoria Basin. The low p-value (<.001) and high F-value (54.810) both suggest a strong relationship between agricultural extension services and the promotion of insect farming for food and feed in the Kenyan Lake Victoria Basin. However, the model might not account for all the variance, as indicated by the residual values. Overall, the model is statistically significant in predicting or explaining the promotion of insect farming for food and feed in the Kenyan Lake Victoria Basin, but there might be other factors not included in this model that could contribute to the variance observed in the dependent variable.
After confirming that indeed the model was a good fit for the data, the next step was to examine the coefficients of agricultural extension services in terms of direction, magnitude, and significance. The following table provides the results of the coefficients.

Table 16: *Coefficients for Agricultural Extension Services and Promotion of Insect Farming*

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	.905	.231		3.913	<.001
	Agricultural Extension Services	.618	.083	.457	7.403	<.001

a. Dependent Variable: Promotion of Insect Farming

Table 16 offers the coefficient of agricultural extension services when it comes to determining its influence on promotion of insect farming for food and feed in the Kenyan Lake Victoria Basin. Starting from the coefficient to constant, the findings indicated that since $\beta_0 = 0.905$ (SE = 0.231) and that the t-value (3.913) has a *p* value $< .05$, it is statistically significant at 5% significance level. Therefore, it can be established that the constant (0.905) is the expected value of the promotion of insect farming for food and feed in the Kenyan Lake Victoria Basin when the predictor variable is zero. Looking at the coefficient to agricultural extension services, $\beta_1 = 0.618$ (SE = 0.083), it has a t-statistic value of 7.403, with a p-value of <.001, signifying that it is statistically significant at 5% significance level. In addition, the standardised beta, which measures the strength of the relationship in standard deviation units, is 0.457.

The findings confirm that when the agricultural extension services are zero, the expected value of the promotion of insect farming for food and feed in the Kenyan Lake Victoria Basin is approximately 0.905. This means that there is some level of promotion even without agricultural extension services within the Kenyan Lake Victoria Basin. From the coefficient of agricultural extension, the study noted that for every one-unit increase in agricultural extension services, the promotion of insect farming for food and feed in the Kenyan Lake Victoria Basin is expected to increase by 0.618 units. The standardized coefficient (Beta) of 0.457 indicates the strength of this relationship in standard deviation units. A higher Beta suggests a stronger influence of agricultural extension services on the promotion of insect farming for food and feed in the Kenyan Lake Victoria Basin.

Overall, the results suggest that agricultural extension services have a statistically significant and positive impact on the promotion of insect farming for food and feed in the Kenyan Lake Victoria Basin. For each unit increase in agricultural extension services, there is an expected increase of approximately 0.618 units in the promotion of insect farming for food and feed in the Kenyan Lake Victoria Basin. The standardized coefficient (Beta) of 0.457 suggests a moderate to strong effect size in standard deviation units, reinforcing the significance of this relationship. Such findings seem to corroborate previous studies suggesting the role of agricultural extension when it comes to promotion of insect farming for food and feed.

The findings are consistent with several previous studies particularly with respect to the role of agricultural extension services on the promotion of insect farming in different regions for food and feed. According to Wu *et al*. (2023), recent years have witnessed a significant surge in the growth of insect farming or production systems worldwide. These systems reflect an emerging and innovative approach to confront a variety of global challenges, including food security, environmental sustainability, and economic development, as highlighted by Alemu *et al*. (2023). The escalating interest in insect farming is primarily driven by its recognized potential as a sustainable and efficient source of food and feed, an observation supported by Specht *et al*. (2019). The rich nutrient content in insects such as crickets, mealworms, and black soldier flies—abundant in protein, essential amino acids, and various micronutrients, as indicated by Chaalala *et al*. (2018)—positions them as a promising solution to global food insecurity, particularly in regions where traditional protein sources are scarce, which is confirmed by Grabowski *et al*. (2022).

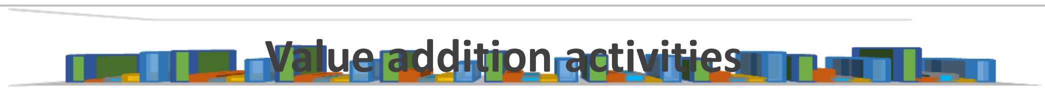
An essential advantage of insect farming lies in its remarkably high efficiency in resource utilization, an observation also highlighted by Matandirotya *et al*. (2022). Compared to conventional livestock like cattle, insects demand substantially fewer resources in terms of feed, water, and space. For instance, crickets as indicated earlier require significantly less feed to produce the same amount of protein as cattle or pigs. Furthermore, these insects have the capacity to thrive on organic waste, thereby presenting an opportunity for sustainable waste management and converting organic by-products into valuable protein sources. Given the aforementioned aspects, the study has established that just like in other regions, the use of agricultural extension services in the Kenyan Lake Victoria Basin has resulted into increased promotion of insect farming for food and feed, which then helps in not only alleviating poverty but also for purposes of attaining sustainability. The interpretation from the findings is that when there are agricultural extension services, small-scale farmers will be able to engage in insect farming for food and feed.

4.6. Agricultural Extension Services and Value addition of Insect Farming

The second objective of the study was ***to investigate the role of agricultural extension towards value addition of insects for food and feeds among small-scale farmers in the Kenyan Lake Victoria Basin***. This objective was meant to establish the influence of agricultural extension on the value addition activities of insect farming and the sustainability of the use of insects as food and feed among the small holder farmers. The objective was attained by finding answers to the question ***"what is the role of agricultural extension in the value addition of insects among food and feed industry players in the Kenyan Lake Victoria Basin?"*** The findings are presented in subsequent sections below.

4.6.1. Descriptive statistics on Value addition activities in Insect Farming

The first step was to understand the level of value addition activities in insect farming in the Kenyan Lake Victoria Basin as well as come up with measures of the same. In this case, the study asked participants to state the extent to which they agreed with the statements on value addition, Figure 14 below gives a multiple bar graph for the value addition activities with their corresponding percentages.



	Processing is done within the small holder farms	Farmers use approved storage procedures	All by products are utilized at farm	Different products including feeds	Other auxiliary ventures are also developed	Extension services support value addition	Microfinance services are available to small holder farmers	Marketing services are available	Consumers normally accept products due to educational interve...
Strongly Disagree	38.6%	45.2%	52.4%	44.3%	43.8%	38.6%	33.3%	38.6%	49.0%
Disagree	2.4%	10.5%	8.1%	15.7%	11.0%	10.5%	13.3%	17.6%	5.2%
Undecided	5.7%	4.3%	4.3%	4.3%	7.6%	11.0%	5.2%	6.7%	11.0%
Agree	10.5%	7.6%	5.2%	8.1%	5.2%	2.4%	5.2%	3.3%	2.9%
Strongly Agree	42.9%	32.4%	30.0%	27.6%	32.4%	37.6%	42.9%	33.8%	31.9%

Figure 14: *Value addition activities*

To investigate the influence of agricultural extension uptake of the value addition of insects for food and feed among the small holder farmers, the research established that more than 10% and about 43% of the respondents agreed and strongly agreed respectively that processing is done within the small holder farms while on the other hand, only 41% of the respondents disagreed and strongly disagreed that processing is done within the small holder farms. About whether farmers use approved storage procedures, only 40% cumulatively agreed and strongly agreed that they use approved storage procedures whereas, more than 55% did not agree with the indicator that Farmers use approved storage procedures.

The question on whether all the by products are utilized in the farm, more than 60% of the farmers cumulatively disagreed and strongly disagreed with only 35% agreed and strongly agreed that all by products are utilized in the farm. As to whether they use different products including feeds as a value addition activity, it's evident that 60% of the farmers disagreed with the activity with only 35% aggregately agreed that they use different products including feeds as value addition activity on insect products. From the findings, only 40% of the small holder farmers collectively agreed and strongly agreed that Extension services support value addition with about 50% disagreeing with the claim. On the matter of whether microfinance services are available to small holder farmers, this was supported by only 48% of the respondents with over 50% failing either to agree or strongly agree that microfinance services are available to small holder farmers as a value addition activity.

The study also asked the participants to indicate whether marketing services were available to the farmers, only 37% of the small holder farmers jointly agreed and strongly agreed that the marketing services were available to the farmers with over 60% not supporting the statement as part of support to value addition activities. Based on the past experience of the farmers, the research tried to assess whether consumers in the region normally accept products due to educational interventions and it was established that only 35% of the respondents agreed that consumers normally accept products due to educational interventions with about 55% of farmers failing to agree with the study variable as supportive to value addition activities.

The responses obtained from the participants are consistent with existing submissions from different scholars particularly on the aspects of value addition activities in insect farming for food and feed. Notably, the study by Roffeis, *et. al.* (2017) indicated that the sector of insect value chains and value addition is diverse, encompassing various uses such as food, feed, pharmaceuticals, and industrial applications. It involves a range of activities from rearing, processing, and distribution to creating innovative insect-based products (Reim et al, 2019). These interconnected chains undergo multiple stages, including rearing and cultivation, harvesting and processing, and value addition, aiming to refine insect-based products for diverse applications (Chia et al, 2019). The evident facts are that insect farming requires value addition activities for purposes of achieving intended goals and objectives.

It is also important to note that the initial steps of insect value chains involve rearing and cultivating insects with specific environmental and dietary requirements to attain a high-quality insect product (Tanga et al, 2021). Harvesting and processing depend on the species and intended uses, with various techniques applied, such as drying, grinding, or extraction of specific components like proteins, lipids, or chitin (Madau et al, 2020). This processing led to ingredients or finished products being suitable for human consumption, animal feed, or other applications. The value addition phase encompasses refining insect-based products, such as insect proteins, which might undergo additional processes like purification to improve functionality or purity (Ameixa et al, 2020). It also involves innovative product development, such as insect-based snacks or protein powders, aimed at diverse markets and consumer preferences (Riccaboni et al, 2021).

Another important aspect that comes out from the present study findings, which are also consistent with previous findings is that efforts to enhance the functionality and market appeal of insect-based products are central to value addition (Berggren et al, 2019). Refining insect materials for different applications involves the extraction of specific nutrients or components, like proteins, fats, or chitin, with unique nutritional or functional properties (Roffeis et al, 2017). This might entail isolating specific amino acids from insect proteins or extracting insect fats for various applications. Value addition also focuses on creating appealing, nutritious insect-based food items that cater to changing consumer demands (Kinyuru & Ndung'u, 2020). However, challenges exist due to varying regulatory frameworks and consumer perceptions across regions, which impact market acceptance (Macombe et al, 2019). Standardization in production methods, quality control, and research and development are necessary to enhance scalability and consistency in the insect-based product industry (Madau et al, 2020). Collaborative efforts among policymakers, researchers, and industry players are crucial to address these challenges and foster growth in the industry.

