ASSESSMENT OF THE SOCIOECONOMIC FACTORS INFLUENCING THE ADOPTION OF INTEGRATED PEST MANAGEMENT PRACTICES AMONG TOMATO FARMERS IN AMURU DISTRICT

A dissertation presented to

FACULTY OF AGRICULTURE

in partial fulfillment of the requirements for the award of the degree

Master of Science in Agro-ecology

UGANDA MARTYRS UNIVERSITY

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2023-M152-22824

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September 2025

UGANDA MARTYRS UNIVERSITY

SCHOOL OF POSTGRADUATE STUDIES AND RESEARCH

Master's Dissertation

Declaration

I have read the rules of Uganda Martyrs University on plagiarism and hereby state that this work is my own.

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DEDICATION

My deepest gratitude goes to my academic supervisor Rev. Sr. Mary Goretti Acila for her rich knowledge, support and guidance she offered to me throughout the entire course up to this final product of the dissertation.

ACKNOWLEDGEMENT

Firstly, my sincere gratitude and appreciation goes to the Almighty God for all the inspiration, love, wisdom and strength.

I would like to express my special gratitude to my supervisor Rev. Sr. Mary Goretti Acila for her special support throughout course. I am greatly indebted for her constant support during study as well as during the research.

Finally, appreciation goes to my family and friends for their courage and company which has contributed to the success of my research study. May God bless them.

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FAO	Food and Agriculture Organization
IPM	Integrated Pest Management
NGOs	Non-Governmental Organizations

ABSTRACT

This study assessed the socioeconomic factors influencing adoption of Integrated Pest Management (IPM) practices among tomato farmers in Amuru District, Uganda. Specifically, it examined the level of adoption of IPM practices, identified socioeconomic factors influencing adoption, and examined the association between socioeconomic factors and level of adoption of IPM among tomato farmers in Amuru district. The study adopted a descriptive cross-sectional design, utilizing both quantitative and qualitative methods. Data were collected from a purposive sample of 140 respondents, including 128 tomato farmers, 7 local leaders, and 5 agricultural extension workers, using structured questionnaires and interviews. Descriptive statistics, chi-square tests, and regression analysis were employed for data analysis. Findings revealed 67% of the level adoption of IPM, and varied levels of knowledge and adoption of IPM practices. Farmers demonstrated high awareness of IPM principles (mean = 4.21, SD = 0.84, $\chi^2 = 26.75$, p = 0.001) and pesticide application (mean = 4.10, SD = 0.88), while knowledge of biological pest control (mean = 3.65, SD = 1.14) and regular use of non-chemical methods (mean = 3.58, SD = 1.18) remained moderate to low. Key factors significantly influencing IPM adoption included education level ($\beta = 0.123$, p = 0.001), farm size, extension contact ($\beta = 0.951$, $p = 0.0006$), group membership, and access to IPM inputs. Conversely, factors such as age and gender were not statistically significant. All proposed strategies to enhance IPM adoption were rated positively, with provision of incentives and market access (mean = 4.50, SD = 0.69, $\chi^2 = 20.34$, p = 0.000) emerging as the most preferred. Others included improved access to credit, resource strengthening, extension support, and integration with existing practices. The study concluded that while awareness of IPM was generally high, actual adoption and practice especially of non-chemical and biological methods were inconsistent. It recommends that government and development partners strengthen agricultural extension services, improve access to IPM inputs and credit, and promote farmer group participation. Further research should explore the socioeconomic impacts of IPM adoption and the influence of gender on knowledge access and decision-making in tomato pest management.

CHAPTER ONE

INTRODUCTION

1.0 Introduction

This chapter presents the background of the study, statement of the problem, objectives of the study, research questions. It further underscores the scope of the study, significance of the study, justification of the study, conceptual framework and the definition of key terms.

1.1 Background of the study

Tomato (*Lycopersicon esculentum Mill*) is an important vegetable in world. The crop is grown in most parts of world, as a 'cash crop' because it helps to alleviate food and cash shortages (Melomey *et al.,* 2022). Tomato farming is predominantly a small-scale enterprise in developing countries, with a few large-scale initiatives at authorized irrigation locations, and its distribution throughout the year is significantly seasonal (Amewu *et al.,* 2020).

Tomato is one of most important edible and nutritional vegetable crops in the world and ranks next to potato and sweet potato with respect to world vegetable production. Tomato originated in South America and was later introduced to Africa. It is widely cultivated in tropical, sub-tropical and temperate climates (Asare-Addo *et al.,* 2022). Adjaye *et al.* (2021) estimates that 126 million tons of tomatoes were produced in the world and China, the largest producer accounted for about one fourth of the global output, followed by United States, Turkey, Iran, Mexico, Brazil, and Indonesia. It is one of the most economically important vegetable crops and is widely cultivated in the world with the total tones in area and production of 5,227,883 ha and 129,649,883 in 2020 (Melomey *et al.,* 2022).

The productivity of tomatoes has also remained relatively low over the last two decades. The average yields were about 7.80Mt/ha in 2018 compared to a global average yields of 34

Mt/ha. The yield of tomatoes in Ghana is also lower than major producing countries in the world, such as Burkina Faso (10 Mt/ha), Ethiopia (15.25 Mt/ha), Netherlands (47.6 Mt/ha), and South Korea (68.21 Mt/ha), (Willer *et al.,* 2021). The low yield is attributed to a lack of improved varieties, low fertilizer usage, no storage facilities, poor farm practices, high cost of farm inputs, inadequate market infrastructure, and poor access to water. These adversely affect the competitiveness and profitability of tomato production in Ghana (Abbade, 2020).

In Uganda, 40,124 tons of tomatoes are produced from 6,671 hectares. The crop is mainly grown by smallholder farmers who sell fresh fruits in regional and domestic markets in their localities to generate income (Ddamulira *et al.,* 2019). It is also a reliable source of food security and employment for on- and off-farm. As such, it is regarded as an economic crop for rural and peri-urban farmers (Sanga and Mgimba, 2016). In Uganda, tomato is consumed by about 3 million households in their most meals due to their nutrition value (Nick and Silva 2016). It can be processed and combined in many different dishes and eaten in different ways, such as tinned paste, fresh vegetables, tomato juice, sauce, or soup (Ssekyewa, 2016). Tomato is known for its nutritive value; it is rich in vitamin C and contains lycopene, a very vital antioxidant which prevents cancers (Ramathani *et al.,* 2018).

The production of a steady supply of food for the growing global population is agriculture's main goal. In the economies of many industrialized and developing nations, it is vital as a source of food, foreign exchange for imports and exports, jobs, and imports for other sectors (Wangithi *et al.*, 2022). Weeds and other insects have posed a threat to crop productivity, though. According to FAO estimates, pre-harvest crop losses from weed infestation, plant diseases, arthropods (mostly insects and termites), and other factors were between 30 and 35 percent; post-harvest losses from storage of grains, among other things, were estimated to be between 10 and 20 percent (FAO, 2021). Aggro chemicals have become an increasingly important component of a consistent and profitable production process in order to address these issues (Gabiri *et al.,* 2022).

Sustainable agricultural production systems are now required due to growing environmental awareness and worries about the safety and quality of food. Reducing the use of chemical inputs in agriculture is one of the main objectives of sustainable agricultural systems (Gabiri *et al.,* 2022). Integrated pest management is one strategy for addressing these problems. Modern agriculture's possible detrimental effects on the environment are well known to be serious public health issues (Muzaare, 2023). According to official estimates, Uganda uses 23,000 tons of pesticides annually on average (not including granules); unofficial calculations show that the country spends $120 million annually on pesticides (Rwangire and Muriisa, 2019). The misuse of pesticides and reliance on chemical pest control has contaminated crops, the environment, and human health.

Thus, a lot of the methods or approaches to put it another way, integrated pest management (IPM) is a sustainable approach to managing pests that combines biological, cultural, physical, and chemical tools in a way that minimizes economic, health, and environmental risks (McGowan, 2022). Essentially, IPM is a management approach that encourages natural control of pest populations by anticipating pest problems and preventing pests from reaching economically damaging levels. All appropriate techniques are used, such as enhancing natural enemies, planting pest-resistant crops, and using pesticides sparingly. While IPM practices emphasize minimal use of pesticides in controlling pests, farmers can adopt them to reduce the use of pesticides and their negative effects.

In Amuru District, Tomato farming faces pest and disease pressures, making it crucial for integrated pest management (IPM) adoption. IPM practices can reduce pest and disease incidence, leading to better yields and quality produce. Case studies show significant reductions in pesticide use and yields. However, barriers to adoption include lack of awareness, limited access to IPM inputs, and inadequate extension services. It is from this background that this research was conducted to assess the level of adoption of Integrated Pest Management practices among tomato farmers in Amuru District.

1.2 Statement of the problem

Tomato farming in Amuru District is a vital agricultural activity that supports the livelihoods of many households. However, these farmers face significant challenges due to pest infestations that reduce crop yields and quality. The prevalent use of chemical pesticides, while initially effective, has led to several adverse consequences, including health hazards for farmers and consumers, environmental degradation, and increased pest resistance (Amuru District Production Report, 2022). Despite the availability of Integrated Pest Management (IPM) practices, which offer a more sustainable and environmentally friendly approach to pest control, their adoption among tomato farmers in Amuru District remains low and inconsistent. Various socio-economic, institutional, and environmental factors hinder the widespread adoption of these practices. The low and inconsistent adoption of IPM practices among tomato farmers in Amuru District highlight the challenges in achieving sustainable pest management (Amuru District Production Report, 2022). Key issues include limited knowledge and awareness of IPM, inadequate training and extension services, insufficient access to financial resources, and a lack of supportive policies and infrastructure. As a result, farmers continue to rely heavily on chemical pesticides, which pose risks to their health and the environment, and are less effective in the long term due to increasing pest resistance. This situation underscores the need for a comprehensive assessment of the factors influencing IPM adoption and utilization to develop targeted interventions that can bridge this gap and promote sustainable agricultural practices in the district. It’s from this background that this research was conducted to assess the level of adoption of Integrated Pest Management practices among tomato farmers in Amuru District.

1.3 Objectives of the study

1.3.1 General objectives

To assess the socioeconomic factors influencing the adoption of Integrated Pest Management practices among tomato farmers in Amuru District.

1.3.2 Specific objectives

i. To assess the socioeconomic factors that influence adoption of Integrated Pest Management practices among tomato farmers in Amuru District.

ii. To determine the level of adoption of Integrated Pest Management practices among tomato farmers in Amuru District.

iii. To examine the association between the factors and level of adoption Integrated Pest Management practices among tomato farmers in Amuru District.

1.4 Research questions

i. What are the socioeconomic factors that influence adoption of Integrated Pest Management practices among tomato farmers in Amuru District?

ii. What is the level of adoption of Integrated Pest Management practices among tomato farmers in Amuru District?

iii. What are the associations between socioeconomic factors and level of adoption of Integrated Pest Management practices among tomato farmers in Amuru District?

1.5 Scope of the study

The scope of the study focused on geographical, content and time scope as listed below;

1.5.1 Geographical scope

The study was conducted in four predominant tomato growing Sub Counties of Lamogi, Atiak, Paboo and Amuru Sub County. Amuru District is bordered by Adjumani District to the north, South Sudan and Lamwo District to the northeast, Gulu District to the east, Nwoya District to the south, Nebbi District to the southwest and Arua District to the west. The administrative headquarters of the district at Amuru lies 60 kilometres (37 mi) northwest of Gulu, the largest city in the sub-region.

1.5.2 Content scope

The study focused on assessing the level of adoption of Integrated Pest Management practices among tomato farmers in Amuru District. It was limited to; assessing the level of knowledge of Integrated Pest Management practices among tomato farmers, determining the factors influencing the adoption of Integrated Pest Management practices among tomato farmers and identifying the possible ways of motivating smallholder farmers to increase the adoption of Integrated Pest Management practices among tomato farmers in Amuru District.

1.5.3 Time scope

The study considered literature collected within a period of 11 years (2014-2025). This period was selected to enable researcher to come up with coherent information from the relevant published articles, journals and books. The study took a period of one year and this included writing the concept note and proposal, collecting data, analyzing and writing up the dissertation.