The future of insect value chains is promising, with ongoing research and development striving to address challenges and capitalize on the potential of insects in various applications (Riccaboni et al, 2021). Advances in processing technologies and genetic improvements in insect strains, along with increased consumer acceptance of insect-based products, signal a promising trajectory for the industry's future growth.

In this respect, the study has confirmed that there are indeed value addition activities in insect farming for food and feed in the Kenyan Lake Victoria Basin. However, one major concern is whether agricultural extension services play a role in the value addition activities in insect farming. This concern formed the basis of the present study. The section that follows tries to examine and establish the relationship between agricultural extension services available in the Kenyan Lake Victoria Basin and the identified value addition activities in insect farming for feed and food.

4.6.2. Agricultural Extension Services and Value Addition in Insect Farming

Upon validating the involvement in value addition processes within insect farming for both food and feed within the Kenyan Lake Victoria Basin, alongside the availability of agricultural extension services, the study aimed to discern the influence of the latter on the former. To address this, the research undertook a comprehensive regression analysis, seeking to establish correlations and potential causations. The outcomes derived from this regression analysis have been meticulously condensed and are outlined in the subsequent tables for further insight and evaluation.:

Table 17: *Model Summary for Agricultural Extension Services and Value addition activities in Insect Farming*

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.443[a]	.196	.192	.83643
a. Predictors: (Constant), Agricultural Extension Services				

The initial step undertaken was to ascertain the model's suitability by evaluating its goodness of fit through the R-squared analysis. The coefficient of determination, expressed as the r-square value at 0.196, illustrates the proportion of variability in the dependent variable, specifically the value addition activities related to insect farming for food and feed within Kenyan Lake Victoria Basin, that can be anticipated from changes in the independent variable, Agricultural Extension Services. This indicates that around 19.6% of the variability in these value addition activities is accountable through alterations in agricultural extension services.

The correlation coefficient, denoted by the r value, stands at 0.443, signifying a moderate positive correlation between agricultural extension services and the value addition activities of insect farming for food and feed. This 'r' value showcases the strength and direction of this relationship between the predictor and outcome variables. On the other hand, the adjusted r-square, slightly lower at 0.192, which factors in the number of predictors in the model, is marginally less than the r-square, implying that an inclusion of more predictors may not substantially enhance the model's efficacy.

The standard error of estimate, observed at .83643, provides an estimate of variability or error in the model's predictions. It delineates the average distance that the actual values deviate from the regression line, signifying the precision of the model's forecasts. This statistical analysis suggests that roughly 20% of the variance in the value addition activities associated with insect farming for food and feed within Kenyan Lake Victoria Basin is explained by agricultural extension services. Although this correlation is moderate, it implies the potential influence of additional factors beyond agricultural extension services on the outcome variable. The indication that the adjusted R-square is marginally lower than the R-square suggests that the inclusion of supplementary predictors may not significantly amplify the model's explanatory capability.

In conclusion, while this analysis demonstrates a moderate relationship between agricultural extension services and the value addition activities of insect farming for food and feed in Kenyan Lake Victoria Basin, it highlights the potential benefit of considering other variables or factors to comprehensively explain the observed variance in the outcome.

Following the confirmation of the model's adequacy through R-squared, an additional validation was performed using ANOVA. The subsequent segment presents the ANOVA findings obtained from this examination.

Table 18: *ANOVA for Agricultural Extension Services and Value addition activities of Insect Farming*

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	35.460	1	35.460	60.685	<.001[b]
	Residual	145.519	208	.700		
	Total	180.979	209			

a. Dependent Variable: Value addition activities in Insect Farming

b. Predictors: (Constant), Agricultural Extension Services

The outcomes derived from the ANOVA offer an in-depth examination into the model’s efficacy in predicting and elucidating the correlation between the predictor variable, agricultural extension services, and the dependent variable, the value addition activities associated with insect farming for food and feed in Kenyan Lake Victoria Basin. The regression model strongly signifies the impact of agricultural extension services on these activities, evident in the significantly low p-value ($p < .001$) and the substantial F-statistic recorded at 54.810, indicating a robust relationship between the predictor and the dependent variable.

Breaking down the information within the regression row, it unveils several key insights. The sum of squares of 35.460 denotes the level of variance in the dependent variable, specifically the value addition activities of insect farming for food and feed in Kenyan Lake Victoria Basin, elucidated by the predictor variable, agricultural extension services. The degrees of freedom (df) for the regression stands at 1, representing the count of predictors within the model. Moreover, the mean square, computed by dividing the sum of squares by its degrees of freedom, amounts to 35.460, indicating that roughly 35.46% of the variance is attributed to the model. Conversely, the residual of 145.519 denotes the proportion of the variance in the dependent variable that the model is unable to explain.

The findings strongly imply that the regression model with agricultural extension services as a predictor substantially clarifies the variability observed in the value addition activities of insect farming for food and feed in Kenyan Lake Victoria Basin. The remarkably low p-value (<.001) and the elevated F-value (60.685) collectively indicate a robust association between agricultural extension services and these activities. Nonetheless, the residual values hint that the model might not encapsulate the entirety of the variance.

In essence, this statistical model significantly contributes to predicting and explaining the value addition activities associated with insect farming for food and feed in Kenyan Lake Victoria Basin. However, it's essential to acknowledge the possibility of other unaccounted factors outside this model that might contribute to the observed variance in the dependent variable.

Following the confirmation of the model's suitability for the data, the subsequent step involved an in-depth exploration of the coefficients pertaining to agricultural extension services in terms of their direction, magnitude, and significance. The subsequent table presents the comprehensive findings of these coefficients for further examination.

Table 19: *Coefficients for Agricultural Extension Services and Value addition activities of Insect Farming*

Coefficients[a]					
	Unstandardized Coefficients		Standardized Coefficients		
Model	B	Std. Error	Beta	t	Sig.
1 (Constant)	.664	.250		2.656	.009
Agricultural Extension Services	.642	.090	.443	7.119	<.001
a. Dependent Variable: Value addition activities of Insect Farming					

Table 19 presents a detailed breakdown of the coefficients associated with agricultural extension services, illuminating their influence on the value addition activities linked to insect farming for food and feed within the expansive context of Kenyan Lake Victoria Basin. Beginning with the constant and coefficient values, the study revealed that the intercept (β0) stands at 0.664 (Standard Error (SE) = 0.250). The t-value of 2.656 with a p-value < .05 signifies statistical significance at a 5% significance level. This affirms that the constant value (0.664) represents the anticipated value of the value addition activities related to insect farming for food and feed within Kenyan Lake Victoria Basin when the predictor variable is zero.

Moving to the coefficient attributed to agricultural extension services (β1) – reported at 0.642 (SE = 0.090), it demonstrates a t-statistic value of 7.119 with a p-value of <.001, underscoring its statistical significance at a 5% level. Additionally, the standardized beta, a measure reflecting the relationship's strength in standard deviation units, is calculated at 0.443. The findings affirm that in instances where agricultural extension services register zero, the expected value of the value addition activities related to insect farming for food and feed in Kenyan Lake Victoria Basin hovers around 0.664. This signifies a certain level of value addition activities even in the absence of agricultural extension services within the region. The coefficient attributed to agricultural extension services indicates that for every one-unit rise in these services, an anticipated increase of 0.642 units in the value addition activities pertaining to insect farming for food and feed is expected within the Kenyan Lake

Victoria Basin. The standardized coefficient (Beta) of 0.443 points towards the strength of this relationship in standard deviation units. A higher Beta value implies a more pronounced influence of agricultural extension services on the value addition activities associated with insect farming for food and feed in Kenyan Lake Victoria Basin.

The comprehensive findings, in summary, suggest a statistically significant and positive impact of agricultural extension services on the value addition activities associated with insect farming for food and feed within Kenyan Lake Victoria Basin. For each increment in agricultural extension services, an expected rise of approximately 0.642 units in the value addition activities is projected. The standardized coefficient (Beta) of 0.443 indicates a moderate to strong effect size in standard deviation units, emphasizing the significance of this relationship. These outcomes seem to align with earlier research highlighting the pivotal role of agricultural extension services in augmenting value addition activities within the domain of insect farming for food and feed.

The findings from the present study are consistent with previous studies particularly with respect to value addition in insect farming. Notably, studies have explained diverse methods of obtaining edible insects and developing or creating values from them (Chia *et al*., 2022; Yen, 2015), emphasizing that while wild harvesting accounts for the majority, only a small percentage of edible insects are farmed (Chia, Tanga, Van loom & Dicke, 2019). Despite limited farming, the practice offers opportunities, including the potential to develop a new economic sector with standardized practices and minimal technology use (Van Huis, 2015; Raheen *et al*., 2019). Notably, this farming type could significantly impact low-income communities by providing nutrient-dense food, creating employment, and advancing local technologies (Chia, Tanga, Van loom & Dicke, 2019).

The potential of edible insects in contributing to global health and sustainability is underscored, emphasizing the need for coordinated efforts between various stakeholders, such as governments, businesses, and academic institutions (Bermúdez-Serrano *et al*., 2020). Highlighting the marketing constraints for edible insects in the Lake Victoria Basin, the study identifies opportunities for enhancing value through standardized practices (C.A. Okia *et al*, 2017). Contrastingly, Latin America lacks significant start-ups for edible insects, revealing a dearth of research and training institutions in the area (Bermúdez-Serrano *et al*., 2020). However, the study acknowledges the potential to recover traditional knowledge. The need for a stronger local framework for edible insect farming and encouragement of entrepreneurship is identified (Bermúdez-Serrano *et al*., 2020).