1.6 Significance of the study

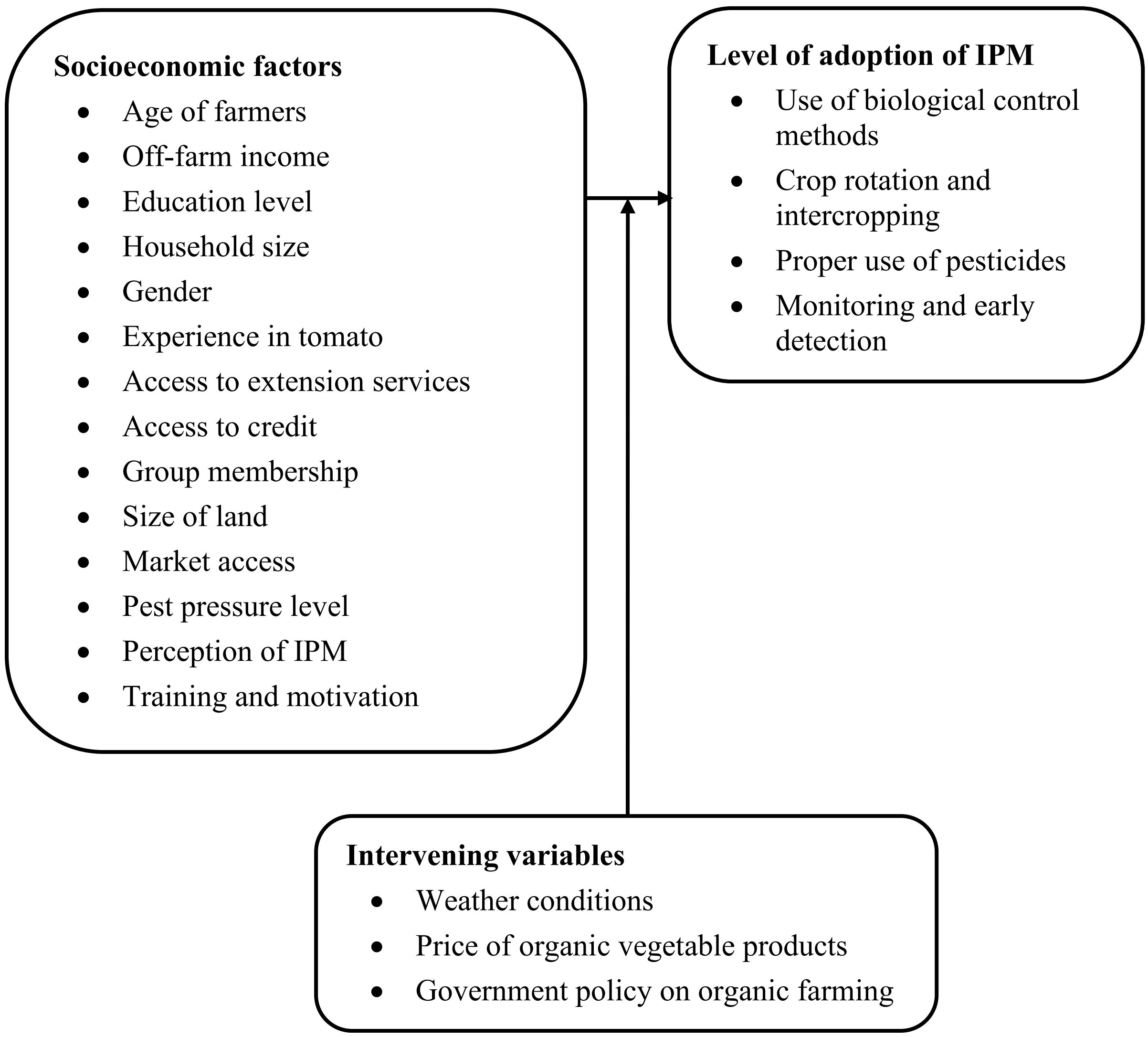
The study aimed at identifying socioeconomic-institutional factors that influence adoption of IPM among tomato farmers. The findings are therefore significant in promoting sustainable farming through reducing chemical dependency. Extension workers will also be guided in designing tailored training and outreach programs, while also providing empirical data to inform policymakers on agricultural practices, pest management, and resource allocation. Additionally, the study will establish baseline data for further research on IPM, supporting innovations that address farmers' specific challenges. Ultimately, it highlights the importance of IPM in reducing pesticide use, conserving the environment, protecting biodiversity, and fostering sustainable agriculture.

1.7 Justification of the study

Tomato farmers in Amuru District rely heavily on chemical pesticides for pest management, leading to environmental and health issues (Amuru District production Report, 2022). However, there is a lack of knowledge and training about Integrated Pest Management (IPM) practices among farmers. IPM practices, which include biological, cultural, mechanical, and chemical control methods, offer economic viability, reduced chemical use, improved health outcomes, and sustainable pest control. However, there is a significant knowledge gap and limited access to resources, hindering the adoption of IPM practices. It is from this basis that this research was conducted to assess the level of adoption of Integrated Pest Management practices among tomato farmers in Amuru District.

1.8 Conceptual framework of the study

Independent variable **Dependent variable**



Source: Researcher, 2024

Figure 1: Conceptual framework of the study

The independent factors such as off-farm income, education level, household size, labor availability, access to extension services, training and motivation, access to credit, and group membership significantly influence the adoption of Integrated Pest Management (IPM) practices, but their effect is often mediated by key intervening variables. For example, educated farmers with access to credit and group networks are more likely to attend training and capacity-building sessions, participate in demonstrations and field visits, and benefit from information dissemination and advisory services, which enhance their knowledge and confidence in adopting IPM. Also, access to extension services and group membership improves farmers' exposure to market information, supportive policy environments, and localized agro-ecological knowledge, enabling them to apply context-specific IPM techniques effectively. These intervening variables act as enablers that strengthen or weaken the relationship between the independent variables and the dependent outcome adoption of IPM practices, including the use of biological control methods, crop rotation and intercropping, proper use of pesticides**,** and monitoring and early pest detection. Therefore, the adoption of IPM is not solely a function of farmers' characteristics, but also how these characteristics interact with institutional and environmental support systems that facilitate learning, access to resources, and the practical application of sustainable pest management approaches.

1.9 Definition of key terms

Adoption. Refers to the process by which individuals, groups, or communities accept, integrate, and implement new ideas, technologies, practices, or innovations into their routines or systems (Mugambi *et al.,* 2021).

Extension services. Refer to organized efforts by institutions, governments, or organizations to provide farmers, communities, or other stakeholders with access to knowledge, technologies, and practices aimed at improving their productivity, livelihoods, and overall well-being (Ddamulira *et al.,* 2021).

Integrated Pest Management (IPM) Practices. Integrated Pest Management (IPM) Practices refer to a holistic and sustainable approach to managing pests that combines multiple strategies to minimize pest damage while reducing the reliance on chemical pesticides (Evans, 2022).

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This chapter focuses on the existing literature that was advanced by other scholars in relation to the research problem. This chapter focuses on the existing literature that was advanced by other scholars in relation to the research problem. The researcher only focused on theoretical review, conceptual review, the level of knowledge of Integrated Pest Management practices among tomato farmers, the factors influencing the adoption of Integrated Pest Management practices among tomato farmers and the possible ways of motivating smallholder farmers to increase the adoption of Integrated Pest Management practices among tomato farmers.

2.1 Theoretical Review

The adoption of Integrated Pest Management (IPM) practices among tomato farmers can be effectively analyzed through Rogers *et al.* (2014) Diffusion of Innovations Theory, which identifies five key attributes influencing adoption: relative advantage, compatibility, complexity, trialability, and observability. IPM is more likely to be adopted when farmers perceive it as offering greater benefits than conventional pesticide use, such as reduced costs, improved crop health, and environmental safety (Rogers *et al.,* 2014). Compatibility with existing farming practices and beliefs enhances acceptance, while perceived complexity especially in understanding pest monitoring and biological control can hinder adoption unless mitigated through farmer training and extension support (Dibra, 2015). Trialability allows farmers to experiment with components of IPM on a small scale, increasing their confidence in full adoption, while observability of successful outcomes in neighboring farms enhances peer influence and adoption decisions (Dibra, 2015). By identifying early adopters and using them as change agents, extension workers can stimulate broader diffusion of IPM, ultimately improving sustainable pest control in tomato production systems.

2.2 Conceptual Review

The adoption of Integrated Pest Management (IPM) practices among tomato farmers is conceptually linked to their level of knowledge, influencing their perceptions, attitudes, and decision-making regarding pest control. Farmers with greater knowledge of IPM are more likely to recognize its benefits, such as reduced chemical use, environmental safety, and sustainable pest control (N'dakpaze, 2022). However, knowledge alone does not guarantee adoption; socioeconomic, institutional, and psychological factors also play critical roles. Education level, farm size, access to extension services, and market incentives significantly affect the rate of adoption (Damalas and Koutroubas, 2017). Furthermore, cultural beliefs, risk perception, and prior experiences with pest outbreaks influence farmers' willingness to try IPM (Barzman *et al.,* 2015). Lack of training, limited access to affordable inputs, and inadequate demonstration plots hinder adoption (Pretty and Bharucha, 2015). Motivating smallholder farmers to increase adoption requires strengthening agricultural extension systems, subsidizing IPM inputs, and fostering farmer-to-farmer learning through community-based approaches (Nyamutukwa *et al.,* 2024). Use of participatory training models such as Farmer Field Schools has proven effective in increasing knowledge and adoption levels (N'dakpaze, 2022). Integrating IPM into agricultural policies and curricula can institutionalize its relevance, promoting wider acceptance and practice among farmers.

2.3 Empirical Review

Empirical studies on the level of adoption of Integrated Pest Management (IPM) practices among tomato farmers in Amuru District reveal a generally low to moderate uptake, shaped by a combination of knowledge gaps, economic barriers, and limited institutional support.

According to Sathiah *et al.* (2021), most tomato farmers in Amuru have limited awareness of holistic IPM approaches, with many relying on conventional chemical methods due to ease of access and familiarity. A study by Deguine *et al.* (2021) found that only 28% of tomato farmers had received formal training on IPM, and even fewer applied a full set of IPM techniques, such as use of biopesticides, crop rotation, and pest monitoring. The research also showed that adoption was higher among farmers who belonged to cooperative societies or had access to extension services. Moreover, Sadique-Rahman (2022) observed that adoption rates were significantly associated with education level, household income, and access to demonstration plots. These findings underscore the critical role of farmer training, financial incentives, and institutional frameworks in promoting wider adoption of IPM practices in the district.

2.4 The level of knowledge of Integrated Pest Management practices among tomato farmers

The level of knowledge of Integrated Pest Management (IPM) practices among tomato farmers plays a critical role in influencing their adoption of sustainable pest control methods. In the United Kingdom, the implementation of the Sustainable Use Directive has facilitated the promotion of IPM by encouraging non-chemical approaches, which has subsequently enhanced farmer awareness and knowledge levels (Chikte *et al.,* 2024). Studies indicate that tomato farmers in the UK exhibit moderate to high knowledge of IPM practices, largely attributed to robust government extension services and private-sector training initiatives. However, despite this awareness, adoption remains inconsistent due to challenges such as the perceived complexity of IPM techniques and the cost associated with implementation. Boros *et al.* (2024) reported that while 70% of UK tomato farmers understood the role of biological control agents like predatory insects, only 45% applied them in practice, primarily due to limited access to such biological products. In Spain, where tomato production is a major agricultural activity particularly in greenhouse settings IPM knowledge and adoption levels are high, largely due to comprehensive farmer education programs and strong cooperative support systems. Benbrook *et al.* (2021) found that 80% of tomato farmers in Almería had advanced knowledge of IPM strategies, including crop rotation, pest monitoring, and the use of biopesticides. Nevertheless, the study highlighted gaps in farmers' ability to integrate these practices into a coherent, system-based approach. These findings underscore that while knowledge is a prerequisite for adoption, it must be supported by access to inputs, institutional support, and simplified guidance to translate awareness into consistent application. Therefore, a high level of IPM knowledge among tomato farmers is necessary but not sufficient on its own to ensure full adoption of IPM practices.

In countries like India and China, which are among the leading producers of tomatoes globally, the level of knowledge of Integrated Pest Management (IPM) practices among farmers varies considerably and directly influences adoption rates. In India, the overuse of chemical pesticides remains a persistent challenge, particularly among smallholder tomato farmers. Although government programs and non-governmental organizations have made efforts to raise awareness about IPM, knowledge remains limited among many producers. According to Sathiah *et al.* (2021), only 35% of tomato farmers in Karnataka were familiar with basic IPM principles, primarily restricted to crop rotation and the use of trap crops, with minimal understanding of biological control or pest monitoring techniques. The lack of access to extension services, training, and affordable biopesticides has further hindered broader knowledge dissemination and adoption. In contrast, China has made notable progress in promoting IPM through government-led campaigns and partnerships with international institutions. However, the level of knowledge among tomato farmers still shows regional disparities. Urban and peri-urban farmers tend to be more informed and likely to adopt IPM, while rural farmers remain less knowledgeable and dependent on chemical pesticides.

Khokhar *et al.* (2024) reported that in Shandong Province, 60% of tomato farmers were aware of IPM, but only 40% adopted it effectively due to limited access to training and skepticism about the effectiveness of non-chemical options. These findings illustrate that while awareness of IPM is gradually increasing in both countries, widespread and effective adoption is constrained by uneven knowledge distribution, limited support services, and economic barriers, particularly for small-scale and rural producers. This highlights the critical need for targeted capacity-building programs and improved access to extension services to bridge the gap between knowledge and practical adoption of IPM.

Turkey's strategic position bridging Europe and Asia provides it with a diverse agricultural environment, including favorable conditions for tomato production. In response to concerns over pesticide misuse and environmental degradation, the Turkish government has actively promoted the adoption of Integrated Pest Management (IPM) through subsidies, awareness campaigns, and farmer training programs. These efforts have led to moderate levels of IPM knowledge among tomato farmers. Fusar-Poli and Fontefrancesco (2024) highlight that government-led educational initiatives have increased general awareness of sustainable pest control practices across key tomato-producing regions. In a recent study conducted by Dağ *et al.* (2025) in Antalyaa major tomato-producing area65% of farmers demonstrated an understanding of basic IPM concepts, including pest monitoring and the use of biological control agents. Despite this, actual implementation remains limited, with only 50% of the surveyed farmers adopting IPM techniques in practice. The primary barriers cited were the high initial costs associated with IPM components and the lack of sufficient market incentives or price premiums for sustainably grown tomatoes. This gap between knowledge and practice suggests that while educational efforts have improved farmer awareness, broader adoption requires enhanced financial support, access to affordable IPM inputs, and stronger market linkages to reward environmentally responsible farming. The Turkish experience reinforces the idea that knowledge alone is not enough; structural and economic support mechanisms must accompany educational interventions to ensure the effective adoption of IPM practices among tomato farmers.