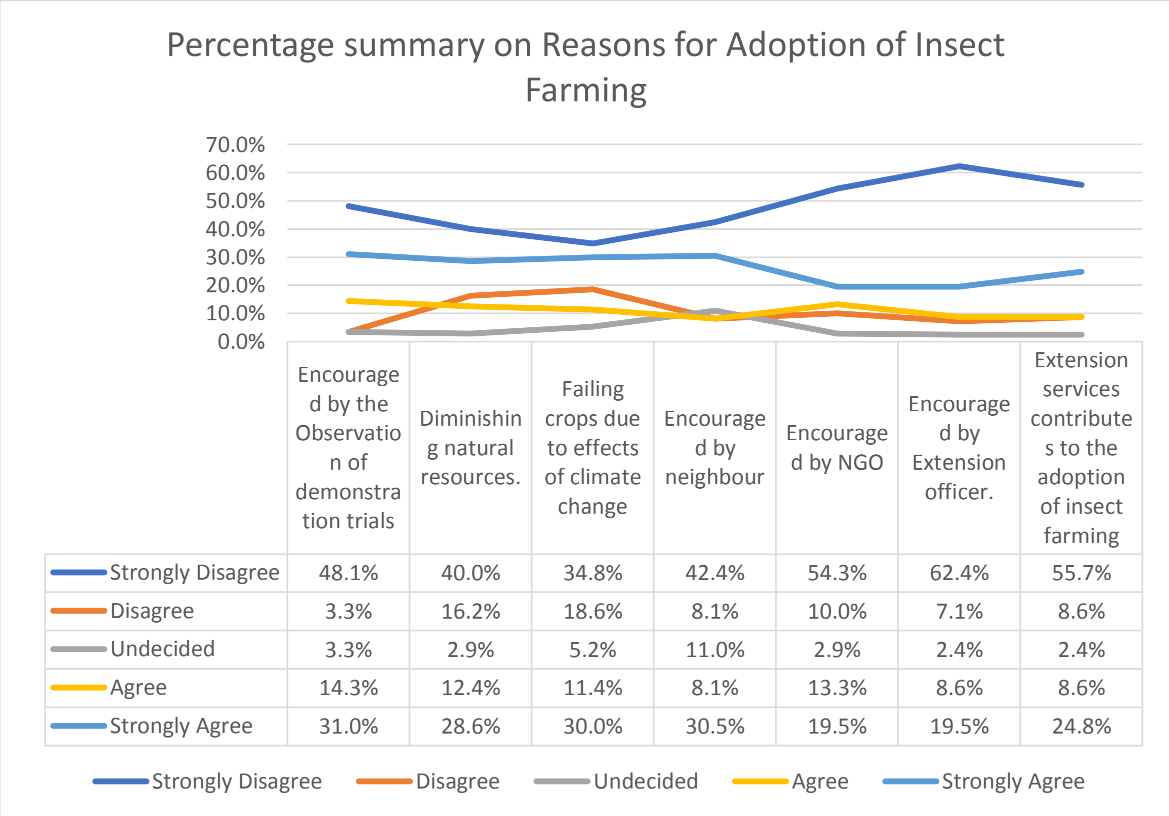
Agricultural extension services, seen as a key liaison between farmers and change, have an untapped potential to influence the transformation of insect farming, especially in the Kenya Lake Victoria Basin (Ebenebe *et al*., 2020). Several studies confirm the effectiveness of agricultural extension services in fostering agricultural developments, urging their adoption to promote farming of edible insects and enhance food security (Kelemu *et al*., 2015; Khan *et al*., 2014; Ibitoye *et al*., 2021). These collective studies emphasize the significance of agricultural extension services in bridging the gap between farming communities and the transformation potential for insect farming, particularly in regions such as the Kenya Lake Victoria Basin. Integration of agricultural extension services might amplify the impact and success of insect farming initiatives, facilitating sustainable food production and enhanced nutritional security.

4.7. Agricultural Extension Services and Adoption Rate of Insect Farming

The third objective of the study ***to assess the determinants of adoption of insect farming as source of nutritious food and feeds among small holder farmers in the Kenyan Lake Victoria Basin***. This objective was meant to establish the influence of agricultural extension on the rate of adoption of insect farming and the sustainability of the use of insects as food and feed among the small holder farmers. The indicators were the extent to which the respondents agreed with the statements on extension and adoption rate of insect farming and whether the extension officer had played a role in up scaling the adoption and sustainability of the use of insects as food and feed among small holder farmers. The objective was attained by finding answers to the question ***"what factors determine adoption of insect farming for food and feed among small holder farmers in the Kenyan Lake Victoria Basin?"*** The findings are presented in subsequent sections below

4.7.1. Descriptive Statistics on Adoption Rate of Insect Farming

In order to achieve the third objective, there was a need to understand the adoption rate of insect farming for food and feed in Kenyan Lake Victoria Basin. The idea was to measure the adoption rate using different items developed from the previous studies. The study used 5-point Likert scale to ask participants state their levels of agreement and disagreement with the statements on the adoption rate of insect farming for food and feeds in the Kenyan Lake Victoria Basin. Figure 15 gives the percentage summary and line graphs from the variable statements.



	Encouraged by the Observation of demonstration trials	Diminishing natural resources.	Failing crops due to effects of climate change	Encouraged by neighbour	Encouraged by NGO	Encouraged by Extension officer.	Extension services contributes to the adoption of insect farming
Strongly Disagree	48.1%	40.0%	34.8%	42.4%	54.3%	62.4%	55.7%
Disagree	3.3%	16.2%	18.6%	8.1%	10.0%	7.1%	8.6%
Undecided	3.3%	2.9%	5.2%	11.0%	2.9%	2.4%	2.4%
Agree	14.3%	12.4%	11.4%	8.1%	13.3%	8.6%	8.6%
Strongly Agree	31.0%	28.6%	30.0%	30.5%	19.5%	19.5%	24.8%

Figure 15: *Summary on the reasons for adoption of insect farming.*

From the results, it was established that only 45% of the small holder farmers agreed and strongly agreed that they were encouraged by the observation of demonstration trials to adopt the insect farming whereas more than 52% collectively disagreed and strongly disagreed with the reason of adoption. To assess whether it was because of the diminishing natural resources that lead to the adoption of insect farming, more than 56% of the small holder farmers disagreed that diminishing natural resources could be the reason why insect farming is adopted in the region with only 40% of the farmers supporting the reason. It was also observed that about 42% of the small holder farmers mutually agreed and strongly agreed that failing of crops due to effects of climate change led to the adoption of insect farming in the region with more than 53% of the farmers disagreeing that they adopted insect farming because of climate change.

Farmers were also asked whether the encouragement from the neighbour could be the reason why they adopted insect farming, it was found that only 38.6% supported the statement fully with more than 50% claiming that encouragement from neighbours was not part of the factors that motivated them to adopt insect farming. Only 32.8% of the farmers agreed and strongly agreed that they were encouraged by the NGO's with over 64% disagreeing with the statement. Over the same, farmers were also asked whether they were encouraged by the extension officers to adopt insect farming, about 70% disagreed with only 28% of the farmers agreed that they were encouraged by the extension officers.

Finally, small holder farmers were also asked whether extension services generally contribute to the adoption of insect farming, on average, only 33.4% supported that statement with over 64% of the farmers cumulatively disagreeing and strongly disagreeing that extension services in the region contributed to the adoption of insect farming. Figure 16 gives the multiple bar graphs from the variable statements discussed above.

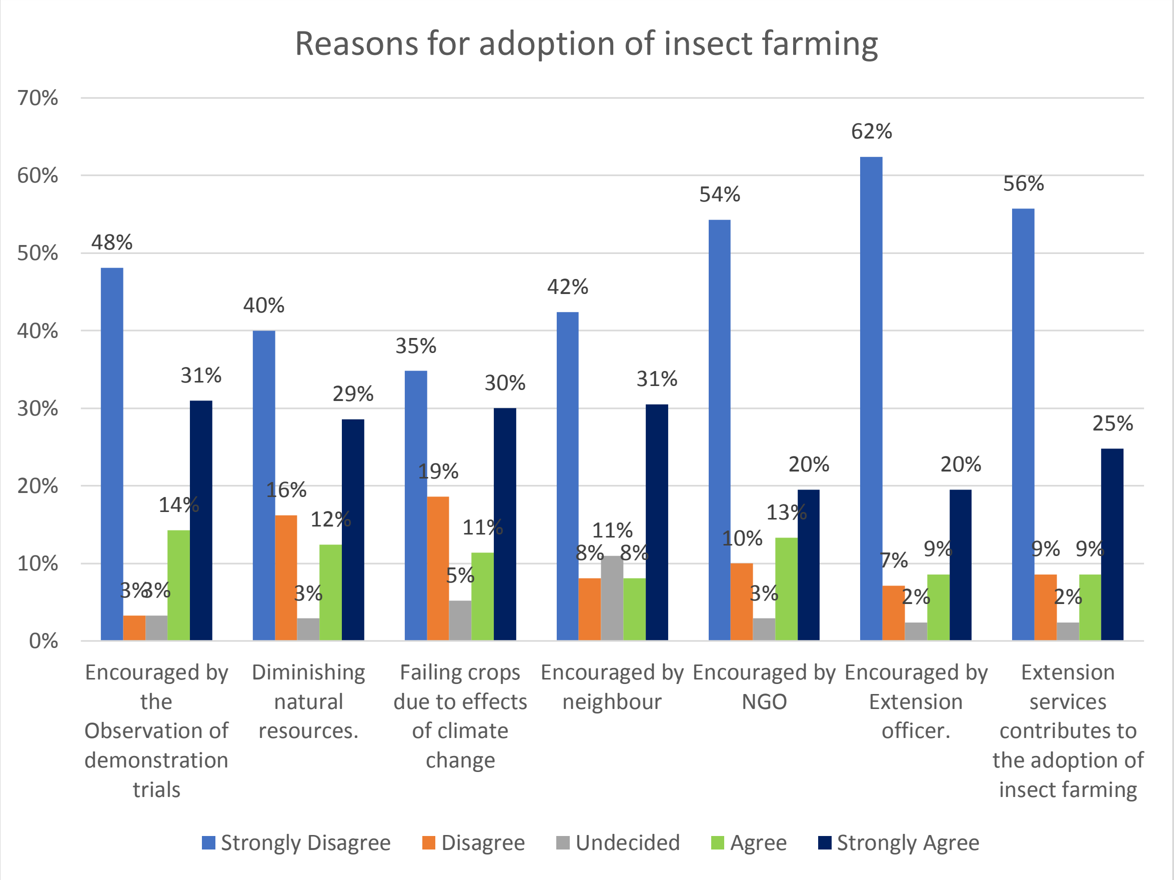
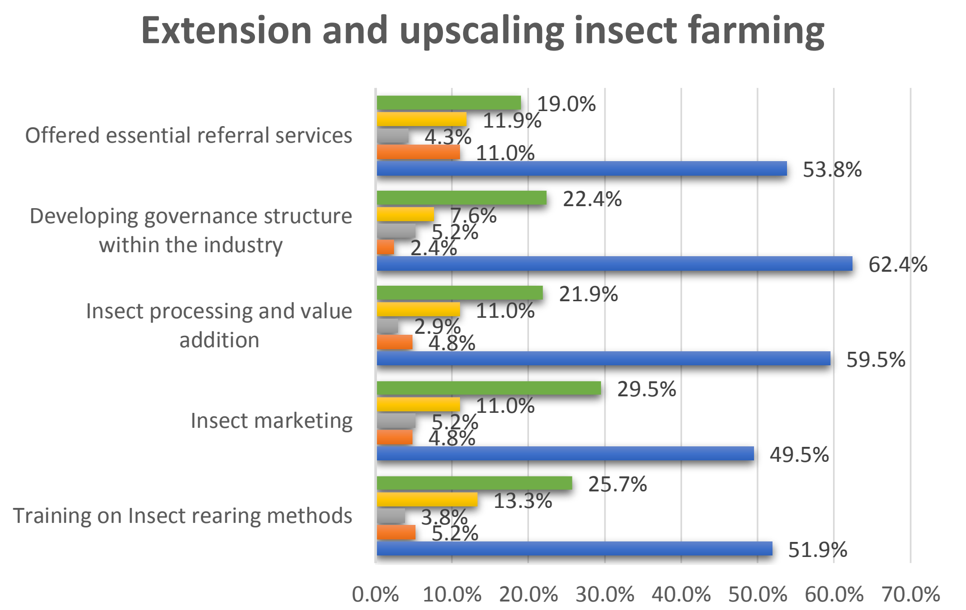


Figure 16: *Reasons for adoption of insect farming*

In addition to understanding reasons for adopting insect farming for food and feed, the study was also interested in extension and upscaling insect farming, which were also used in measuring the adoption rate of the insect farming for food and feed in the Kenyan Lake Victoria Basin. In this respect, participants were asked to state the extent to which they agreed with the statements on the extension and upscaling of insect farming among small holder farmers in the adoption and sustainability of the use of insects as food and feed, Figure 17 gives the percentage summary and bar graph from the variable statements.