Integrated Pest Management (IPM) is widely recognized as a sustainable and environmentally sound approach to pest control, incorporating biological, cultural, physical, and, when necessary, chemical methods in a harmonized manner to minimize risks to human health and the environment (Sadique-Rahman, 2022). However, the level of knowledge and adoption of IPM practices varies significantly across regions, largely influenced by socioeconomic, institutional, and policy-related factors. In developed countries, IPM has been successfully mainstreamed into agricultural systems due to strong institutional frameworks, research support, and consistent farmer training. In contrast, developing countries often face barriers such as inadequate extension services, low literacy levels among farmers, and limited access to IPM technologies and inputs (Khan *et al.,* 2020). As a result, many smallholder farmers continue to rely heavily on synthetic pesticides, often without adequate knowledge of their safe and effective use. Rahman (2021) highlights that one of the major gaps in IPM adoption globally is the lack of structured and continuous education and capacity-building programs tailored to farmers' local needs. Addressing this gap is essential to improving not only farmers' knowledge but also their ability to implement IPM strategies effectively and sustainably. Therefore, increasing global awareness and adoption of IPM requires a concerted effort that combines policy support, practical training, access to inputs, and localized knowledge dissemination strategies.

In Africa, the level of knowledge regarding Integrated Pest Management (IPM) practices among farmers remains generally low, primarily due to systemic challenges such as weak extension service delivery, insufficient farmer training programs, and limited access to modern agricultural technologies (Deguine *et al.,* 2021). These constraints contribute to a heavy reliance on chemical pesticides, often used indiscriminately without adequate understanding of their environmental and health risks or awareness of safer, sustainable alternatives (Rossi *et al.,* 2019). The limited dissemination of IPM knowledge has led to minimal adoption, particularly among smallholder farmers who dominate the agricultural landscape in many African countries. However, targeted initiatives focused on farmer education, participatory training, and community-based learning have shown positive impacts in improving IPM awareness and uptake. Deguine *et al.* (2021) report that in regions where such programs have been implemented, farmers demonstrate better understanding of pest ecology and are more likely to adopt practices such as biological control, crop rotation, and pest monitoring. These findings highlight the importance of strengthening institutional support systems and investing in knowledge transfer mechanisms to enhance the level of IPM adoption across the continent. Bridging the knowledge gap through tailored extension models is essential for promoting sustainable pest management and reducing dependency on hazardous agrochemicals in African agriculture.

In Uganda, tomato farming plays a vital role in enhancing food security and contributing to household incomes and national economic development. Despite its significance, the level of knowledge regarding Integrated Pest Management (IPM) practices among tomato farmers remains low. According to Deere *et al.* (2023), many Ugandan tomato farmers have limited understanding of sustainable pest management approaches, relying predominantly on chemical pesticides as their primary control method. This knowledge gap has contributed to increased incidences of pesticide misuse, pest resistance, and adverse environmental impacts. Wanyama (2024) conducted a national survey and reported that only 30% of tomato farmers were aware of IPM strategies, with even fewer implementing core practices such as pest monitoring, crop rotation, or the use of biological controls. The low awareness levels are largely attributed to inadequate access to extension services, limited training opportunities, and poor dissemination of IPM-related information at the grassroots level. This situation underscores the urgent need for government and development partners to invest in farmer education, strengthen agricultural extension systems, and promote IPM through practical demonstrations and participatory learning approaches. Enhancing farmer knowledge and awareness of IPM in Uganda is crucial for reducing chemical dependency, improving environmental sustainability, and promoting resilient tomato production systems.

Focusing on Amuru District in Northern Uganda, research reveals a significant knowledge gap regarding Integrated Pest Management (IPM) among local tomato farmers. A case study by Okwakol *et al.* (2022) found that the majority of tomato growers in the district had not received any formal training in pest management techniques, relying instead on traditional or chemical-based practices. While some farmers exhibited basic awareness of pest control such as the use of pesticides or rudimentary physical methods their understanding of integrated approaches remained limited. The study emphasized that few farmers were knowledgeable about critical IPM components such as biological control, pest monitoring, cultural practices, and environmentally safe pesticide use. This lack of comprehensive knowledge not only limits the effectiveness of pest management but also contributes to long-term issues such as pest resistance, reduced yields, and environmental harm. The findings underscore the need for targeted training programs, improved extension service delivery, and community-level demonstrations to promote awareness and practical application of IPM. Strengthening farmers' knowledge in Amuru District is essential to increasing the level of IPM adoption, enhancing tomato productivity, and supporting sustainable agricultural practices.

2.5 The socioeconomic factors influencing the adoption of Integrated Pest Management practices among tomato farmers

2.5.1 Knowledge and awareness

Farmers' knowledge about IPM principles significantly influences its adoption. A study by Khatun *et al.* (2022) in Bangladesh found that farmers with higher awareness levels about pest management techniques were more likely to adopt IPM practices. Educational programs and workshops can enhance this knowledge. Farmers with higher levels of education and access to information are more likely to adopt innovative pest management strategies. According to a study by Tabriz *et al.* (2021), farmers who participated in training programs demonstrated significantly improved knowledge about pest identification and management techniques compared to those who did not receive such training. Furthermore, the dissemination of information through extension services has been shown to enhance farmers' understanding of IPM principles. A case study conducted in India by Rai *et al.* (2023) highlighted that farmers who received regular updates from agricultural extension officers were more adept at implementing IPM practices effectively. An initiative led by local NGOs provided workshops for tomato farmers emphasizing the importance of sustainable pest management methods over chemical pesticides. The program resulted in a marked increase in both knowledge levels and practical application of IPM strategies among participants (Beevi *et al.,* 2013).

2.5.2 Market demand for sustainable products

One of the key factors influencing the adoption of Integrated Pest Management (IPM) practices among tomato farmers is the growing consumer demand for sustainably produced food, which serves as a strong economic incentive. As market preferences shift toward health-conscious and environmentally friendly products, farmers are increasingly motivated to adopt sustainable practices that align with these demands. Griebel *et al.* (2012) conducted a comprehensive study in California, revealing that tomato farmers who adopted IPM practices were able to access premium markets, including organic and specialty produce outlets, where they commanded higher prices for their crops. These farmers not only experienced improved yields due to better pest control but also benefited from the added economic value of producing food that met sustainability standards. The case studies demonstrated that market-driven incentives can play a critical role in motivating farmers to transition from conventional pesticide-reliant methods to integrated pest management systems. The promise of higher income and market access thus acts as a catalyst for adoption, particularly when farmers are supported by policies, certification schemes, and consumer education that promote sustainable agriculture. These findings indicate that economic viability driven by consumer preferences can significantly enhance the level of IPM adoption, provided that farmers are aware of the opportunities and equipped with the necessary knowledge and support systems. Consequently, integrating market-based incentives into agricultural extension and policy strategies may be vital in scaling up the adoption of IPM among tomato farmers globally.

2.5.3 Economic incentives

Economic factors are widely recognized as critical determinants influencing the adoption of Integrated Pest Management (IPM) practices among tomato farmers. Financial capacity often dictates whether farmers can access the necessary inputs, training, and technologies required for successful IPM implementation. A recent study by Abbey (2023) in Ghana revealed that farmers who received financial incentives or subsidies were significantly more likely to adopt IPM practices than those without such support, suggesting that economic relief reduces the burden of initial investment. McCarthy (2014) examined smallholder tomato farmers in Brazil engaged in an agroecological transition, finding that access to microfinance played a pivotal role in facilitating the shift toward IPM. Farmers who received credit not only adopted more sustainable pest management practices but also reported improved profitability, demonstrating the dual benefit of economic and environmental gains. In India, Dhotre *et al.* (2025) found that government subsidies helped farmers invest in necessary resources such as biopesticides, pheromone traps, and technical training, thereby accelerating the transition to integrated approaches. Collectively, these studies highlight that the availability of financial support whether through credit schemes, subsidies, or market-based incentives enhances farmers' capacity and willingness to adopt IPM. Without such support, especially in resource-constrained settings, even well-informed farmers may be unable to transition from conventional practices to more sustainable pest management systems. Therefore, economic empowerment emerges as a foundational element in scaling up the adoption of IPM practices among tomato farmers.

2.5.4 Input costs

Economic considerations are a critical factor influencing the adoption of Integrated Pest Management (IPM) practices among tomato farmers. According to economic theory, farmers tend to adopt agricultural practices that either enhance profitability or reduce production risks. However, the high initial costs associated with adopting IPM often act as a deterrent, especially for resource-constrained smallholder farmers. Kabir *et al.* (2023) emphasized that although IPM offers substantial long-term benefits in terms of yield improvement and environmental sustainability, the upfront financial investment required for training, biopesticides, and specialized equipment limits its widespread uptake. This concern is echoed by Khokhar *et al.* (2024), whose study on tomato farmers in Punjab, India, identified the cost of biopesticides and the expenses associated with acquiring new technical knowledge as significant barriers to IPM adoption. Mwangi (2021) found that smallholder tomato farmers in Kenya struggled to implement IPM due to the unaffordability of essential inputs. However, the study also noted that adoption rates significantly increased when governments provided subsidies or financial support for IPM inputs. These findings underscore the importance of economic support mechanisms such as subsidies, credit access, and reduced input costs in facilitating the adoption of IPM practices. Without addressing the financial burden on farmers, especially in low-income settings, efforts to scale up sustainable pest management may remain limited. Thus, economic interventions are essential to making IPM adoption both feasible and attractive for tomato farmers.

2.5.5 Farm income

The socioeconomic status of farmers plays a significant role in shaping their capacity and willingness to adopt Integrated Pest Management (IPM) practices. Farmers with higher income levels are typically better positioned to invest in the tools, training, and inputs required for effective IPM implementation. Rege *et al.* (2022), in a study conducted in Nigeria, observed that wealthier farmers had greater access to resources and were more likely to adopt IPM technologies than their lower-income counterparts, who continued to rely on conventional and often less effective pest control methods. Agandaa (2023) reported that tomato farmers with higher annual incomes were more likely to engage in IPM-related workshops and training programs, reflecting their capacity to allocate both time and money toward improving farm practices. The ability to afford inputs such as biopesticides, pheromone traps, and organic fertilizers often integral to IPM is also more prevalent among higher-income farmers, as noted by Wongnaa *et al.* (2023). This highlights a socioeconomic divide in access to sustainable agricultural technologies. In low-income farming communities, the lack of disposable income limits the adoption of IPM despite awareness of its benefits. Therefore, socioeconomic status not only influences the decision to adopt IPM but also determines the extent to which farmers can sustain its application, underscoring the need for targeted support and financial assistance to bridge the gap among disadvantaged farmer groups.

2.5.6 Farm size

Farm size can significantly influence the adoption of agricultural practices, including IPM. Larger farms may have more resources to invest in training and technology compared to smaller farms (Afriyie *et al.,* 2023). Conversely, smaller farms might be more flexible and quicker to adopt new practices due to fewer bureaucratic hurdles. Larger farms often have better access to financial resources, which allows them to invest in advanced pest management technologies and training programs. For instance, a study conducted by Ali *et al.* (2021) found that larger tomato farms were more likely to adopt IPM practices due to their ability to afford the initial costs associated with these methods. Larger farms benefit from economies of scale when implementing IPM strategies. They can spread the fixed costs of training and technology over a larger area or volume of production. A case study by Egyir *et al.* (2015) highlighted that large-scale tomato producers in Spain adopted IPM practices more readily than smallholders because they could reduce per-unit costs through bulk purchasing of inputs.

2.5.7 Farming experience

Farming experience refers to the duration and breadth of knowledge that farmers accumulate over time through practical engagement in agricultural activities. It encompasses not only the number of years spent farming but also the diversity of crops managed, exposure to pest management techniques, and participation in training programs. Research indicates that experienced farmers are more likely to adopt IPM practices due to their accumulated knowledge about pest life cycles, ecological interactions, and effective management strategies. For instance, a study conducted by Adesina *et al.* (2023) found that tomato farmers with over ten years of experience were significantly more knowledgeable about pest identification and control methods compared to novice farmers. Experienced farmers often have a better understanding of the risks associated with pest outbreaks and the potential benefits of adopting IPM practices. A case study by Zhang and Chaudhary (2021) highlighted that seasoned tomato growers exhibited lower levels of risk aversion when considering new pest management strategies, leading them to adopt IPM more readily than less experienced counterparts.

2.5.8 Gender

Gender roles significantly impact agricultural practices and decision-making processes. In many regions, men and women have different responsibilities in farming activities (Neway and Zegeye, 2022). For instance, men often control land ownership and financial resources while women may be responsible for household food production and pest management. This division can lead to disparities in access to information about IPM practices. A study by Karki *et al.* (2023) highlights that women farmers are often less informed about new agricultural technologies due to limited access to extension services compared to their male counterparts. This gap in knowledge can hinder the adoption of effective pest management strategies. Gender disparities in resource access can significantly affect women's ability to implement these practices. According to Kumar *et al.* (2023) women often face barriers in accessing credit facilities which limits their capacity to invest in necessary inputs for IPM. In contrast, male farmers generally have better access to financial resources and agricultural inputs. A case study conducted in Kenya by Krishna and Veettil (2022) found that male-headed households were more likely to adopt IPM practices due to better access to information and resources compared to female-headed households.

2.5.9 Education level

Education plays a crucial role in shaping farmers' knowledge and attitudes towards pest management strategies. Higher education levels are often associated with better understanding of agricultural practices, including IPM (Rana *et al.,* 2024). Research indicates that educated farmers are more likely to adopt innovative farming techniques due to their enhanced ability to process information and evaluate the benefits of new practices (Khan *et al.,* 2021). A study conducted by Tiwari *et al.* (2020) in Nigeria found that tomato farmers with higher educational attainment were significantly more likely to implement IPM strategies compared to those with lower education levels. The study utilized surveys and interviews to assess the educational backgrounds of farmers and their corresponding pest management practices. Results indicated that educated farmers were more aware of the ecological impacts of pesticides and preferred environmentally friendly alternatives. In a study by Singh *et al.* (2020), researchers examined tomato farmers in Punjab, India, focusing on how education influenced their adoption of IPM practices. The findings revealed that farmers with secondary or higher education were 40% more likely to adopt IPM compared to those with primary education or less. The study attributed this trend to educated farmers' access to information through extension services and agricultural training programs.

2.5.10 Extension services

Extension services refer to educational programs designed to provide farmers with information and skills necessary for improving agricultural productivity. These services can include training sessions, workshops, field demonstrations, and one-on-one consultations. The effectiveness of extension services is often determined by their ability to communicate relevant information effectively and engage farmers in participatory learning (Akter *et al.,* 2020). Extension services are pivotal in disseminating knowledge about IPM practices. Studies have shown that farmers who receive training from extension agents are more likely to adopt IPM strategies. For instance, a study conducted by Begum *et al.* (2023) in Bangladesh found that farmers who participated in extension programs demonstrated significantly higher knowledge levels regarding pest management compared to those who did not. Effective extension services provide access to resources such as pest-resistant seeds, biological control agents, and information on safe pesticide use. A case study by Thanh Tung, *et al.* (2021) in Vietnam highlighted how access to these resources through extension agents facilitated the adoption of IPM among smallholder tomato farmers.

2.5.11 Government policies

Regulatory frameworks established by governments can either facilitate or hinder the adoption of IPM practices. For instance, stringent pesticide regulations may encourage farmers to seek alternative pest management strategies such as IPM. A study conducted in India highlighted that the enforcement of pesticide regulations led to increased awareness and adoption of IPM practices among cotton farmers (Kumar *et al.,* 2021). Similar findings were reported in tomato farming where regulatory measures prompted farmers to adopt safer pest control methods. The integration of environmental sustainability into agricultural policy frameworks enhances the likelihood of adopting IPM practices. Policies that promote biodiversity conservation and ecosystem health often align with the principles of IPM. A comparative analysis between countries revealed that nations with integrated agricultural policies saw higher rates of sustainable practice adoption among tomato farmers compared to those with fragmented approaches (Voss *et al.,* 2024).

2.5.12 Age of farmers

The age of farmers plays a crucial role in their willingness to adopt new agricultural practices. Younger farmers tend to be more open to innovation and are often more educated about modern farming techniques compared to older generations. Research indicates that younger farmers are more likely to engage with extension services and participate in training programs related to IPM (Kassie *et al.,* 2015). A study conducted in Kenya by Mugambi *et al.* (2021) found that younger tomato farmers were significantly more likely to adopt IPM practices than their older counterparts. The research highlighted that younger farmers had higher levels of education and were more engaged with agricultural extension services. Another case study from India by Misango (2023) showed similar trends where younger tomato growers adopted IPM techniques at a rate 30% higher than older farmers. This study emphasized the importance of training programs tailored for different age groups to enhance the adoption rates among older farmers.

2.5.13 Cultural beliefs and practices

Cultural beliefs encompass the values, norms, and practices that shape the behaviors of individuals within a community. In agricultural contexts, these beliefs can significantly influence farmers' decisions regarding pest management. For instance, traditional knowledge about pest control methods may lead farmers to rely on indigenous practices rather than adopting modern IPM techniques. Cultural beliefs can either facilitate or hinder the adoption of IPM practices. Research by Fajardo *et al.* (2024) in Zambia highlighted how traditional farming practices sometimes conflicted with modern pest management approaches, leading to resistance against adopting IPM. Traditional Knowledge Systems Traditional knowledge systems play a crucial role in shaping pest management strategies among tomato farmers. Studies have shown that many farmers possess extensive knowledge about local pests and their natural enemies, often passed down through generations (Venette and Morey, 2019). This knowledge can either complement or conflict with formal IPM recommendations. For example, some farmers may prefer using traditional herbal remedies for pest control instead of synthetic pesticides due to cultural beliefs about health and safety (Kondo *et al.,* 2024).

2.5.14 Pest pressure

Pest pressure refers to the intensity and impact of pest populations on crops. High levels of pest pressure can lead to significant crop losses if not managed effectively. In tomato farming, common pests include aphids, whiteflies, spider mites, and various caterpillars. A study conducted in Maharashtra highlighted how tomato farmers experiencing high levels of whitefly infestation adopted IPM practices after participating in government-sponsored training programs focused on integrated approaches (Patil *et al.,* 2022). The findings suggested that direct experiences with severe pest damage prompted many farmers to seek out alternative management strategies. In Kenya's Central Rift Valley, Ochieng *et al.* (2022) documented how smallholder tomato farmers responded to increasing aphid populations by integrating biological control measures into their farming systems after realizing the limitations of chemical pesticides alone.

2.6 The possible ways of motivating smallholder farmers to increase the adoption of Integrated Pest Management practices among tomato farmers

2.6.1 Education and training programs

One of the most effective ways to motivate smallholder farmers is through education and training programs focused on IPM principles. A study conducted in Kenya demonstrated that farmer field schools (FFS) significantly improved knowledge about pest management among tomato farmers. Participants reported increased confidence in implementing IPM practices after receiving hands-on training (Kassie *et al.,* 2019). The FFS model encourages active participation and peer learning, which can lead to higher adoption rates. Education initiatives provide farmers with information about pest biology, identification, monitoring techniques, and the ecological impacts of various pest management strategies. For instance, a study by Kasyoka *et al.* (2020) demonstrated that training sessions significantly improved tomato farmers' understanding of pest dynamics and management options.

2.6.2 Access to resources

Access to resources such as financial support, quality seeds, and pest management tools is essential for the successful implementation of IPM. Research indicates that providing subsidies or low-interest loans can incentivize farmers to invest in IPM technologies (Pecenka *et al.,* 2021). For instance, a program in Ghana offered financial assistance for purchasing biopesticides and organic fertilizers specifically for tomato growers. As a result, there was a notable increase in the use of environmentally friendly pest control methods. Access to resources encompasses various forms of support that farmers need to implement new agricultural practices. These include financial resources (credit and subsidies), informational resources (training and extension services), technological resources (tools and equipment), and social resources (networks and cooperatives). Studies have shown that when smallholder farmers have better access to these resources, they are more likely to adopt innovative agricultural practices. For instance, a study by Kassie *et al.* (2015) found that access to credit significantly influenced the adoption of improved agricultural technologies among smallholder farmers in Ethiopia. The availability of financial resources allowed farmers to invest in necessary inputs for IPM practices such as biopesticides or pest-resistant seeds.

2.6.3 Peer influence and social networks

Social networks play a critical role in influencing agricultural practices among smallholders. Studies have shown that when farmers observe their peers successfully adopting IPM techniques, they are more likely to follow suit (Diaz *et al.,* 2020). Community-based approaches that leverage local leaders or successful farmers as champions for IPM can create a ripple effect within communities. In Uganda, community-led initiatives resulted in increased adoption rates of IPM among tomato growers due to shared experiences and collective problem-solving. A case study conducted by Wang *et al.* (2014) in Kenya demonstrated that farmers who were part of well-connected social networks were more likely to adopt IPM techniques than those who were isolated. The study found that information shared through trusted peers was perceived as more credible than information from external sources. This underscores the importance of leveraging existing social structures to promote IPM adoption.

2.6.4 Incentives and market access

Creating market incentives for adopting sustainable practices can also motivate smallholder farmers. Certification schemes that reward environmentally friendly farming practices have been effective in some regions. For example, the Rainforest Alliance certification has encouraged many tomato producers in Latin America to adopt IPM by providing them with better market access and premium prices for certified products (Gómez-Guzmán *et al.,* 2022). Such initiatives not only improve farmer incomes but also promote sustainable agricultural practices. Financial support through subsidies or grants can encourage farmers to invest in IPM technologies. For instance, a study by Desneux *et al.* (2022) found that providing financial incentives significantly increased the likelihood of adopting IPM practices among smallholder farmers in Greece. The study highlighted that direct payments or cost-sharing arrangements helped alleviate the initial investment burden associated with implementing IPM.A case study conducted in Kenya by Blanco-Pérez *et al.* (2022) demonstrated that training sessions on pest identification and management led to a 40% increase in the adoption rate of IPM practices among tomato farmers. The study emphasized that continuous education helps build farmer confidence in using new methods.

2.6.5 Integration with existing practices

Smallholder farmers often rely on traditional pest management methods due to limited access to information, resources, and technology. These methods may include the use of broad-spectrum pesticides or cultural practices that do not consider ecological interactions. A study by Desneux *et al.* (2022) highlights that many farmers are unaware of the benefits of IPM or lack confidence in its implementation due to insufficient training and support. In Kenya's Central Rift Valley region, a project implemented by the International Centre of Insect Physiology and Ecology (icipe) focused on training tomato farmers in IPM techniques while integrating traditional knowledge with scientific research findings. The project reported a 30% reduction in pesticide use alongside improved tomato yields over three growing seasons (Sadique-Rahman, 2022). In Bangladesh, an initiative by the Food and Agriculture Organization (FAO) introduced a participatory approach where local farmer groups were trained on pest monitoring using pheromone traps combined with cultural control methods like crop rotation. This led to significant reductions in pest populations without relying heavily on chemical pesticides (Kabir *et al.,* 2023).

2.6.6 Improving farmer networks

Integrated Pest Management (IPM) is a sustainable approach that combines various management strategies and practices to control pests effectively while minimizing risks to human health, beneficial organisms, and the environment. For smallholder farmers, particularly those growing tomatoes, the adoption of IPM practices can lead to increased yields, reduced pesticide use, and improved economic viability. However, motivating these farmers to adopt IPM requires understanding their challenges and leveraging effective networks. In Kenya, the implementation of farmer field schools has been instrumental in educating tomato growers about pest identification and management through hands-on learning experiences (Josue-Canacan, 2022). A project in India focused on forming women-led farmer groups which not only empowered women but also facilitated greater acceptance of innovative agricultural techniques including IPM (Singh *et al.,* 2022). In Ghana, a collaborative effort between NGOs and local governments provided training on pest management while also improving access to markets for sustainably grown tomatoes (Jarial *et al.,* 2024).

2.6.7 Policy and institutional support

Governments can provide financial assistance or subsidies for purchasing IPM-related inputs such as biopesticides or pest-resistant seeds. For example, a study conducted in Kenya showed that providing subsidies significantly increased the adoption rates of IPM practices among tomato farmers (Ochieng *et al.,* 2022). Establishing training programs focused on educating farmers about IPM techniques is essential. A case study in India demonstrated that farmer field schools effectively improved knowledge and skills related to pest management among smallholders (Wang *et al.,* 2021). Creating platforms for information dissemination through extension services or digital technologies can help bridge the knowledge gap. Research indicates that mobile applications providing real-time pest alerts have successfully motivated farmers to adopt IPM strategies (Singh *et al.,* 2025).

CHAPTER THREE

RESEARCH METHODOLOGY

3.0 Introduction

A research methodology is the conceptual structure within which research is conducted; it constitutes the blue print for the collection, measurement and analysis of data. Under this chapter, the researcher presents the instruments that were employed during the process of collecting data from various sources. Therefore, the chapter presents, the research design, area of the study, study population, sample size, sampling procedures, data sources, data collection methods, research procedure, data quality control, data processing and analysis, ethical considerations and research limitations.

3.1 Research design

The study utilized a cross-sectional design to collect information from a specific segment of the population at a particular point in time. This approach enabled the researcher to gain a comprehensive understanding of the level of adoption and utilization of Integrated Pest Management practices among tomato farmers in Amuru District, as it exists during the study period. Data was gathered through a survey conducted across Amuru district, providing various categories of tomato farmers the opportunity to share their insights and experiences regarding the socioeconomic factors influencing the adoption of integrated pest management practices among tomato farmers in Amuru district.

3.2 Area of the study

The study was conducted in four tomato predominant growing Sub Counties of Lamogi, Atiak, Paboo and Amuru Sub County. Amuru District is bordered by Adjumani District to the north, South Sudan and Lamwo District to the northeast, Gulu District to the east, Nwoya

District to the south, Nebbi District to the southwest and Arua District to the west. The administrative headquarters of the district at Amuru lies 60 kilometres (37 mi) northwest of Gulu, the largest city in the sub-region.

3.3 Target population

Joncas and Foy (2012) define a study population as the entire group of elements (individuals or objects) that share specific characteristics determined by the researcher's sampling criteria. Similarly, Aroma (2011) explains that a target population encompasses all units for which survey data will be used to draw inferences, representing the group to which the study's findings are intended to apply. According to Aroma (2011), the target population consists of all individuals, cases, or objects with common traits that the researcher aims to generalize results to. For this study, the target population comprised of 500 tomato farmers registered in Amuru District, as reported in the Amuru district Production Report (2022). These farmers were chosen because they actively manage various aspects of tomato production, making them well-informed about the socioeconomic factors influencing the adoption of integrated pest management practices among tomato farmers in Amuru district.

3.4 Sample size determination

Sample size, according to Joncas and Foy (2012), is just a subset of the population. The incapacity of researchers to test every member of a particular population gives rise to the idea of a sample. The sample's primary purpose is to enable researchers to select a small number of people from the population so that findings from their investigation can be extrapolated to the full population. Five hundred tomato farmers were the total number of responders solicited. It is quite improbable that all tomato farmers were surveyed due to time and budget constraints. As a result, the sample was chosen from the district total, as shown below;

The study adopted the Kothari formula of calculating the sample size from the population.

$$n = \frac{z^2 . p. q N.}{(N\text{-}1)\, e^2 + z^2 p.q}$$

Where N = size of population

n = size of sample

e = acceptable error (the precision)

p= sample proportion,

q = 1 - p z = standard variety at a given confidence level

z=1.96 (area of normal curve for the given confidence level of 95%)

e= 0.02 (by assumption; estimate should be within 2% of true value). Therefore P=0.02 and q = 1-P = 0.98. The total numbers of tomato farmers are 500.

$$n = \frac{(1.96)^2\,(0.02)\,(0.98)\,(500)}{(0.02)^2\,(400\text{-}1) + (1.96)^2\,(0.02)\,(0.98)}$$

$$n = \frac{30.118144}{00.2349}$$

n=128 farmer

12 key informants.