	Training on Insect rearing methods	Insect marketing	Insect processing and value addition	Developing governance structure within the industry	Offered essential referral services
Strongly Agree	25.7%	29.5%	21.9%	22.4%	19.0%
Agree	13.3%	11.0%	11.0%	7.6%	11.9%
Undecided	3.8%	5.2%	2.9%	5.2%	4.3%
Disagree	5.2%	4.8%	4.8%	2.4%	11.0%
Strongly Disagree	51.9%	49.5%	59.5%	62.4%	53.8%

Figure 17: *Extension and upscaling insect farming*

From the findings in Fig. 17, with respect to the extension and up scaling of insect farming among small holder farmers in the adoption and sustainability of the use of insects as food and feed, findings revealed that more than 57% disagreed that training on insect rearing methods led to the up scaling of insect farming on the adoption and sustainability of the use of insects as food and feed with only 39% of farmers supporting the statement. From the finding, it is clear that insect marketing has not been intensified to promote the adoption and sustainability of the use of insects with more than 55% of farmers disagreeing with the statement whereas only 41.5% agreed that insect product marketing has contributed to the adoption and sustainability of the use of insects.

According to small holder farmers in the region, about 65% of the respondents jointly disagreed and strongly disagreed that insect processing and value addition promotes the adoption and sustainability of the use of insects with only 32.9% supporting the statement. On the development of governance structure within the industry in promoting adoption of insect farming, about 65% disagreed with the statement with only 30% approving that there was development of governance structure within the industry in promoting adoption of insect farming. Asked whether the offered essential referral services promoted adoption and sustainability of insect farming in the region, about 65% differed with the statement with only 29.9% supporting that the offered essential referral services promote adoption and sustainability of insect farming in the region.

In respect to the adoption of insect farming for food and feed, it is evident from the responses obtained that indeed small-scale farmers have been adequately involved in the said farming. In other words, the responses confirm increased adoption of insect farming. Such findings are also highlighted in previous research particularly with respect to understanding the level of insect farming for food and feed. Previous studies have indicated different methodologies used in adopting insect farming for food and feed. Various methodologies for insect farming and production systems, as described by Corrado, *et. al.* (2019), often involve controlled environments for breeding, rearing, and processing insects. These systems, according to Gamborg, *et. al.* (2018), emphasize providing specific diets or feed to insects for maximizing growth and nutritional content. Kusch-Brandt (2020) notes that these methods are adaptable and dependent on factors such as the species being farmed, the intended purpose, and the scale of operation.

Delgado, *et. al.* (2022) affirms that these controlled systems are tailored to suit the specific needs of the reared insects, ensuring an ideal environment for their growth and development. Temperature, humidity, and lighting regulation are crucial in these controlled environments, as emphasized by Halloran, *et. al.* (2018). Maintaining precise temperature ranges is essential for the successful breeding and growth of diverse species, according to Halloran, *et. al.* (2018). Halloran, *et. al.* (2018) also asserts the importance of humidity regulation in ensuring a conducive environment for rearing by avoiding excessively dry or moist conditions. These methodologies in controlled environments are adaptable to meet the diverse needs of various species of insects, ensuring optimal conditions for their growth and development. It is evident from the aforementioned studies that adoption of insect farming for food and feed has been on the rise not only in the Kenyan Lake Victoria Basin but also across the globe.

This further confirms the need to establish some of the reasons behind the adoption. The study was interested in agricultural extension services; hence, the concern was whether agricultural extension services had something to do with the increasing adoption of insect farming for food and feed.

4.7.2. Agricultural Extension Services and Adoption of Insect Farming

Since the study had established that the Kenyan Lake Victoria Basin region has been adopting insect farming for feed and food, there was a need to examine whether the increased agricultural extension services established earlier had anything to do with it. For purposes of achieving this, the study conducted a regression analysis in which agricultural extension services formed the independent variable with adoption rate of insect farming for food and feed in Kenyan Lake Victoria Basin being the dependent variable. The results of the regression analysis are summarised in the following tables:

Table 20: *Model Summary for AES and Adoption Rate of Insect Farming*

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.525[a]	.276	.273	.60277
a. Predictors: (Constant), Agricultural Extension Services				

The first step was to confirm the goodness of fit of the model using r-squared as illustrated in Table 20. The r value in the model is 0.525, signifying the correlation coefficient, which measures the strength and direction of the relationship between the predictor variable (Agricultural Extension Services) and the outcome variable (Adoption rate of Insect Farming for Food and Feed). A value of 0.525 suggests a relatively strong positive correlation between these variables since it is > 0.5.

The coefficient of determination, r-square, stands at 0.276 in the context of the adoption rate of insect farming for food and feed in Kenyan Lake Victoria Basin. This figure implies that approximately 27.6% of the variability observed in the adoption rate can be explained by alterations in agricultural extension services. Interestingly, this proportion signifies a higher level of explanatory power in comparison to a previous model that investigated the promotion of insect farming, where changes in agricultural extension services accounted for only 20.9% of the variability observed.

Conversely, the adjusted coefficient of determination, adjusted r-squared = 0.273 confirms that even though slightly lower than the r-squared, it signifies a robust predictive capacity. However, this marginal difference suggests that the inclusion of additional predictors might not considerably bolster the model's explanatory strength. In the realm of statistical accuracy, the standard error of estimate, quantified at 0.60277, acts as a vital gauge of the model’s predictive variability. This metric indicates the average deviation between observed values and the regression line, hence delineating the model's precision in making predictions.

The r-squared value delineates that agricultural extension services shed light on approximately 28% of the variance observed in the adoption rate of insect farming for food and feed in Kenyan Lake Victoria Basin. This percentage is notably higher compared to the 21% accounted for in the context of the promotion of insect farming. Despite a relatively strong correlation, these metrics suggest the potential influence of other variables on the final outcome. The adjusted r-squared, slightly less than the r-squared, indicates that the addition of further predictors may not significantly augment the model's explanatory power. This analysis collectively hints at a robust relationship between agricultural extension services and the adoption rate of insect farming for food and feed in Kenyan Lake Victoria Basin. However, it also highlights the importance of considering other contributing factors to thoroughly comprehend the observed variability in the final outcome

There was also a need to further confirm the goodness of fit of the model using F-statistics as established from the ANOVA. The results of ANOVA are as follows:

Table 21: *ANOVA for Agricultural Extension Services and Adoption Rate of Insect Farming*

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	28.825	1	28.825	79.335	<.001[b]
	Residual	75.573	208	.363		
	Total	104.398	209			

a. Dependent Variable: Adoption rate of Insect Farming

b. Predictors: (Constant), Agricultural Extension Services

Notably, the ANOVA outcomes in Table 21 provide an enhanced perspective on how the model efficiently predicts the association between the independent variable (agricultural extension services) and the dependent variable (adoption rate of insect farming for food and feed in the Kenyan Lake Victoria Basin). The regression model underscores that the predictor, agricultural extension services, significantly influences the adoption rate of insect farming in the mentioned region, as demonstrated by the markedly low p-value ($p < .001$). Moreover, the F-statistic, marking 79.335, underscores a robust relationship between the predictor and the dependent variable.

Specifically, the regression analysis yields comprehensive insights. Notably, the sum of squares reaching 28.825 elucidates the portion of variance in the dependent variable (adoption rate of insect farming) explicated by the predictor (agricultural extension services). The degrees of freedom (df) for the regression stands at 1, indicating the count of predictors within the model. The mean square, equivalent to 28.825, derived from dividing the sum of squares by the degrees of freedom, signifies that approximately 28.83% of the variability is attributed to the model. In contrast, the residual figure, marking 104.398, represents the unexplained variance in the dependent variable.

In analysing these results, it becomes evident that the regression model featuring agricultural extension services as a predictor significantly elucidates the variance in insect farming adoption for food and feed in Kenyan Lake Victoria Basin. The notably low p-value (<.001) and a high F-value (79.34) both indicate a compelling association between agricultural extension services and the adoption rate. However, the model might not encompass the entirety of the variance, as suggested by the residual values. Overall, the model presents statistical significance in projecting and elucidating the adoption rate of insect farming in the region, although other unaccounted factors could contribute to the observed variability in the dependent variable.

Upon confirming the model's suitability for the data, the subsequent step involved a comprehensive examination of the coefficients of agricultural extension services in terms of their direction, magnitude, and significance. The ensuing table presents the detailed results of these coefficients.

Table 22: *Coefficients for Agricultural Extension Services and Promotion of Insect Farming*

Coefficients[a]					
	Unstandardized Coefficients		Standardized Coefficients		
Model	B	Std. Error	Beta	t	Sig.
1 (Constant)	.712	.180		3.947	<.001
Agricultural Extension Services	.579	.065	.525	8.907	<.001

a. Dependent Variable: Adoption Rate of Insect Farming

Table 22 provides the coefficients to agricultural extension services, offering insights on its impact on the adoption rate of insect farming for food and feed in Kenyan Lake Victoria Basin. Commencing from the constant to the coefficient, the findings reveal significant statistical insights. Notably, β_0, at 0.712 (SE = 0.180), accompanied by a t-value of 3.947 and a p-value $< .05$, indicates statistical significance at a 5% level. This infers that the constant value (0.712) stands as the anticipated rate of adoption for insect farming in the region when the predictor variable rests at zero.

The study further indicates that the coefficient to agricultural extension services, $\beta_1 = 0.579$ (SE = 0.065) has a t-statistic of 8.907 and a p-value of <.001, signifying statistical significance at the 5% level. Additionally, the standardized beta, denoting the relationship's strength in standard deviation units, reaches 0.525. These results affirm that with agricultural extension services at zero, the anticipated adoption rate of insect farming in Kenyan Lake Victoria Basin rests at approximately 0.712. This infers that there exists a certain rate of adoption even without the involvement of agricultural extension services in the region. Moreover, with each unit increase in agricultural extension services, an expected 0.579-unit rise in the adoption rate of insect farming for food and feed in the region is anticipated, as revealed by the coefficient. The standardized coefficient (Beta) at 0.525 emphasizes the strength of this relationship in standard deviation units. A higher Beta signifies a more robust influence of agricultural extension services on the adoption rate.

Overall, the findings underscore the statistically significant and positive impact of agricultural extension services on the adoption rate of insect farming for food and feed in Kenyan Lake Victoria Basin. For every unit escalation in agricultural extension services, there is an anticipated increase of around 0.579 units in the adoption rate in the mentioned region. The standardized coefficient, with a value of 0.525, points to a moderate to strong effect size in standard deviation units, underlining the relevance of this relationship. These results echo previous studies highlighting the pivotal role of agricultural extension in the adoption rate of insect farming for food and feed.

The findings tend to corroborate and confirm findings from previous studies. Verbeke (2015) delved into the exploration of consumer willingness to include edible insects and seaweed in their dietary habits as a critical determinant. The study found that technical challenges often impede various innovative food production approaches, leaving some innovations at the prototype stage. In their study, Specht *et al*. (2016) noted that technological feasibility alone does not guarantee the success of an innovation. Social acceptance and perceived benefits are crucial factors in determining an innovation's proliferation. From the study by Specht *et al*. (2016), it can be established that innovations contradicting traditional agricultural perceptions could face consumer rejection, and local government officials might resist deployment if they lack comprehension. This explains the adoption rate of the insect farming for food and feed.

The present study findings illuminate trends concerning different approaches and their effects to various sustainability dimensions. The results accentuate the societal benefits offered by techniques like rooftop greenhouses and vertical farming. Surprisingly, the considerable social potentials for insect production contrast with the few social potentials observed in algae production (Yen, 2015). Potential hindrances include unfamiliarity with new techniques, uncertainty about their advantages, concerns about health risks, lack of familiarity with the food products, and moral apprehensions about animal welfare. The need for a more streamlined approach, especially in terms of extension services, becomes evident to better address ethical, acceptability, health, safety, and cultural concerns surrounding edible insects (Ebenebe *et al*., 2020). Chia *et al*. (2022) identified three primary methods for obtaining edible insects: wild harvesting, semi-domestication by manipulating their habitat, and farming—ranging from small-scale operations to large factory setups (Yen, 2015).

However, according to Yen (2015), the consumption of edible insects by humans predominantly relies on wild harvesting, constituting around 92% of the total consumption, while semi-domesticated insects account for about 6%. The farming approach contributes only 2% due to seasonal and geographical variations that affect the availability of insects in the wild throughout the year. Despite this, employing environmentally friendly insect breeding, farming, and processing technologies could ameliorate cost and supply-side constraints. Van Huis (2015) highlights farming as the most efficient method for producing insects intended for food and feed, holding potential to develop a new economic sector with industrial-scale standardized practices. Moreover, small to medium-scale insect farming, as proposed by Raheen *et al*. (2019), offers rapid, minimal technology-dependent, nutrient-dense food production, delivering faster investment returns due to low investment costs and straightforward management. Therefore, in reference to the previous studies, the present study confirms that adoption rates of insect farming for food and feed vary from one region to another even though there has been an increase rate in the recent years.

4.8. Qualitative Findings

To augment the quantitative findings above, the study also conducted an interview on different aspects associated with insect farming for food and feed. During the interview, the main aspects of interest included effects of insect farming, interactions with farmers and other stakeholders in small holder segment, involvement with mainstream extension department, future support perceptions, perceptions of current and past extension support and coordination, as well as suggestions and recommendations.

4.8.1. Effects of Insect Farming

The first focus was on the effects of insect farming. In this part, the study delved into the world of insect farming within the Lake Victoria Basin in Kenya. The interviewee, a key player in this niche agricultural sector, shared valuable insights into their role, the growth of insect farming over the years, and the pivotal support they receive. The interview commenced by exploring the interviewee's role in insect farming and the key activities they undertake. When asked “what’s your role in insect farming (Key activities)?”, the interviewee revealed engaging in extensive research on the breeding of various insects in the region, specifically highlighting the black soldier fly (BSF) and crickets. This emphasizes a commitment to diversifying insect species for farming purposes. The subsequent line of inquiry aimed to understand the evolution of insect farming in the Lake Victoria Basin. When asked “how has insect farming grown over the years?”, it was noted that despite the evident growth, the interviewee noted that the journey has not been without challenges. Inconsistency among farmers practicing insect farming emerged as a significant hurdle. The inherent difficulty in rearing insects and the need for unwavering dedication were underscored as key factors affecting the sustained growth of insect farming.

Understanding the support systems in place for insect farming was a crucial aspect of the interview, shedding light on the external factors influencing the industry. In this respect, the interviewee was asked “who is supporting you (Key items of support)?”. In the response, the interviewee highlighted a spectrum of challenges faced by insect farmers, with inadequate training opportunities and limited resources for supervision standing out. These hurdles, however, are being addressed by various organizations. The World Bank, GIZ, and the European Union were mentioned as instrumental supporters of insect farming research. Nevertheless, the interviewee pointed out that financial and material support required to sustain insect farming practices is often lacking, leading to a high rate of farmer dropout within a short time.

The interview findings underscore the nuanced landscape of insect farming in the Lake Victoria Basin. The growth trajectory, though promising, is hindered by persistent challenges. Inconsistent practices among farmers indicate the need for targeted interventions, such as improved training opportunities and enhanced supervision. The noteworthy support from global organizations is a positive sign, yet the apparent lack of sustained financial and material backing at the grassroots level poses a threat to the longevity of insect farming initiatives.

For the broader research topic of "The effects of agricultural extension on insect farming for food and feed on smallholder farms in Lake Victoria Basin, Kenya," these findings emphasize the crucial role that agricultural extension services can play. Strengthening extension services to address the identified challenges, such as providing consistent training, facilitating access to resources, and ensuring ongoing support, can significantly contribute to the sustainable growth of insect farming. This approach aligns with the broader goal of leveraging insect farming for enhanced food and feed production in the region.

4.8.2. Interactions with farmers and other stakeholders in the small holder segment

Continuing our exploration of insect farming in the Lake Victoria Basin, we now turn our attention to the critical aspects of participant recruitment, enrolment strategies, and the collaborative network that supports this agricultural initiative. Understanding how participants, particularly farmers, are brought into the fold of insect farming operations was the initial focus of inquiry. The study asked "what's the mode of recruitment of participants/farmers?" Farmers are primarily recruited through outreach personnel operating in different regions, collaborations with various stakeholders, and referrals from research institutions such as KALRO. This multi-pronged approach emphasizes the importance of networking and partnerships in bringing farmers into the insect farming community. The discussion then shifted to the number of farmers/sites enrolled, the rationale behind these enrolments, and the challenges faced. The study asked "how many farmers/sites have you enrolled, and why? What informs your choice of groups/farmers?" According to the findings, enrolment numbers are contingent upon the success of mobilization and capacity-building efforts. However, these efforts face a significant challenge due to the scarcity of resources. The low enrolment numbers are attributed to the allure of traditional farming practices that farmers find more familiar and attractive. This reveals a critical need for increased capacity-building initiatives to shift perceptions and make insect farming more appealing.

Understanding how information is managed within the insect farming community and the strategies employed for growth were next on the agenda. The study asked "how do you manage information flow back and forth? How do you ensure growth?" The interviewee highlighted a significant challenge in the flow of information due to the absence of a structured system, both in personnel and infrastructure, primarily caused by a lack of resources. The current temporary structures fade with each research intervention, hindering effective communication. Growth, on the other hand, relies heavily on the documentation of research undertakings and lessons learned. Finally, the discussion touched upon the network of partners supporting the insect farming initiative. To achieve this, the study asked "can you provide a list of partners and their roles?" according to the participants, partners play diverse roles, including the Ministry of Agriculture, Livestock, and Fisheries running extension programs, KALRO offering technical support, other learning institutions providing incubation/laboratory opportunities, non-governmental organizations working with vulnerable segments of society, and schools and religious organizations serving as entry paths to the community.

The interview findings underscore the interconnected nature of participant recruitment, enrolment, information flow, and growth strategies in insect farming. The challenges, predominantly stemming from resource scarcity, highlight the need for comprehensive support systems to strengthen outreach, capacity building, and communication structures. In the context of the broader research topic, "The effects of agricultural extension on insect farming for food and feed on smallholder farms in Lake Victoria Basin, Kenya," addressing the challenges in participant recruitment, enrolment, and information flow is pivotal. Strengthening partnerships, increasing resource allocation, and developing sustainable communication channels are essential components for the successful extension of insect farming practices in the region.

4.8.3. Involvement with mainstream extension department

In the ongoing exploration of insect farming in the Lake Victoria Basin, our attention now shifts towards the involvement of government entities, specifically the Ministry of Agriculture, and the dynamics of coordination among various partners in this agricultural initiative. The first aspect of interest was on formal arrangements with the Ministry of Agriculture. The interview sought to unravel the nature of the relationship between insect farming initiatives and the Ministry of Agriculture. The study asked "is there any formal or otherwise arrangement with the Ministry of Agriculture for extension support?" According to the response obtained from the interview, the Ministry of Agriculture is characterized as a passive member within the insect farming domain. Contrary to expectations, there are no deliberate arrangements or allocated resources from the Ministry to support insect farming initiatives. The engagement with the Ministry is reactive, initiated only when concerned partners request coordination meetings. However, funding for these meetings must be provided by the respective stakeholders.

The next aspect was on coordination and communication among partners. Understanding how various partners communicate and coordinate their activities, especially in alignment with government programs, was the next focus. The study asked “how do other partners communicate with groups or sites? How are activities of other partners coordinated and harmonized with mainstream government programs?” Communication among partners relies on collaborative efforts, with the Ministry of Agriculture acting as a coordinator upon request. However, it was emphasized that the Ministry's role is more about creating a harmonious work environment, ensuring that partners operate within an enabling framework. The absence of a structured system for extension in insect farming was acknowledged, indicating a need for improved communication channels and coordination mechanisms. The interview concluded with insights into the future trajectory of insect farming and the necessary support structures. The study asked “what is the future of insect farming and extension support?” Based on the responses, the future of insect farming hinges on the establishment of a dedicated structure for extension support. Notably, the current extension staff need training and capacity building to effectively carry out extension programs for insect farming. This highlights a critical area for development and investment in the insect farming domain.