Sample size 140

The sample size of the study was 140 respondents. These included 128 tomato farmers and 12 key informants. Details of the respondent categories in the sample are as shown in table 1 below;

Table 1: Respondent categories, sampling methods and data collection tools

Respondent category	Number selected	Data collect method/tool	Sampling method used
Tomato farmers	128	Questionnaire	Random sampling
Local leaders	7	Interview guide	Purposive sampling
Agriculture extension workers	5	Interview guide	Purposive sampling
Total	**140**		

Source: Primary data, 2024

3.5 Sampling technique

Sampling is the process or method of selecting a subgroup from a population to take part in the study, according to Ogula (2005). It is the process of choosing a number of participants for a study such that they are representative of the sizable population from which the sample was drawn. The respondents were selected using both purposive and basic random sample methods, as indicated below;

3.5.1 Simple random sampling

Random sampling, as defined by Galvan (2013), encompasses a range of selection methods where sample members are chosen at random but with a known probability of selection. In order to pick survey participants or sample units which could be individuals, businesses, land sites, or other units for analysis the majority of social science, business, and agricultural surveys use basic random sampling procedures. An essential component of the entire survey study design used was random sampling. It has been said that the reasoning behind simple random sampling was that it eliminated bias from representative samples and the selection process. Because research findings from the use of simple random sampling were generalizable, this method was used to choose tomato farmers.

3.5.2 Purposive sampling

Purposive sampling, according to Saunders *et al.* (2012), is the deliberate selection of particular individuals, components, occasions, or episodes that provide rich information about the phenomenon being studied. Gravetter *et al.* (2011) state that individuals with a wealth of information should be chosen for the study. Key informants were chosen using this technique. These were chosen based on their responsibilities and positions in spreading knowledge, especially that related to tomato cultivation.

3.6 Data sources

Both primary and secondary sources provided data for the research. The use of questionnaires and interviews to get data directly from field surveys was prioritized under primary sources. The researcher employed published and documented sources under the heading of secondary sources, which included research work documents, textbooks, publications, journals, office records and statistics, and online sources.

3.6.1 Primary data

Agriculture extension agents, local council officials, and tomato farmers provided primary data. Primary data offered trustworthy and precise first-hand knowledge pertinent to the research.

3.6.2 Secondary data

Galvan (2013) defines a secondary source as one that offers information or data that is neither original nor secondhand. In order to help address the research topic, the researcher employed secondary data from published and documented sources, such as research work documents, textbooks, periodicals, journals, newspapers, office records and statistics, and online sources.

Gathering crucial information to help the researcher validate or disprove the original data was the goal of using secondary data.

3.7 Data collection methods

The researcher used two data collection methods namely the questionnaire and interviews methods.

3.7.1 Questionnaire

Saunders (2007) states that explanatory research, which allows the researcher to analyze and explain correlations between variables, particularly cause-and-effect interactions, use a questionnaire. As a result, the questionnaire (Appendix I) was utilized to determine the sample's literacy rate while also saving time. The questionnaires were self-administered to farmers who actively participated in the production of tomatoes. Both structured and semi-structured questions were included in the questionnaire to collect respondents' qualitative and quantitative answers. When the researcher delivers the surveys to the respondents, the researcher read the questions to each one of them, paying particular attention to any unfamiliar terms. The researcher did this action in order to save time during data collection and to ensure that quality data was captured.

3.7.2 Interview method

An interview is a verbal exchange between two individuals with the aim of gathering pertinent data for a study (Kothari, 2012). Using oral questions, the interview is a one-on-one discussion that gathers comprehensive personal information from people. Interviews were utilized extensively to learn about the thoughts, feelings, and behaviors of an individual or individuals. An interview guide (Appendix II) was used to assist with the interview process. Since illiterate farmers and key informants were needed to provide a lot of specific information, this was utilized to collect data from them. Probing was employed during the interview process if respondents provide insufficient responses to the queries.

3.8 Quality control

Precautionary steps were implemented throughout the investigation to guarantee high data quality. A pre-test of the questionnaire was carried out before the survey to make sure it was comprehensive, accurate, and easy to understand. Following the pre-test, additional information was added for clarification and some questions were revised. Respondents were chosen by simple random sampling. Additionally, data was only collected by certified research assistants.

3.8.1 Validity of instruments

The questionnaire was examined by the supervisor to guarantee the validity and reliability of the information included inside. To examine the validity and reliability of the questionnaire, ten respondents participated in a pilot study. This study employed the following procedures to guarantee authenticity and reliability, validated the data, and ultimately gave the research report credibility.

For questionnaire

The Content Validity Index (CVI) for the questionnaire should be above 0.7 for the questionnaire to be declared valid (Saunders *et al.,* 2003). The validity of the instrument was determined by the formula:

$$CVI = \frac{\text{Number of items declared valid}}{\text{Total number of Items}}$$

$$CVI = \frac{10}{12}$$

$$CVI = 0.83$$

For interview guide

$$CVI = \frac{17}{20}$$

$$CVI = 0.8$$

Given that the CVI values were above 0.7 and therefore both the questionnaire and interview guide were considered valid.

3.8.2 Reliability of instruments

Pre-testing and re-testing the questionnaires and interview determined the instruments' reliability for this study. Since dependability is defined as the ability to measure something consistently across time or steadily in a range of conditions, the most widely used method for estimating reliability was to employ a measure of association. As advised, the questionnaires and interview guide were pre-tested and re-tested in the field to determine the reliability of the study's instruments. By pre-testing and re-testing the questionnaire with the same respondents from various case studies, the researcher determined the questionnaire's dependability.

3.9 Ethical considerations

The following ethical issues were taken into account throughout the research process in accordance with the university's policies and procedures regarding the use of human beings in research. Both the quantitative and qualitative research portions of this study were subject to these considerations.

3.9.1 Permission

Following the presentation of the concept, the proposal was shared with the research supervisor. As part of the ethical considerations for the research, the consent letter was included. To make sure the research was legitimate; the researcher got written consent from the Faculty of Agriculture of Uganda Martyrs University after submitting the proposal. Permission letters were supplied for every questionnaire. Additionally, the researcher sent the proposal to the supervisor, where the feedback and recommendations were taken into consideration.

3.9.2 Confidentiality and privacy

Handling respondent information in a private way is referred to as confidentiality. Respondents were guaranteed the utmost confidentiality about the handling of their names. This component involved the trust principle, whereby the researcher guaranteed that the participants' trust were not abused for private gain or advantage by misleading or betraying them during the research process or its published results.

3.9.3 Voluntary participation and informed consent

Respondents were given an explanation of the voluntary participation concept and made aware of their freedom to leave the study at any moment. Both the questionnaire and a verbal explanation of the informed consent principle were given to the interviewers. Both required participants to be informed about the goals and methodology of the study.

3.10 Research procedure

After presenting the proposal, the researcher secured an introductory letter which was presented to the authorities in Amuru District. With authorization from the relevant authorities, the researcher began data collection by personally delivering the questionnaires. Data collection tools were administered in accordance with the agreed schedule. During the administration of questionnaires and interviews, the researcher established a rapport with respondents, assured them of confidentiality, and explained the purpose of the study. This approach was designed to foster maximum cooperation from participants. The researcher personally conducted the data collection at the respondents' respective locations, ensuring clear communication by reading and explaining the interview guide while recording responses on a separate sheet. After completing data collection, the researcher analyzed the data and prepared a report to fulfill the requirements for a master's degree. The findings were shared with stakeholders through published and printed dissertation reports, which were made available in university libraries, public libraries, and the district offices.

3.11 Data analysis

To ensure that the collected data was complete, accurate, and of the necessary quality, it was assembled, sorted, revised, and coded. The Statistical Package for Social Scientists (SPSS v26.0) was then used to enter quantitative data from the questionnaires and interview guides in order to facilitate the creation of frequency tables. The level of adoption of IPM was measured using statistical analyses such as frequencies, percentages, means, and standard deviations. Furthermore, the factors influencing the adoption and use of IPM were assessed using inferential statistics such regression coefficients, Pearson correlation, and chi-square and the possible measures to motivate the adoption of IPM technologies were assessed using descriptive statistics. The qualitative narratives from key informant interviews were used to support the quantitative numbers in order to better comprehend them.

3.12 Limitations and delimitations of the study

The time for the study was too short, given the size of the study and population to be covered as well as the whole exercise of compiling data. This was solved by using research assistants to assist in data collection exercise to save time.

The researcher faced the challenges of getting adequate information from different study sources like textbooks, novels, journals to mention but a few. The researcher spent a lot of her time looking for the literature to be reviewed which was tiresome.

The study was limited by funds because funds were not enough to cater for secretarial services. The researcher however got some financial support from friends and relatives.

CHAPTER FOUR

DATA PRESENTATION, ANALYSIS AND INTERPRETATION

4.0 Introduction

This chapter presents the results obtained from the analyses of the data collected and also discusses the results as thoroughly as possible. The study was about assessing the socioeconomic factors influencing the adoption of integrated pest management practices among tomato farmers in Amuru district. Data was collected from 140 respondents who were tomato farmers, extension workers, and local leaders and the findings are presented in the following tables.

4.1 Questionnaire response rate

The study achieved a 100% response rate, aligning with Fincham's (2008) recommendation of a 60.0% response rate for survey research. This was achieved through efficient data collection planning, effective contact with respondents, and proper mapping of PDM beneficiaries and callbacks were made.

4.2 Demographic characteristics of respondents

Responses on demographic information of the respondents were recorded in table 2 below;

Table 2: Demographic characteristics of respondents (n = 140)

Demographic Characteristic	Category	Number of respondents (n)=140	Percent	Mean	Std. Deviation
Gender of respondents	Male Female	106 34	75.7 24.3	1.24	0.43
	Total	**140**	**100**		
Age of respondents	18-25 26-35 36-45 46-55 56 and above	21 33 49 27 10	15.0 23.6 35.0 19.3 7.1	30.5	0.86
	Total	**140**	**100**		
Education level	No formal education Primary Secondary Tertiary	29 61 41 09	20.7 43.6 29.3 6.4	2.21	0.84
	Total	**140**	**100**		
Marital status	Single Married Widowed Separated	24 111 3 2	17.1 79.3 2.1 1.5	1.88	0.48
	Total	**140**	**100**		

Source: Field data, 2025

Results established that majority of the respondents 106 (75.7%) were male compared to their female counterparts 34 (24.3%). This gender imbalance affects the adoption of IPM practices, since men had more access to agricultural training and extension services compared to women. This is because in northern Uganda, men are more involved in commercial crop farming, such as tomato production, compared to women who focus on subsistence crops and household duties. They have greater access to resources and land ownership, making them the primary decision-makers in tomato production. Amuru District's patriarchal norms hinder women's involvement in agricultural activities, particularly pest management, due to societal expectations promoting domestic roles over commercial farming. However, women, though fewer in number, played a vital role in pest control decisions at the household level. Therefore, gender-sensitive extension approaches are essential to ensure inclusive adoption of IPM practices. This is in agreement with Venette and Morey (2019) who pointed out that men normally participate in agricultural networks and participate in IPM practices, as they are more accessible to extension services and training programs, and are more willing to invest in high-value crops like tomatoes compared women.

Results established that majority of the respondents 49 (35.0%) were aged between 36-45 years, 33 (23.6%) revealed between 26-35 years, 27 (19.3%) mentioned between 46-55 years, 21 (15.0%) revealed between 18-25 years and only 10 (7.1%) mentioned 56 years and above. This shows that most tomato farmers were in their productive years and were likely more open to new practices like IPM. Younger farmers (18-35 years) were more receptive to modern farming methods and technologies due to exposure to education and training. Conversely, the low percentage (7.1%) of farmers above 55 implied that older farmers were less engaged in tomato farming or less likely to adopt new practices. This implies that commercial tomato farming, particularly with integrated pest management (IPM), was more prevalent among farmers aged 26-45 due to their energy, risk tolerance, and entrepreneurial drive. They also had access to training and information, making them more aware and adopting new practices. This is in agreement with Kassie *et al.* (2015) who pointed out that younger farmers were more open to innovation and educated about modern farming techniques, making them more likely to adopt IPM practices and even more engaged with extension services and participate in training programs related to IPM.

Results established that majority of the respondents 61 (43.6%) had completed primary education, 41 (29.3%) secondary, 29 (20.7%) had no formal education and 9 (6.4%) mentioned tertiary. This shows that majority of respondents (72.9%) had either primary or secondary education, which enhanced their ability to understand and apply basic IPM principles when appropriately trained. However, a significant portion (20.7%) had no formal education, which limited their understanding of technical aspects of IPM, emphasizing the need for visual and practical demonstrations during training. The low percentage (6.4%) of tertiary-educated farmers suggests limited exposure to advanced agricultural knowledge. This is in agreement with Rana *et al.* (2024) who revealed that education significantly influences farmers' knowledge and attitudes towards pest management strategies, with higher levels often associated with better understanding of agricultural practices, including Integrated Pest Management (IPM). Research shows educated farmers are more likely to adopt innovative farming techniques and are more aware of ecological impacts of pesticides.

Results established that majority of the respondents 111 (79.3%) were married, 24 (17.1%) single, 3 (2.1%) widowed and 2 (1.5%) had separated. The high percentage of married farmers suggests a likelihood of farming being a household livelihood activity. This is because married individuals were more committed to long-term investments in sustainable practices like IPM due to their responsibility to support their families and household decision-making in pest management involved both spouses, which enhanced adoption if both were adequately informed. This is in line with Kumar *et al.* (2023) who pointed out that married individuals in Uganda engage in sustainable farming practices like IPM, due to increased household responsibilities, access to labor, land ownership, and higher participation in farming. They have to settled lifestyles and adopt improved practices like IPM in order to ensure food security and income for their families whereas single or separated individuals are always more mobile or engaged in off-farm activities.

The results revealed a mean value of 1.24 with a low standard deviation, indicating that the majority of respondents were male and that there was limited variability in gender distribution among tomato farmers in Amuru District. This male dominance in tomato farming highlights the significant role men play in agricultural decision-making and production, likely influenced by factors such as land ownership, access to agricultural inputs, and extension services that tend to favor men. This implies that while men currently dominate the sector, Integrated Pest Management (IPM) adoption strategies should be designed with a gender-sensitive lens. Ensuring that women are actively included through tailored training, equitable access to resources, and deliberate gender mainstreaming in IPM programs is crucial for achieving inclusive and sustainable pest management adoption across farming households. This is in agreement with Venette and Morey (2019) who pointed out that men normally participate in agricultural networks and participate in IPM practices, as they are more accessible to extension services and training programs, and are more willing to invest in high-value crops like tomatoes compared women.

The results showed a mean age of 2.80 with a standard deviation of 0.86, indicating that the majority of respondents were within the 36-45 years age bracket, with a relatively balanced distribution across other age groups. This suggested that most tomato farmers in Amuru District were middle-aged, a group often characterized by a combination of physical capability, accumulated farming experience, and active involvement in agricultural decision-making. As such, this demographic was more likely to appreciate and adopt innovative approaches such as Integrated Pest Management (IPM). This implies that IPM adoption programs needed to strategically target middle-aged farmers as key agents of change, while also integrating mentorship and tailored support to both younger farmers who might have lacked practical experience and older ones who could have been more resistant to new technologies to promote inclusive and sustained IPM adoption. This is in agreement with Kassie *et al.* (2015) who pointed out that younger farmers were more open to innovation and educated about modern farming techniques, making them more likely to adopt IPM practices and even more engaged with extension services and participate in training programs related to IPM.

The results showed a mean education level of 2.21 with a standard deviation of 0.84, indicating that the average respondent had attained education between the primary and secondary levels, with the majority having only primary education. This suggested that most tomato farmers in Amuru District had relatively low levels of formal education. Such limited educational attainment likely influenced their ability to understand and apply complex agricultural practices like Integrated Pest Management (IPM), as they may have struggled with interpreting pest behavior, reading application guidelines, or comprehending written extension materials. This implies that low literacy levels could have posed a barrier to effective IPM adoption, highlighting the need for extension approaches that employed visual aids, local language training, radio broadcasts, and farmer field schools to ensure that key messages were accessible to farmers with minimal formal education. This is in agreement with Rana *et al.* (2024) who revealed that education significantly influences farmers' knowledge and attitudes towards pest management strategies, with higher levels often associated with better understanding of agricultural practices, including Integrated Pest Management (IPM). Research shows educated farmers are more likely to adopt innovative farming techniques and are more aware of ecological impacts of pesticides.

The results showed a mean marital status value of 1.88 with a standard deviation of 0.48, indicating that the majority of respondents were married, accounting for 79.3% of the sample. This indicates that farming in Amuru District was predominantly family-based. Married farmers were likely to have larger households and greater responsibilities, which may have motivated them to adopt sustainable practices such as Integrated Pest Management (IPM) to minimize production risks and improve yields. Also, they often benefited from shared labor and collaborative decision-making within the household. This implies that extension agents and policy planners needed to recognize the influence of family dynamics on technology adoption. Involving both spouses in IPM training sessions could have enhanced joint decision-making and improved the rate and effectiveness of adoption within farming households. This is in line with Kumar *et al.* (2023) who pointed out that married individuals in Uganda engage in sustainable farming practices like IPM, due to increased household responsibilities, access to labor, land ownership, and higher participation in farming. They have to settled lifestyles and adopt improved practices like IPM in order to ensure food security and income for their families whereas single or separated individuals are always more mobile or engaged in off-farm activities.

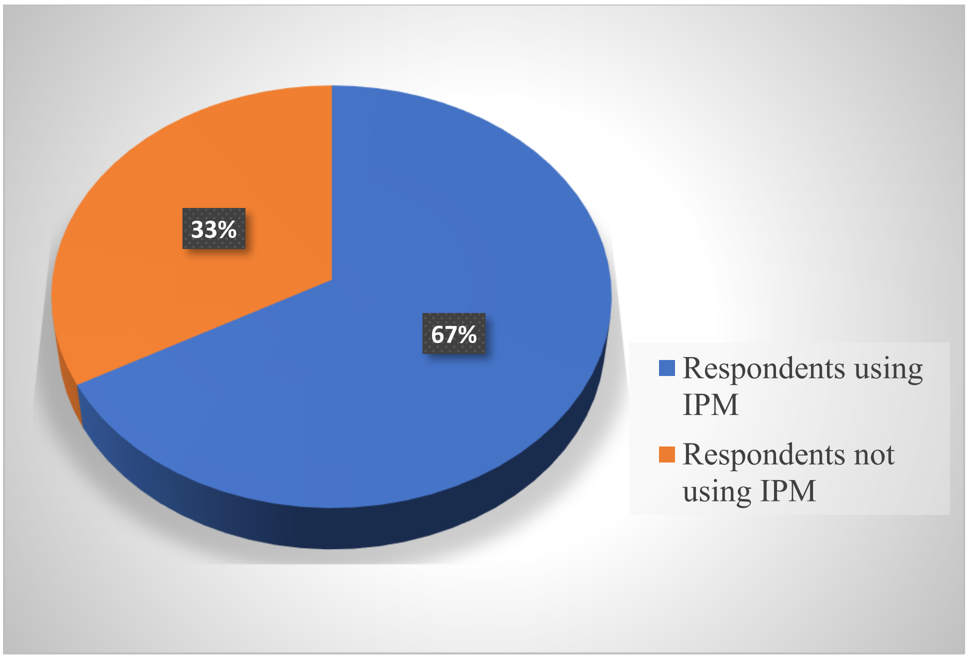
4.3 Level of adoption of IPM

This was measured in terms of the number of farmers using IPM practices.

Table 3: The level of adoption of IPM among farmers in Amuru district

	Number (n)	**Percentage (%)**
Respondents using IPM	94	67
Respondents not using IPM	46	33

Source: Field data, 2025



Source: Field data, 2025

Figure 2: The level of adoption of IPM among farmers in Amuru district

According to the findings 67% of the farmers have adopted IPM, however they are majorly practicing mulching, crop rotation, monitoring of pest population, physical killing of pests, and mechanical method. Practices like bio pesticide application and use of biological control agents are not being practiced probably because of limited knowledge and access to IPM inputs. There is high chemical pesticide use among tomato farmers in Amuru district.

4.4 The level of knowledge of Integrated Pest Management practices among tomato farmers

Tomato farmers' knowledge of Integrated Pest Management (IPM) practices is crucial for sustainable pest control and crop productivity. IPM, a combination of ecological, cultural, biological, and chemical methods, is essential in regions like Amuru District. Respondents were asked about the level of knowledge of Integrated Pest Management practices among tomato farmers and their responses were recorded in table 4 below;

Table 4: Relationship between socio-demographic variables and IPM adoption (n = 140)

Variable	Category	Adopted IPM (n)	Not Adopted (n)	Total	Chi-square (χ²)	p-value
Gender of respondents	Male Female	78 16	28 18	106 34	9.25	0.0024
Age of respondents	18-25 26-35 36-45 46-55 56 and above	11 24 37 18 04	10 09 12 09 06	21 33 49 27 10	8.74	0.067
Education level	No formal education Primary Secondary Tertiary	12 45 30 07	17 16 11 02	29 61 41 09	12.87	0.0049
Marital status	Single Married Widowed Separated	14 78 01 01	10 33	24 111 3 2	2.86	0.413
Years growing tomatoes	1-3 years 4-7 years 8+ years	18 35 41	13 16 17	31 51 58	24.59	0.003
Land size for tomato (acres)	Less than 1 Between 1-2 2.1 and above	46 37 19	14 18 06	60 55 25	18.93	0.009

Source: Field data, 2025

The results showed a statistically significant association between gender and the adoption of Integrated Pest Management (IPM) ($\chi^2 = 9.25$, $p = 0.0024$). Male farmers (78 adopters) were significantly more likely to adopt IPM than female farmers (16 adopters), as indicated by the chi-square value of 9.25 and the p-value of 0.0024 ($p < 0.05$). This difference may have been due to men having greater access to extension services, training opportunities, or decision-making power. This reflects gender-based disparities in access to agricultural training, extension services, or education. Male farmers traditionally were involved in decision-making roles and had more opportunities to attend IPM trainings or workshops. This is because males attended training sessions and accessed extension services, while females had limited access due to cultural norms and time constraints. Men dedicated more time to farm management activities, including pest control. The findings implied that targeted support and capacity-building initiatives for female farmers were necessary to bridge the gender gap in IPM adoption. This is in agreement with Neway and Zegeye (2022) who pointed out that Traditional gender norms and perceptions of agriculture as male-dominated hinder women's involvement in decision-making on farms, including the adoption of pest management technologies like IPM. Men's higher formal education and lower literacy levels affects their ability to apply technical knowledge about IPM compared to females.

Results established that the association between age and the adoption of Integrated Pest Management (IPM) was not statistically significant, as evidenced by a chi-square value of 8.74 and a p-value of 0.067, which exceeded the conventional threshold of 0.05. Although farmers aged 36-45 years recorded the highest number of adopters (37), the results suggested that age alone did not have a significant influence on IPM knowledge or use. Therefore, programs aimed at promoting IPM should not place excessive emphasis on age groups but rather focus on other enabling factors that may influence adoption. This is in disagreement with Kumar *et al.* (2023) who pointed out that middle-aged farmers were more active, practical, and open to innovation, promoting knowledge about advanced pest management practices like IPM. They participated in training programs and agricultural information, while younger farmers were in school or partially involved.

Results established that there was a strong and statistically significant relationship between education level and the adoption of Integrated Pest Management (IPM), as indicated by a chi-square value of 12.87 and a p-value of 0.0049 ($p < 0.05$). Farmers with primary (45 adopters) and secondary (30 adopters) education were significantly more likely to adopt IPM compared to those with no formal education or tertiary education. This implies that education strongly influences knowledge of IPM. Those with formal education, especially at secondary and tertiary levels, were better able to understand, adopt, and implement IPM concepts, possibly due to improved literacy, access to information, and analytical skills. This finding implied that basic education enhanced farmers' understanding and appreciation of IPM principles, highlighting the need to promote farmer education through simplified training materials and adult learning strategies. This is in agreement with Singh *et al.* (2020) who pointed out that educated farmers possess advanced technical knowledge, access to diverse information, and confidence in training and field schools. They embrace innovation and science-based practices, enabling effective pest management and monitoring pest populations.

Results showed that the relationship between marital status and the adoption of Integrated Pest Management (IPM) was not statistically significant, as indicated by a chi-square value of 2.86 and a p-value of 0.413. This result suggested that marital status whether single, married, widowed, or separated did not meaningfully influence a farmer's likelihood of adopting IPM. Consequently, marital status may not serve as a key determinant in IPM knowledge dissemination or in the targeting of training interventions. However, married individuals benefited from greater household labor and resource pooling, enabling better access to training and technologies. In contrast, widowed or separated farmers faced resource and labor constraints, limiting their ability to learn or apply IPM. This is because married farmers benefit from spousal support, shared decision-making, and knowledge exchange, leading to increased knowledge and implementation of IPM strategies. Marriage provides economic and social stability, encouraging farmers to invest in learning and adopt sustainable practices. Additionally, their higher responsibility to provide food and income drives them to seek effective farming practices, including IPM, to improve yield and reduce losses. This is in line with Karki *et al.* (2023) who pointed out that single farmers, widowed, and separated face emotional stress, reduced labor, limited financial resources, and gender-related barriers, limiting access to IPM training and practices.

The results indicates that there was a highly significant association between farming experience and the adoption of Integrated Pest Management (IPM), as demonstrated by a chi-square value of 24.59 and a p-value of 0.003 ($p < 0.05$). Farmers with more years of experience, particularly those with over eight years in tomato cultivation, were more likely to adopt IPM. This was because experience in tomato farming was a key contributor to knowledge acquisition. Over time, practical exposure, experimentation, and interaction with extension agents or fellow farmers improves understanding of IPM practices. Experienced farmers gain practical knowledge through observation, trial-and-error, training, and extension services, gradually integrating IPM practices into their farm routines. They become more confident in trying new techniques, reducing traditional pesticide use. This finding suggested that hands-on farming experience enhanced awareness of pest-related challenges and available solutions, underscoring the importance of promoting peer learning and mentorship from experienced farmers to encourage wider adoption of IPM practices. This is in agreement with Tabriz *et al.* (2021) who pointed out that new farmers with 1-3% experience often focus on basic crop production and pest control techniques, lacking exposure to advanced management approaches like IPM. They also have less time to build relationships with extension workers, reducing their chances of receiving targeted guidance.

Results revealed a statistically significant relationship between land size and the adoption of Integrated Pest Management (IPM), as indicated by a chi-square value of 18.93 and a p-value of 0.009 ($p < 0.05$). This implies that farmers with larger land sizes (1 acre and above) were significantly more likely to adopt IPM practices. This was due to the increased likelihood of investing in risk management technologies among those with greater landholdings. The findings highlighted the need to support smallholder farmers through incentives or demonstration plots to encourage the adoption of IPM on smaller farms. Larger landholders adopt sustainable pest management methods due to financial risk, access to extension services, and resources, while smallholder farmers practice intensive management. This is in line with Okwakol *et al.* (2022) who pointed out that smaller farms make IPM more practical, making practices like pest scouting and biocontrols more cost-effective. This practicality leads to greater use of IPM strategies among smallholder farmers. Many NGOs and government programs target vulnerable smallholders for IPM education, resulting in high knowledge levels.