The findings illuminate the passive role of the Ministry of Agriculture in supporting insect farming and the reactive nature of coordination efforts. The absence of a dedicated structure for extension in insect farming calls attention to the need for comprehensive planning and training to ensure the sustainability and success of such initiatives. In the context of the broader research topic, "The effects of agricultural extension on insect farming for food and feed on smallholder farms in Lake Victoria Basin, Kenya," the findings underscore the urgency of formalizing arrangements with government entities and establishing dedicated extension structures. Collaboration, coordination, and capacity building are essential elements for the future success of insect farming initiatives in the region.

4.8.4. Future support perceptions

As the study continued exploration of insect farming in the Lake Victoria Basin, we now turn our attention to the future plans and strategies envisioned by those at the forefront of this innovative agricultural venture. The interview sought insights into the short-term plans and priorities for the insect farming project. Question asked was “what is planned for your project in the next few weeks?”. The interviewee outlined that the upcoming weeks will witness the rollout of new programs focused on insect value addition and the expansion of insect breeding programs. These priorities signify a commitment to not only enhance the existing practices but also to explore new avenues for the sustainable growth of insect farming initiatives. In addition, understanding how awareness about these new programs and expansions will be disseminated was the subsequent focus. The study asked “how do you plan to create awareness for the same?” Based on the findings from creating awareness will be a multi-faceted effort, with stakeholder engagements taking a central role. Additionally, the interviewee highlighted the use of various communication channels, including radio talk shows, WhatsApp groups, and other social media platforms. This comprehensive approach aims to reach diverse audiences and ensure that information about the new programs is widely disseminated.

A final aspect of the discussion highlighted the importance of collective action and advocacy for the future success of insect farming initiatives. There is a need for the formation of farmer/user groups to strengthen their voices in pushing for better attention from the government. This statement emphasizes the crucial role that collective advocacy plays in ensuring that the government allocates the necessary resources and attention to insect farming initiatives. Forming farmer/user groups creates a platform for shared experiences, knowledge exchange, and a unified voice that can advocate for the needs and challenges faced by those engaged in insect farming. The future support perceptions reflect a proactive approach to advancing insect farming initiatives. The prioritization of new programs, coupled with a diverse set of awareness creation strategies and the emphasis on collective advocacy, signals a comprehensive and forward-thinking vision for the future of insect farming in the Lake Victoria Basin.

In the context of the broader research topic, "the effects of agricultural extension on insect farming for food and feed on smallholder farms in Lake Victoria Basin, Kenya," these future plans highlight the importance of continuous innovation, communication, and collective action. Agricultural extension services can play a vital role in supporting these initiatives by providing technical expertise, facilitating stakeholder engagements, and promoting the formation of farmer/user groups for effective advocacy.

4.8.5. Perceptions of current and past extension support and coordination

Our investigation into the landscape of insect farming in the Lake Victoria Basin delves deeper into the perceptions of current and past extension support, the need for coordination, and suggestions for improvement in project management. The interview aimed to uncover the interviewee's views on the effectiveness of current and past extension support. The study asked "is there a role for coordination required within the existing extension framework?" The interviewee emphasized the crucial need for a more significant role in the coordination of extension services to ensure the success of insect farming initiatives. This highlights a perceived gap in the existing framework that, if addressed, could contribute significantly to the effectiveness of extension support. The discussion then delved into specific challenges faced in coordinating extension efforts for insect farming. The study asked "are there occasions you found things not happening as expected? Give more information?" The interviewee pointed out a state of total confusion in the coordination of extension services for insect farming. The absence of clear responsibilities and accountability within the coordination framework creates obstacles and inhibits the smooth execution of extension activities. This highlights a critical area for improvement.

The interview concluded by seeking insights into what could make a difference in the management of insect farming projects. In this respect, the study asked, "what do you think can make a difference in the way your project has been managed?" The interviewee stressed the need for the government to play a more active role by mainstreaming insect farming into the extension curriculum. Additionally, equipping extension workers with the necessary tools and providing financial support were identified as crucial steps to address challenges in the adoption of insect farming. The final section explored specific suggestions for enhancing extension support in insect farming. The interview asked the participant "suggest how extension support can be improved". The interviewee proposed the mainstreaming of insect farming into the extension curriculum, equipping extension workers with necessary tools, and providing the necessary financing for these initiatives. These recommendations, if implemented, could significantly improve the effectiveness of extension support in insect farming.

The interview findings highlight the urgent need for enhanced coordination, clearer responsibilities, and improved support structures within the extension framework for insect farming. The perceived confusion and challenges underscore the importance of addressing these issues to ensure the successful implementation of insect farming initiatives. In the context of the broader research topic, "the effects of agricultural extension on insect farming for food and feed on smallholder farms in Lake Victoria Basin, Kenya," the recommendations point to the critical role that organized and well-coordinated extension services play in the success of insect farming projects. Policymakers and educators can use this information to guide the development of training programs and policies that address the specific needs of extension workers engaged in insect farming initiatives.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.0 Introduction

The present chapter provides summary of the findings, conclusions, and recommendations. Both summary of findings and conclusions are provided based on objectives. Recommendations on the other hand come from the study limitations, which are also highlighted in this chapter. The chapter also provides areas that would warrant additional research.

5.1 Summary of Findings

5.1.1.To determine the effects of agricultural extension on the promotion of insects as food and feeds among small-scale farmers in the Kenyan Lake Victoria Basin

The first objective of the study was *to determine the effects of agricultural extension on the promotion of insects as food and feeds among small-scale farmers in the Kenyan Lake Victoria Basin*. This objective was attained by answering the question *"what is the role of agricultural extension in the promotion of insects for food and feeds among small-holder farmers in the Kenyan Lake Victoria Basin?"* The attainment of the objective was informed by the need to understand how agricultural extension services can be used to inform insect farming for food and feed particularly with respect to the Kenyan Lake Victoria Basin. In addition to utilizing descriptive statistics to comprehend the extents of agricultural extension services and the levels of promotion regarding insect farming for food and feed, a descriptive statistical analysis was employed to gauge these variables. The research leveraged regression analysis as a means to ascertain and quantify the relationship between agricultural extension services and the promotion of insect farming within the geographical expanse of Kenyan Lake Victoria Basin.

Using descriptive statistics and a Likert scale, the study has been able to gauge perceptions and opinions of participants regarding insect farming promotion. The study obtained detailed varied opinions among smallholder farmers, in addition to discrepancies in information sources and trust in different providers. Further insights revealed discrepancies in the impact of extension services and varied levels of competencies among farmers in aspects related to insect farming. These statistics unveiled potential areas for improvement in disseminating knowledge, training, and fostering collaboration among stakeholders. The study then proceeded to assess the correlation between agricultural extension services and the promotion of insect farming. Regression analysis revealed a moderate positive correlation (R = 0.457, r-square = 0.209), elucidating that approximately 20.9% of the variance in insect farming promotion could be explained by these services. ANOVA reinforced these findings, emphasizing the significant impact of agricultural extension on promoting insect farming.

From the regression analysis findings, the study obtained coefficients affirming the statistical significance of agricultural extension services in promoting insect farming. In other words, the study established a statistically significant positive relationship between agriculture extension services provided in the Kenyan Lake Victoria Basin and the promotion of insect farming for feed and food. Notably, an increase in these services correlated with an anticipated rise in the promotion of insect farming for food and feed. These comprehensive findings underscore the vital role of agricultural extension in advancing insect farming. They echo previous research on the global rise in interest in insect farming due to its potential to address diverse challenges. The analysis points towards the necessity of exploring additional variables to comprehensively elucidate the variances observed, signifying a foundation for further investigation and development in this sector.

5.1.2 To investigate the role of agricultural extension towards value addition of insects for food and feeds among small-scale farmers in the Kenyan Lake Victoria Basin

The second objective of the study *to investigate the role of agricultural extension towards value addition of insects for food and feeds among small-scale farmers in the Kenyan Lake Victoria Basin*. This objective was meant to establish the influence of agricultural extension on the value addition activities of insect farming and the sustainability of the use of insects as food and feed among the small holder farmers. The objective was attained by finding answers to the question *"what is the role of agricultural extension in the value addition of insects among food and feed industry players in the Kenyan Lake Victoria Basin?"* The study used descriptive statistics to understanding the levels of agricultural extension services and promotion levels of insect farming for food and feed. In addition, the study measured the constructs using additional descriptive statistical analysis. In establishing the relationship between agricultural extension services and value addition activities in insect farming for food and feed, the study adopted a regression analysis.

Findings revealed distinct insights regarding the various aspects of value addition activities. The study revealed that while a notable percentage of farmers processed insect products within their small farms, fewer adhered to approved storage procedures. Moreover, not all by-products were utilized, and the usage of different products for value addition remained relatively low. Extension, microfinance, and marketing services also showed limited acknowledgment and utilization among participants. Additionally, the acceptance of products by consumers due to educational interventions was found to be relatively low, indicating potential barriers to market acceptance and consumer perception. The investigation underscored the complexity of insect value chains, emphasizing multiple uses such as food, feed, pharmaceuticals, and industrial applications. These chains involve various stages from rearing to processing and distribution, aiming to refine insect-based products for diverse applications. The process involves extracting specific nutrients or components from insects and creating appealing, nutritious food items to meet changing consumer demands.

In the analysis of the relationship between agricultural extension services and value addition activities in insect farming, the study revealed a moderate positive correlation. The influence of these services accounted for about 20% of the variability in the value addition activities, indicating the potential involvement of additional unaccounted factors. These findings align with earlier research emphasizing the pivotal role of agricultural extension services in enhancing value addition activities within insect farming. Collaborative efforts among stakeholders are emphasized for promoting standardized practices and addressing constraints. The results also underscore the need for a comprehensive understanding of factors influencing these activities to further enhance and promote these practices.

5.1.3 To assess the determinants of adoption of insect farming as source of nutritious food and feeds among small holder farmers in the Kenyan Lake Victoria Basin

The third objective of the study *to assess the determinants of adoption of insect farming as source of nutritious food and feeds among small holder farmers in the*

Kenyan Lake Victoria Basin. This objective was meant to establish the influence of agricultural extension on the rate of adoption of insect farming insect farming and the sustainability of the use of insects as food and feed among the small holder farmers. The objective was attained by finding answers to the question *"what factors determine adoption of insect farming for food and feed among small holder farmers in the Kenyan Lake Victoria Basin?"* Descriptive statistics were employed to gain insights into the extents of agricultural extension services and the levels of promotion pertaining to insect farming for food and feed. Furthermore, additional descriptive statistical analyses were utilized to measure these constructs. In order to explore the correlation between agricultural extension services and the enhancement of value addition activities within insect farming for food and feed, the research incorporated regression analysis as a methodology.