4.4.1 Level of knowledge of IPM practices among tomato farmers

Farmers' awareness and access to resources are essential for effective implementation of different IPM Practices among tomato farmers. Respondents were asked about the level of knowledge of IPM Practices among tomato farmers and their responses were recorded in table 5 below;

Table 5: Analysis of the level of knowledge of IPM practices among tomato farmers (n = 140)

Level of knowledge of Integrated Pest Management practices among tomato farmers	Mean	Std. Dev.	Chi-square (χ^2)	p-value
I am aware of the principles and objectives of Integrated Pest Management (IPM).	4.21	0.84	26.75	0.001
I know how to identify common pests that affect tomato crops.	4.08	0.91	22.60	0.003
I understand how to use cultural methods (e.g., crop rotation) to manage pests.	3.89	1.02	19.15	0.012
I can distinguish between harmful and beneficial insects in my tomato field.	3.77	1.10	17.80	0.015
I am knowledgeable about the safe use of biological pest control methods.	3.65	1.14	16.90	0.018
I know how to correctly apply chemical pesticides as part of an IPM strategy.	4.10	0.88	24.45	0.002
I have received training or guidance on IPM practices in tomato farming.	3.42	1.23	14.60	0.026
I understand how environmental conditions influence pest outbreaks.	4.00	0.95	21.10	0.005
I am confident in making pest management decisions based on field monitoring.	3.71	1.08	18.35	0.014
I regularly use non-chemical methods (e.g., mulching, trap crops).	3.58	1.18	15.85	0.022

Source: Field data, 2025

The findings revealed a high level of awareness of Integrated Pest Management (IPM) principles and objectives among farmers, as indicated by a high mean score of 4.21 and a low standard deviation of 0.84, suggesting that the majority of respondents agreed or strongly agreed with the statements related to IPM awareness. The chi-square value of 26.75 with a p-value of 0.001 showed a statistically significant variation in levels of agreement, confirming that awareness was not uniform across all respondents. This implied that IPM awareness campaigns or informal knowledge-sharing mechanisms in the area had been relatively effective. This indicates that farmers benefitted from regular contact with extension officers, NGOs, and agricultural programs promoting IPM. Government policies prioritized awareness and adoption of IPM to reduce chemical pesticide use. Training workshops and farmer sensitization campaigns boosted awareness. Consequently, extension services and relevant stakeholders could leverage this existing awareness to introduce more advanced or targeted IPM practices aimed at improving pest management strategies.

During an interview one of the local leaders had this to say;

> *"Farmers with basic formal education are more likely to understand and retain information about scientific and sustainable farming practices, including IPM. They are proactive in seeking knowledge and adopting best practices through peer-to-peer learning and farmer networks"*

This is in disagreement with Sathiah *et al.* (2021) who reported that only 35% of tomato farmers in Karnataka were familiar with IPM concepts, with knowledge primarily limited to crop rotation and trap crops.

The results showed that farmers had a high level of knowledge regarding common tomato pests, as reflected by a high mean score of 4.08 and a moderate standard deviation of 0.91, indicating general agreement among respondents on their ability to identify these pests. The chi-square value of 22.60 and a p-value of 0.003 indicated a statistically significant variation in responses, suggesting that this knowledge was meaningfully distributed across the sample. This finding suggested that farmers were observant and had likely encountered major tomato pests frequently enough to recognize them. This implies that leveraging farmer-to-farmer training along with strengthening extension services can enhance IPM dissemination. The lower percentages for mass media and agro-input dealers suggest these channels are underutilized. This is because peer learning in rural farming communities fosters informal communication among farmers, while extension workers promote information dissemination through field demonstrations and home visits. Therefore, training programs could build on this foundational knowledge by shifting focus from basic pest identification to more advanced aspects such as pest behavior, damage thresholds, and timely intervention to improve pest management decisions.

During an interview one of the local leaders had this to say;

> *"Farmers' hands-on experience, frequent interactions with agro-input dealers, and access to agricultural extension services help them recognize common pests, increase awareness, and benefit from practical pest identification and management training. Farmers are more likely to adopt information about Integrated Pest Management (IPM) when they see real-life success stories, use local language and simplicity, and have trained farmers as local trainers or information hubs. These strategies help build confidence, reduce skepticism, and increase IPM dissemination within communities"*

This is in agreement with Dağ *et al.* (2025) who pointed out that extension officers educate farmers on best practices, including IPM, through structured training, farm visits, and demonstrations, promoting credibility and technical expertise, and collaborating with NGOs. Farmers benefit from government or NGO-led extension programs, farmer field schools, and group trainings on pest recognition and management. Local radio and media programs also help disseminate pest knowledge.

The findings indicated a moderate level of understanding of cultural pest management methods among farmers, with a mean score of 3.89 and a relatively high standard deviation of 1.02, suggesting notable variation in responses. The chi-square value of 19.15 and a p-value of 0.012 demonstrated a statistically significant distribution, confirming differences in the level of knowledge across respondents. This result implied that while many farmers were familiar with cultural practices such as crop rotation, others might lack the capacity to apply them effectively within an IPM framework. As a result, it is recommended that extension services prioritize practical demonstrations and continuous follow-up to enhance the integration and application of cultural methods in pest management.

During an interview one of the local leaders had this to say;

> *"Farmers often lack formal training on cultural pest control methods, preferring chemical control due to its immediate results. Insufficient extension coverage and lack of emphasis on cultural practices can further hinder farmers' understanding and application"*

This is in line with Fusar-Poli and Fontefrancesco (2024) who pointed out that inadequate extension services, literacy and education levels, lack of practical demonstrations, inconsistent results from cultural practices, insufficient knowledge on integration into IPM, and peer influence can limit farmers' awareness and adoption of non-chemical methods. In areas where chemical control is dominant, farmers may be less exposed to successful examples of cultural pest control, limiting their confidence in these methods.

The results showed that farmers had varying levels of ability to distinguish between harmful and beneficial insects, as reflected by a mean score of 3.77 and a relatively high standard deviation of 1.10, indicating inconsistent knowledge across respondents. The chi-square value of 17.80 with a p-value of 0.015 confirmed a statistically significant variation in responses. This suggested that some farmers might confuse beneficial insects, such as ladybirds and parasitoid wasps, with harmful pests, potentially leading to inappropriate pest control actions. Therefore, the development and dissemination of educational materials featuring visual aids or field-based scouting guides are essential to improve farmers' capacity to accurately identify insect roles and make informed pest management decisions.

During an interview one of the agriculture extension workers had this to say;

> *"Farmers struggle with insect identification due to limited visual resources, inadequate training on insect roles, and heavy reliance on chemical pesticides, which may lead to mistreatment of all insects"*

This is in agreement with Sadique-Rahman (2022) who pointed out that chemical pesticides, lack of field-based scouting experience, misconceptions, and traditional beliefs can lead farmers to misunderstand the ecological importance of beneficial insects. Variations in education levels, lack of local demonstration plots, and environmental changes may also complicate the process. Farmers may struggle to recognize less frequently seen beneficial insects due to these factors.

The findings revealed that farmers had limited but existing knowledge of biological pest control methods, as indicated by a relatively low mean score of 3.65 and a standard deviation of 1.14, reflecting considerable variation in responses. The chi-square value of 16.90 with a p-value of 0.018 showed a statistically significant difference in levels of awareness among respondents. This suggested that the adoption of biological control methods remained low, likely due to limited accessibility or insufficient awareness of such practices. To address this gap, it is essential to enhance farmers' access to bio-control agents and conduct practical demonstrations to showcase their use and effectiveness within an Integrated Pest Management framework.

During an interview one of the local leaders had this to say;

> *"Farmers may face limited access to bio-control agents, lack of training, and perceived complexity of biological control methods, leading to low adoption and understanding of these methods, as agricultural extension services often focus on chemical control"*

This is in disagreement with Dağ *et al.* (2025) who pointed out that biological control adoption is often hindered by perceived complexity, slow and indirect results, limited local success stories, misinformation, high costs, and education gaps. Farmers may view biological methods as technical or difficult to implement, and their understanding may be limited due to lack of visible case studies, misinformation, high costs, and limited formal education.

The results indicated that farmers possessed good knowledge regarding the proper application of chemical pesticides as part of Integrated Pest Management (IPM), as reflected by a strong mean score of 4.10 and a low standard deviation of 0.88, showing consistent agreement among respondents. The chi-square value of 24.45 with a p-value of 0.002 confirmed a statistically significant level of agreement. This suggested that farmers were generally familiar with chemical pesticide use, likely due to prior training or exposure through agro-dealer promotions. However, to enhance the effectiveness of IPM, training programs should go beyond basic application and emphasize safe handling, appropriate timing, correct dosage, and the integration of chemical control within a broader IPM strategy rather than promoting its use in isolation.

During an interview one of the local leaders had this to say;

> *"Farmers can benefit from regular agricultural extension services, participation in IPM training programs, prior experience, and easy access to pesticide use guidelines. These resources can help improve their confidence and understanding of correct application techniques, promoting consistent and accurate usage among farmers"*

This is in agreement with Sathiah *et al.* (2021) who pointed out pesticide use guidelines, peer learning, market demands, and past misuse incidents have all contributed to consistent and correct usage among farmers. Knowledge-sharing through cooperatives, community groups, and market standards encourage farmers to follow good agricultural practices. Increased access to media and ICT tools, such as radios and mobile phones, further reinforces knowledge and application skills.

The findings showed that training or guidance on Integrated Pest Management (IPM) had the lowest mean score of 3.42 among all items, with a high standard deviation of 1.23, indicating inconsistent exposure to structured training across respondents. Despite this variability, the chi-square value of 14.60 and a p-value of 0.026 confirmed a statistically significant difference in responses. This result suggested that many farmers had not received formal or consistent IPM training, which likely hindered their full understanding and adoption of IPM practices. Therefore, there is a critical need for institutions and extension services to expand the frequency, reach, and quality of farmer training programs, particularly through farmer field schools and demonstration plots to enhance practical learning and adoption.

During an interview one of the local leaders had this to say;

> *"Integrated pest management training opportunities in rural farming areas are limited, leading to uneven knowledge. Extension services may not reach all farmers equally, and low awareness of integrated pest management concepts reduces motivation to participate in training programs"*

This is in agreement with Benbrook *et al.* (2021) who pointed out that the training of farmers on Integrated Pest Management (IPM) can be hindered by factors such as inadequate publicization, reliance on traditional methods, language and literacy barriers, variation in institutional support, and lack of hands-on demonstration farms or practical sessions, which can lead to low perceived training value.

The findings indicated that farmers generally had a good understanding of the relationship between environmental conditions and pest outbreaks, as shown by a mean score of 4.00 and a standard deviation of 0.95, reflecting consistent awareness among respondents. The chi-square value of 21.10 with a p-value of 0.005 confirmed that this distribution was statistically significant. This understanding likely stemmed from experiential knowledge, particularly as farmers observed changes in pest pressure linked to shifting weather patterns. Building on this foundation, the introduction of simple climate-based forecasting tools or advisory services could enhance farmers' ability to time their IPM interventions more effectively, ultimately improving pest management outcomes.

During an interview one of the local leaders had this to say;

> *"Farmers' firsthand experience, traditional ecological knowledge, frequent exposure to changing weather and pest patterns, and exposure to radio and agricultural media have all contributed to their understanding of the relationship between environment and pests.*

This is in agreement with Okwakol *et al.* (2022) who pointed out that radio and agricultural media, basic training from extension agents, community information sharing, understanding of pest impact on yields, and increased awareness of climate change are all contributing to improved knowledge about environment-pest interactions among farmers. These factors, along with climate change awareness, are enhancing understanding of pest behavior in agriculture.

The results revealed moderate confidence among farmers in making pest management decisions based on field monitoring, as indicated by a mean score of 3.71 and a standard deviation of 1.08, reflecting variability in confidence levels across respondents. The chi-square value of 18.35 with a p-value of 0.014 confirmed that this variation was statistically significant. This suggested that many farmers might lack adequate tools or techniques, such as pest thresholds or monitoring traps, necessary for effective pest population assessment. To address this gap, the introduction of participatory scouting methods and digital decision-support tools is recommended to empower farmers to make more accurate and timely pest management decisions.

During an interview one of the local leaders had this to say;

> *"Farmers often lack formal pest identification training, use infrequent monitoring tools, and rely heavily on external advice for pest control decisions, reducing confidence in data-driven decisions and affecting their confidence"*

This is in line with Benbrook *et al.* (2021) who pointed out that farmers' confidence in pest control decisions is influenced by factors such as external advice, field experience, unpredictable pest behavior, access to resources, fear of economic losses, and lack of practical demonstration or mentorship. These factors can affect farmers' self-assurance and the effectiveness of their decisions, potentially affecting their ability to make informed decisions.

The findings showed that farmers exhibited moderate confidence in pest management decision-making based on field monitoring, as indicated by a mean score of 3.71 and a standard deviation of 1.08, suggesting varied confidence levels among respondents. The chi-square value of 18.35 with a p-value of 0.014 demonstrated a statistically significant variation in responses. This variation implied that many farmers lacked access to effective tools or techniques, such as pest thresholds and monitoring traps, which are critical for accurate pest population assessment. Therefore, the introduction of participatory scouting methods and digital monitoring tools is recommended to enhance farmers' capacity to make informed and timely pest management decisions.