Through the use of a 5-point Likert scale, participants expressed their agreement or disagreement with statements concerning the reasons behind the adoption of insect farming. The findings revealed that factors such as observation of demonstration trials, diminishing natural resources, and encouragement from neighbours, NGOs, and extension officers elicited mixed responses among farmers. The study further noted that only 45% of small-scale farmers attributed their adoption of insect farming to the observation of demonstration trials, while 56% disagreed that diminishing natural resources drove the adoption. Similarly, 42% concurred that crop failure due to climate change influenced their adoption, whereas 53% disagreed. Encouragement from neighbours, NGOs, and extension officers also received mixed responses, indicating that these factors didn't prominently influence the farmers' decisions.

The study also probed into extension services and upscaling of insect farming, discovering that training on insect rearing methods, insect marketing, processing, governance structures, and essential referral services received varying levels of support. While approximately 39% agreed that training on rearing methods led to upscaling, over 55% disagreed that insect marketing intensified adoption. A majority, around 65%, did not believe that insect processing and value addition, governance structures, and essential referral services significantly promoted the adoption and sustainability of insect farming. Furthermore, the regression analysis between agricultural extension services and the adoption rate of insect farming revealed a moderately strong positive correlation. Approximately 28% of the variance in adoption rates was associated with changes in agricultural extension services. The coefficients underscored the significant positive impact of agricultural extension services on the adoption rate.

These findings align with previous research suggesting that technical challenges, social acceptance, and perceived benefits significantly influence the adoption of innovative agricultural practices. The study confirms that while certain factors, such as neighbour encouragement, extension services, and demonstration trials, hold relevance, they do not singularly drive the adoption of insect farming. Agricultural extension services, however, exert a discernible influence, emphasizing their vital role in promoting the adoption of insect farming for food and feed in the Kenyan Lake Victoria Basin.

5.2 Conclusions

5.2.1 To determine the effects of agricultural extension on the promotion of insects as food and feeds among small-scale farmers in the Kenyan Lake Victoria Basin

The analysis in this study revealed multifarious disparities in farmers' perceptions and the role of various information sources, particularly highlighting divergent levels of trust and reliance on information from extension services, researchers, fellow farmers, and non-governmental organizations (NGOs). These disparities suggest existing challenges in information dissemination, implying a need for enhanced collaboration and tailored information-sharing strategies among these stakeholders to foster the promotion of insect farming.

The study revealed that an increase in agricultural extension services correlates with a substantial rise in the promotion of insect farming. These findings underscore the crucial role played by agricultural extension in facilitating and encouraging small-scale farmers to engage in insect farming, offering significant implications for sustainability, food security, and economic opportunities within the region. However, the study also revealed disparities in farmers' competencies, indicating potential areas for targeted training and education to enhance their abilities in various facets of insect farming. These variations in competency levels signal an opportunity for capacity-building initiatives to equip farmers with the necessary skills and knowledge to further promote insect farming in the region. The insights revealed a need for collaborative efforts and targeted interventions to enhance knowledge dissemination, skill development, and foster greater engagement in insect farming practices among the farming community.

5.2.2. To investigate the role of agricultural extension towards value addition of insects for food and feeds among small-scale farmers in the Kenyan Lake Victoria Basin

The research indicated a moderate positive correlation between agricultural extension services and the value addition activities related to insect farming. The relationship between extension services and value addition in insect farming is significant, but it is clear that additional factors contribute to the complexity of this ecosystem.

The study also highlighted the multifaceted nature of the insect value chains, emphasizing the diverse uses of insects in various sectors. It underlined the necessity of processes such as rearing, processing, and distribution, crucial for refining insect-based products to meet an array of applications, from food to pharmaceuticals. The findings emphasize the importance of innovative approaches to extract nutrients and develop appealing food items that align with changing consumer preferences. Moreover, there's a need for a more comprehensive understanding of the complexities of these value chains and the influence of other variables to optimize agricultural extension services for promoting and advancing value addition in insect farming.

5.2.3. To assess the determinants of adoption of insect farming as source of nutritious food and feeds among small holder farmers in the Kenyan Lake Victoria Basin

Unveiling the reasons for the adoption of insect farming provided crucial revelations about the primary motives behind its embrace. Farmers expressed divergent perspectives, with demonstration trials, climate change effects on crop failures, and encouragement from neighbours appearing as moderate contributors to insect farming adoption. Surprisingly, most respondents contradicted the impact of diminishing natural resources and the influence of agricultural extension services, negating their significant role in propelling the adoption of insect farming.

The statistical findings of the model showcased the substantial impact of agricultural extension services on the adoption rate of insect farming, emphasizing the necessity of these services in enhancing adoption. The regression analysis demonstrated a notable increase in the adoption rate concerning the involvement of agricultural extension services, denoting its pivotal role in fostering insect farming adoption in the region.

Additionally, past studies confirmed that various methods and socio-cultural factors significantly influence the success of innovative food production approaches. Consumer acceptance and government support play pivotal roles in the proliferation of innovations, as seen in the insect farming adoption context. Moreover, the broader study revealed the multifaceted nature of insect farming adoption. The study reinforces the need for cohesive support, social acceptance, and robust extension services to amplify the adoption rate of insect farming for food and feed in the Kenyan Lake Victoria Basin. Recommendations

5.3. Suggestions for Further Studies

The studies conducted in the context of insect farming and its adoption among smallholder farmers in the Kenyan Lake Victoria Basin faced several limitations that can guide future research in this domain. One of the limitations lies in the self-reported nature of the data. The study heavily relied on participants' responses to Likert-scale questions, which might introduce response bias or inaccuracies due to recall errors or subjective interpretation. To mitigate this, future studies should incorporate a mixed-methods approach, combining qualitative insights through interviews or focus group discussions to complement quantitative data, thus providing a more comprehensive understanding of the factors influencing insect farming adoption.

The study focused on the Kenyan Lake Victoria Basin as the study area. This study area consisted of five main counties, which are not only large but also differ in various aspects. Therefore, another limitation relates to the geographical specificity of the study area. This means that the results were specific to the Kenyan Lake Victoria Basin. While the research focused on the Kenyan Lake Victoria Basin, the results might not be generalizable to other regions or communities due to varying sociocultural and environmental contexts. Studies that are specific to study areas have limited applications in other areas especially when it comes to replicating of the results. Future research could expand the scope to encompass diverse geographical locations and cultural backgrounds, allowing for a more comprehensive understanding of how insect farming adoption varies across regions, communities, and economic landscapes.

Additionally, the present studies largely focused on the perception and adoption of insect farming among smallholder farmers, overlooking the influence of external market dynamics and policy interventions. A suggestion for further studies could be exploring the broader ecosystem encompassing market forces, governmental policies, and their impact on the adoption and scalability of insect farming. Investigating the economic and policy frameworks that facilitate or hinder the integration of insect farming into the larger agricultural landscape could provide a more nuanced view of the industry's growth and sustainability in diverse agricultural settings. This comprehensive approach might yield valuable insights for policymakers and industry stakeholders looking to enhance the role of insect farming within the broader agricultural domain.

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APPENDICES

Appendix 1: Study Area

Map of the study area

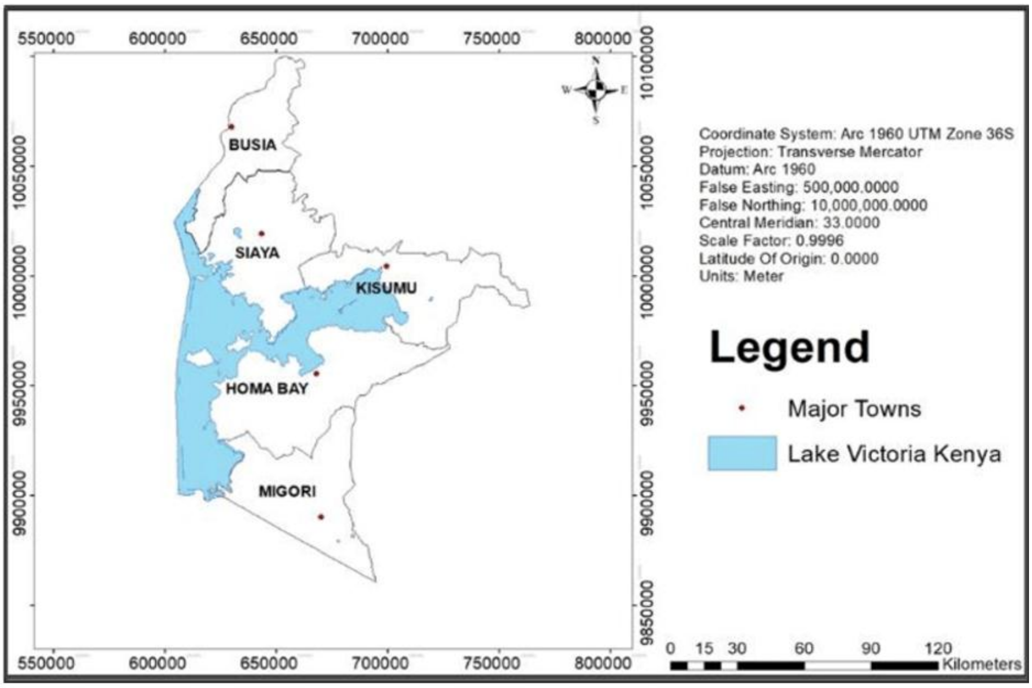


Figure 1: Map of Kenyan Lake Victoria Basin (KLVB).

Appendix 2: Questionnaire

Dear Participant,

RE: QUESTIONNAIRE

My name is ------------------a student undertaking PhD of Science in Food security and sustainable Agriculture at Jaramogi Oginga Odinga University of Science and Technology. This questionnaire has been developed to gather information from farmers and other actors regarding the effects of extension to edible insect farming among small holder farmers. The purpose is purely academic research and not for financial or material gain whatsoever. Confidentiality will be kept regarding the information gathered.
Thank you for your time.

Instructions

When responding to the survey, please be honest and relate the questions to your own experience on effects of agricultural extension to edible insect farming for nutritional security. All your responses will be treated with confidentiality.

Indicate your response by ticking (√) within the check boxes provided.

Section A: Respondent Socio-Economic Profile

Section A: General Information

1. Gender
    1) Male [ ]
    2) Female [ ]
2. Age
    1) Less than 36 years [ ]
    2) Between 36 years and 60 years [ ]
    3) Above 60 years [ ]
3. Civil Status
    1) Married [ ]
    2) Single [ ]
    3) Widow/Widower [ ]
4. Number of dependents ……………………...
5. Size of the land
    1) 1. Less than 6 Ha [ ]
    2) Between 5 –to- 10 Ha [ ]
    3) Above 10 Ha [ ]
6. Religious affiliation
    1) Christian [ ]
    2) Muslim [ ]
    3) Others [ ]
    4) (specify)……………………

7. Highest education level attained
    1) Primary [ ]
    2) Secondary [ ]
    3) Postsecondary [ ]
8. Employment Status
    1) Farming [ ]
    2) Salaried Employment [ ]
    3) Others (specify)…………………………………
9. Estimated monthly income
    1) Less than KES 50,000/- [ ]
    2) Between KES 50,000/ and KES 100,000- [ ]
    3) Above KES 100,000/- [ ]

Section C: The role of agricultural extension in the promotion of insects for food and feeds among small-holder farmers in the study area

This section is meant to provide information to establish the role agricultural extension has played in promoting insect farming. To what extent do you agree with the following statements on access to information on insect farming? Key: 5 Strongly Agree, 4 Agree, 3 Undecided, 2 Disagree, 1 Strongly Disagree (please put an X as appropriate).

The role of extension in the promotion of insect farming	**1**	**2**	**3**	**4**	**5**
There is adequate information on insects farming coming from extension workers					
There are has been significant efforts in promoting insect as food and feed among small holder farmers					
Information on insect farming Extension officers comes Researchers					
Information on insect farming Extension officers comes Colleagues farmers					
Information on insect farming Extension officers comes NGO					
Extension services on insect farming has made me to consistently practice insect farming.					

3.2. Level of competence/capacity building

How far do you agree with your level of competence to handle the following **1 2 3 4 5**

Mechanization of the insect farms/designs (1)

Rearing methods (2)

Value addition (3)

Pest and disease management (4)

Breeding technologies (5)

Marketing, consumption and other forms of utilization (6)

Credit acquisition and management

Climate change and its effects

3.3. How many times are you visited by your agent in a year?

More than Four times { }Four times { } Three time { } Twice { } Ones { }Not Visited { }

3.4. How far is the nearest location of the agent station

Less than 5 kilometres { } Above 5 kilometres { }

Section C: Influence of extension on adoption rate of insect farming

This section is meant to provide information to establish the influence of agricultural extension on the rate of adoption of insect farming among small holder farmers. To what extent do you agree with the following statements on extension and adoption rate of insect farming? Key: 5 Strongly Agree, 4 Agree, 3 Undecided, 2 Disagree, 1 Strongly Disagree (please put an X as appropriate).

Reason for adoption of insect farming	**1**	**2**	**3**	**4**	**5**
Encouraged by the Observation of demonstration trials					
Diminishing natural resources.					
Failing crops due to effects of climate charge					
Encouraged by neighbor					
Encouraged by NGO					
Encouraged by Extension officer.					
Extension contributes to the adoption of insect farming					

4.2. For how long have you known and participated in insect farming activities?

Less than 3 Years { }
Above 3 Years { }
Above 5 years (3) { }

.4.3. Do you practice other of other climate smart technologies? Yes { } No { }

If yes, specify……………………

4.4. Extension and up scaling insect farming among small holder farmers

How far do you agree extension has done the following to upscale the adoption and sustainability of the use insects as food and feeds	1	2	3	4	5
Training on Insect rearing methods					
Insect marketing					
Insect processing and value addition					
Developing governance structure within the industry					
Offered essential referral services					

Section D: Role of agricultural extension in the development and promotion of value addition of insects for food and feeds

5. This section is meant to provide information to establish the influence of agricultural extension the uptake of the value addition of insects for food and feed among small holder farmers. To what extent do you agree with the following statements on value addition activities? Key: 5 Strongly Agree, 4 Agree, 3 Undecided, 2 Disagree, 1 Strongly Disagree (please put an X as appropriate).

Value addition activities	1	2	3	4	4
Processing is done within the small holder farms					
Farmers use approved storage procedures					
All by products are utilized at farm					
Different products including feeds					
Other auxiliary ventures are also developed					
Extension services support value addition					
Microfinance services are available to small holder farmers					
Marketing services are available					
Consumers normally accept products due to educational interventions.					

End

Thank you**.**

Appendix 3: Interview Guides

INTERVIEW GUIDE I

FOR HIGHER LEARNING AND RESEARCH INSTITUTIONS

NAME OF THE INSTITUTION…………………………………Date ..……………………

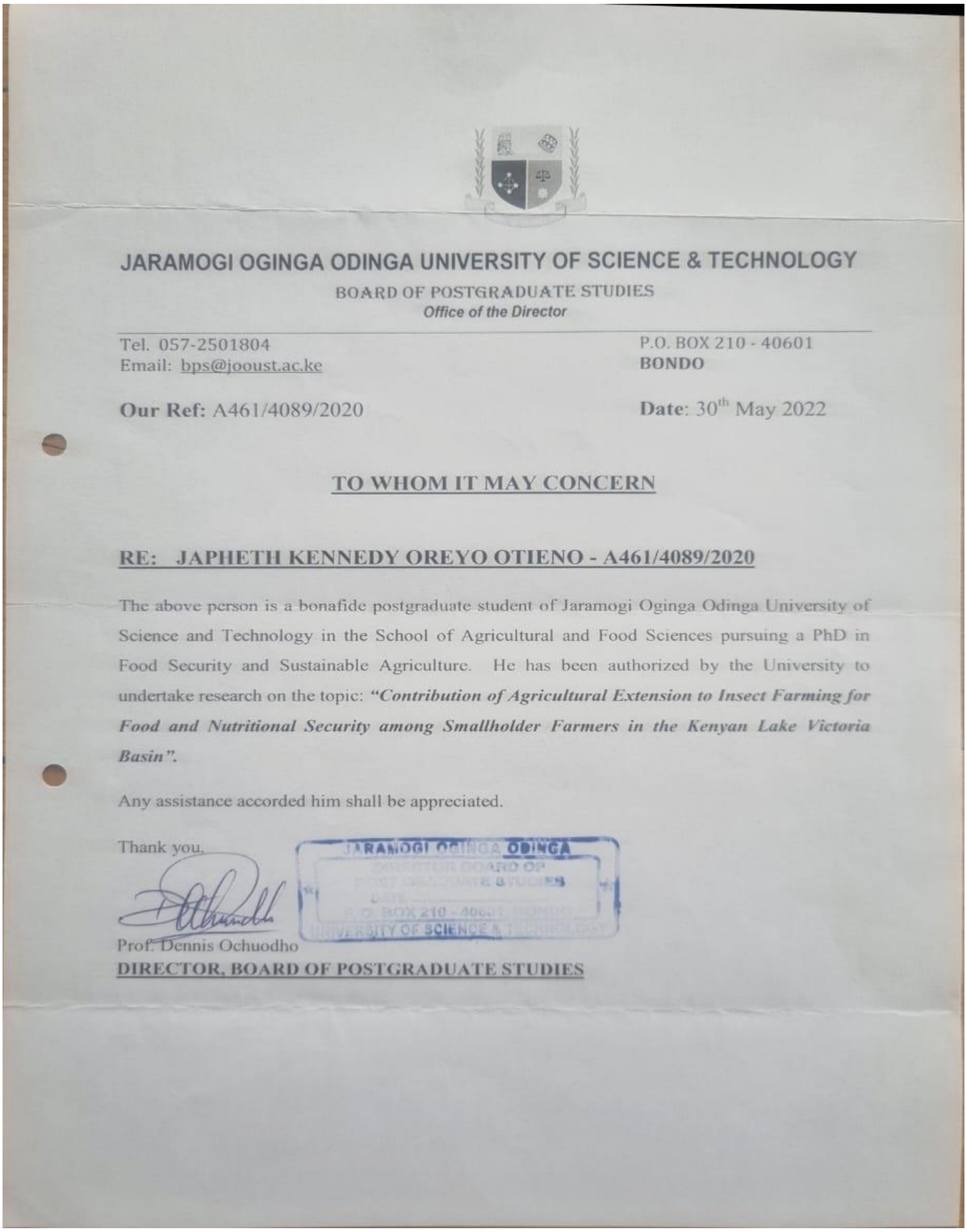
Focus area	**Questions**	**Responses**
Study and participants introduction		
Contribution to insect farming	What's your role in insect farming (Key activities) How has it grown over the years? Who is supporting you(key items of support)	
Interactions with farmers and other stakeholders in the small holder segment	What's the mode of recruitment of participants/farmers? How many famers/ sites have you enrolled and why? What informs your choice of groups/farmers? How do you manage information flow back and forth? How do you ensure growth List of partners and their roles	
Involvement with mainstream extension department	Is there any formal or otherwise arrangement with the ministry of agriculture for extension support? Any inputs from the ministry How do other partners communicate with other groups or sites? How are activities of other partners coordinated and harmonized with mainstream government programmes? What is the future of insect farming and extension support	
Future support perceptions	What is planned for your project in the next few weeks How do you plan to create the awareness for the same	
Perceptions of current and past extension support and coordination	Is there a role for coordination required within the existing extension framework? Are there occasions you found things not happening as expected? Give more information What do you think can make a difference in the way your project has been managed?	
Suggestions and recommendations	Suggest how extension support can be improved	

INTERVIEW GUIDE II

MINISTRY OF AGRICULTURE AND OTHER EXTENSION SERVICE PROVIDERS

s/no	Focus area	Questions/Probes	Responses
1.	Study and participant introduction	Explanation of the study and its scope introductions	
2.	Extension service provision framework	Brief explanation on the participants job Is insect farming part of the extension package? The main successes The main challenges Your feeling on targeted support to furthering extension to insect farming	
3.	Future perceptions (awareness on opportunities)	What are the potential value addition opportunities for the small holder insect farmers What is planned for the next months?	
4.	Perceptions on current and past extension support programmes	What does mainstreaming insect farming in the current extension framework mean? What is your feeling on the level of support from partners? How well do you think the extension services framework is consolidated? Howe can it be improved?	
5.	Models	Suggest preferred models to drive the insect food farming and innovation In each case give reasons	
			Thank you

Appendix 4: Letter of Data collection



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P.O. BOX 210 - 40601
BONDO

Our Ref: A461/4089/2020

Date: 30th May 2022

TO WHOM IT MAY CONCERN

RE: JAPHETH KENNEDY OREYO OTIENO - A461/4089/2020

The above person is a bonafide postgraduate student of Jaramogi Oginga Odinga University of Science and Technology in the School of Agricultural and Food Sciences pursuing a PhD in Food Security and Sustainable Agriculture. He has been authorized by the University to undertake research on the topic: ***"Contribution of Agricultural Extension to Insect Farming for Food and Nutritional Security among Smallholder Farmers in the Kenyan Lake Victoria Basin".***

Any assistance accorded him shall be appreciated.

Thank you,

Prof. Dennis Ochuodho
DIRECTOR, BOARD OF POSTGRADUATE STUDIES