During an interview one of the local leaders had this to say;

> *"Farmers' confidence in field monitoring can be impacted by inadequate practical training, inconsistent practices, limited pest identification skills, and reliance on external inputs, such as advice from agro-input dealers or extension workers, which can lead to moderate confidence in decision-making"*

This is in line with Sathiah *et al.* (2021) who pointed out that farmers' confidence in monitoring their fields can vary due to inconsistent practices, limited pest identification skills, reliance on external inputs, unpredictable pest dynamics, partial adoption of Integrated Pest Management principles, lack of access to technology and tools, and peer influence and cultural norms. These factors can lead to moderate and inconsistent confidence levels in decision-making, affecting the effectiveness of field monitoring as a central decision-making tool.

The results indicated that the regular use of non-chemical pest control methods among farmers was moderate, with a mean score of 3.58 and a standard deviation of 1.18, reflecting variation in knowledge and usage levels. The chi-square value of 15.85 and a p-value of 0.022 confirmed a statistically significant difference in responses. This suggested that while some farmers employed practices such as mulching or trap cropping, these methods were not consistently adopted across the farming community. To address this, extension agents should strengthen the promotion of sustainable pest control practices that reduce dependence on chemical pesticides while enhancing soil health and crop resilience.

During an interview one of the local leaders had this to say;

> *"Farmers often lack awareness of non-chemical pest control methods, which may be perceived as slow and less effective than chemical options. Lack of practical demonstrations and limited access to resources also hinder adoption and consistent use"*

This is in agreement with Okwakol *et al.* (2022) who pointed out that non-chemical methods for farming are hindered by inadequate demonstrations, resource availability, lack of institutional support, mixed farmer attitudes, peer influence, and inconsistent monitoring and record-keeping. These factors can lead to underutilization of alternatives, varying practices across the population, and social pressures from neighboring farmers. Proper field monitoring and documentation are crucial for accurate assessment of non-chemical methods' effectiveness.

4.5 The factors influencing the adoption of Integrated Pest Management practices among tomato farmers

Tomato production is crucial for smallholder farmers, but pest infestations can lead to yield losses and increased reliance on synthetic pesticides. Integrated Pest Management (IPM) offers a sustainable alternative, but adoption remains low. This study examines socioeconomic, institutional, and perceptual factors influencing IPM adoption among tomato farmers, using regression analysis to identify key determinants and results were recorded in table 6 below;

Table 6: The factors influencing the adoption of Integrated Pest Management practices among tomato farmers

Variable	Coefficient (β)	Standard Error	t-value	p-value
Age	-0.015	0.009	-1.67	0.095
Education level	0.123	0.037	3.32	0.001
Farm size	0.084	0.041	2.05	0.040
Extension contact	0.951	0.278	3.42	0.0006
Access to information	0.793	0.332	2.39	0.017
Group membership	0.611	0.293	2.09	0.037
Experience in tomato	0.058	0.024	2.42	0.015
Access to credit	0.347	0.212	1.64	0.102
Market access	0.266	0.139	1.91	0.056
Gender	0.143	0.128	1.12	0.264
Access to IPM inputs	0.793	0.180	4.40	0.0001
Pest pressure level	0.187	0.081	2.31	0.021
Perceived effectiveness of IPM	0.455	0.102	4.46	0.0001

Source: Field data, 2025

Results established that age was among the least significant the factor influencing the adoption of Integrated Pest Management practices among tomato farmers since the p-value was great than 0.05 (β = -0.015, p = 0.095). This indicates that a one-year increase in age slightly reduces the likelihood of adopting IPM by 0.015 units. This suggests that older farmers were less likely to adopt IPM practices. Age doesn't necessarily reflect farming experience, and experience was a stronger predictor than age. Risk perception isn't strongly age-dependent, as both young and older farmers might perceive benefits and risks. Cost, labor requirements, and availability of bio-pesticides also affect all age groups equally.

During an interview one of the local leaders had this to say;

> *"Community-based decision making in farming communities may consider individual farmers' age less than collective norms. Technology acceptance may be uniform, with both young and old farmers willing to adopt IPM if promoted and supported"*

This is in line with Kassie *et al.* (2015) who pointed out that the age of farmers plays a crucial role in their willingness to adopt new agricultural practices. Younger farmers tend to be more open to innovation and are often more educated about modern farming techniques compared to older generations. Younger farmers, with higher education levels, are more likely to adopt IPM practices, according to a Kenyan study, with younger tomato farmers showing higher engagement with agricultural extension services.

Results established that education among the significant factor influencing the adoption of Integrated Pest Management practices among tomato farmers since the p-value was less than 0.05 ($p=0.001$) and beta ($\beta = 0.123$). This implies that **e**ach unit increase in education level (e.g., years of schooling) significantly increases the likelihood of adopting IPM. More educated farmers were more likely to adopt. This shows that education improves farmers' understanding of Integrated Pest Management (IPM) concepts, enabling them to grasp long-term benefits and access information about IPM. Literate farmers are able to read and interpret materials, follow instructions, and engage with media channels to disseminate information.

During an interview one of the agriculture extension workers had this to say;

> *"Education enhances farmers' decision-making and critical thinking skills, enabling them to evaluate pest management options and trade-offs. It also fosters a willingness to innovate and experiment with non-conventional methods, such as biological control"*

This is in agreement with Rana *et al.* (2024) who pointed out that higher education levels significantly influence farmers' knowledge and attitudes towards pest management strategies, with educated farmers more likely to adopt innovative farming techniques. A study in Nigeria found that tomato farmers with higher education were more likely to implement IPM strategies.

The study findings established that farm size was among the significant factor influencing the adoption of Integrated Pest Management practices among tomato farmers since the p-value was less than 0.05 ($p=0.040$) and beta ($\beta = 0.084$). This implies that larger farm sizes positively influence IPM adoption. This could be due to greater exposure to pests or capacity to try new technologies. This is because larger farms face greater financial investment and potential output, leading to more adoption of effective pest control measures like integrated pest management (IPM). They also have better financial capacity and are more likely to absorb the costs of IPM, thereby reducing risk and losses.

During an interview one of the local leaders had this to say;

> *"Larger farms benefit from targeted government and NGO agricultural programs, increased access to extension services and training, greater return on investment due to reduced pesticide resistance, improved yields, and environmental sustainability, and better farm management capacity due to better organizational skills and skilled laborers or farm managers trained in IPM"*

This is in line with Afriyie *et al.* (2023) farm size significantly impacts the adoption of agricultural practices, including IPM. Larger farms have more resources for training and technology, while smaller farms may be more flexible. Larger farms benefit from economies of scale, allowing them to invest in advanced pest management technologies and training programs.

Results established that extension contact was among the significant factor influencing the adoption of Integrated Pest Management practices among tomato farmers since the p-value was less than 0.05 ($p=0.0006$) and beta ($\beta =0.951$). This means that farmers who had contact with extension agents were much more likely to adopt IPM. Extension plays a critical role in awareness and training. This is because extension workers offer farmers reliable information on pest identification, thresholds, and IPM techniques, with frequent contact for updates. They also provide hands-on training on IPM tools, improving farmers' skills and confidence in implementing effective practices.

During an interview one of the local leaders had this to say;

> "*Extension agents promote eco-friendly pest management (IPM) to correct misconceptions about chemical pesticides. They link farmers to resources like biopesticides and resistant seed varieties, enhance problem diagnosis and personalized support, and provide motivation and reinforcement of good practices. Regular extension contacts help sustain IPM adoption by providing encouragement, follow-up, and feedback, ultimately improving soil and human health"*

This is in agreement with Akter *et al.* (2020) who pointed out that extension services are educational programs that enhance agricultural productivity by providing farmers with information and skills. They include training sessions, workshops, field demonstrations, and consultations. Effective communication and participatory learning are crucial. Extension agents' training increases farmers' adoption of Integrated Pest Management (IPM) strategies, as demonstrated in Bangladesh.

Results established that access to information among the significant factor influencing the adoption of Integrated Pest Management practices among tomato farmers since the p-value was less than 0.05 ($p=0.017$) and beta ($\beta =0.793$). This means that farmers with better access to information (media, training, ICT) were significantly more likely to adopt IPM. This implies that farmers with better access to agricultural extension services and technical information are more aware of IPM practices, preventing them from using conventional chemical methods without safer alternatives. Understanding these techniques, such as biological control and pest monitoring, is crucial for successful implementation.

During an interview one of the local leaders had this to say;

> "*Farmers adopt IPM after accessing reliable information from trusted sources, reducing uncertainty. Skill development through training and continuous updates builds farmers' capacity and technical skills for proper IPM execution"*

This is in agreement with Dhotre *et al.* (2025) who pointed out that farmers can adopt Integrated Pest Management (IPM) through cost-benefit awareness, peer learning, and access to support services. Information on reduced pesticide costs, improved yields, and health risks encourages adoption. Community-based learning platforms and field schools boost confidence and motivation.

Results also established that group membership among the significant factor influencing the adoption of Integrated Pest Management practices among tomato farmers since the p-value was less than 0.05 ($p=0.037$) and beta ($\beta=0.611$). This implies that being a member of a farmers' group positively influences adoption. Groups facilitate peer learning and collective access to resources. This is because farmer groups offer shared information and knowledge, promoting sustainable pest management. Extension officers and NGOs prioritize group members' access to IPM-related knowledge. Peer learning builds trust in new technologies.

During an interview one of the agriculture extension workers had this to say;

> *"Farmers associations or cooperatives often conduct collective training programs on Integrated Pest Management (IPM) techniques. These programs provide structured learning opportunities, enhance access to subsidized IPM inputs, and facilitate IPM implementation. Group dynamics create social accountability and motivate members to adopt recommended practices, with successful adopters acting as role models"*

This is in agreement with McCarthy (2014) who pointed out that group farming methods like IPM can reduce risk and share experimentation, lower perceived barriers to adoption, and provide access to credit and external support. Non-grouped farmers, like tomato farmers in cooperatives, farmer field schools, or savings and credit groups, are more empowered and well-informed, leading to higher adoption rates.

Results established that experience in tomato farming among the significant factor influencing the adoption of Integrated Pest Management practices among tomato farmers since the p-value was less than 0.05 ($p=0.015$) and beta ($\beta=0.058$). This implies that more experienced tomato farmers were more likely to adopt IPM, possibly due to greater understanding of pest dynamics and management needs. This is because tomato farmers' experience increases pest and disease awareness, leading to interest in sustainable alternatives like Insecticide-Pest Management (IPM). Their problem-solving ability, evaluating various pest management approaches, allows them to make informed decisions.

During the interview one of the agriculture extension workers had this to say;

> *"Farmers with extensive knowledge of crop cycles and pest behavior are better equipped to implement IPM interventions. They have witnessed the long-term effects of pesticide use, making them more receptive to alternative approaches. Experience also boosts confidence and risk management, enabling farmers to evaluate the costs and benefits of IPM"*

This is in agreement with Adesina *et al.* (2023) who pointed out that farming experience refers to the knowledge farmers accumulate over time through practical agricultural activities, including years spent, crop diversity, pest management techniques, and training. Experienced farmers are more likely to adopt IPM practices due to their knowledge about pest life cycles and effective strategies.

Results established that access to credit among the least significant factor influencing the adoption of Integrated Pest Management practices among tomato farmers since the p-value was greater than 0.05 (p=0.102) and beta (β =0.347). The positive relationship, suggesting that credit helps farmers afford IPM inputs, but this effect was not statistically significant ($p > 0.05$). IPM practices often focus on low-cost methods, such as crop rotation and manual pest removal, which did not require credit for adoption. Credit can be used for other priorities, and farmers did not associate credit with IPM adoption due to limited awareness of financing needs.

During an interview one of the local leaders had this to say;

> *"IPM practices often focus on low-cost methods, such as crop rotation and manual pest removal, which may not require credit for adoption. Credit may be used for other priorities, and farmers may not associate credit with IPM adoption due to limited awareness of financing needs"*

This is in agreement with Kabir *et al.* (2023) who pointed out that farmers may not associate credit with IPM adoption due to limited awareness of its financial benefits. Credit schemes may not be tailored to support sustainable practices like IPM. Knowledge and training are more important than financial access, and access to information and group membership are more influential. Credit access doesn't guarantee effective use, as farmers may lack the capacity to invest wisely in IPM practices without technical guidance.

Results established that market access was the least significant factor influencing the adoption of Integrated Pest Management practices among tomato farmers since the p-value was greater than 0.05 (p = 0.056) and beta (β = 0.266). This is because better access to markets may encourage IPM adoption due to quality and safety standards, though this was only marginally significant. This is because market access does not directly influence pest management decisions, as it mainly affects income and sales, not on-farm production practices. Farmers may focus on quantity and timing demands, ignoring sustainable practices like IPM, even when markets are accessible.

During an interview one of the local leaders had this to say;

> *"Market incentives for IPM-grown tomatoes are lacking, leading farmers to adopt pest management practices for agronomic reasons rather than market reasons. Market access alone does not justify changing pest management practices"*

This is in line with Griebel *et al.* (2012) who pointed consumer demand for sustainable food has compelled farmers to adopt Integrated Pest Management (IPM) practices, with studies in California showing higher prices for organic and specialty markets, encouraging farmers to shift towards sustainable practices.

Results established that gender had a positive but statistically insignificant effect, suggesting no strong difference between male and female farmers in IPM adoption since the p-value was greater than 0.05 ($p = 0.264$, $\beta = 0.143$). This is because agricultural extension systems now provide equal access to information and training on Integrated Pest Management (IPM) practices, minimizing knowledge differences. Gender-neutral tasks like pest population monitoring, trap use, and cultural practices can be performed by both men and women.

During an interview one of the local leaders had this to say;

> *"There are shared farming responsibilities, access to information, group membership, and farming experience can reduce gender-based differences in pest management adoption. Cultural context can also promote equal participation, as women are increasingly involved in decision-making and technical aspects of farming. When both genders are equally motivated and supported, gender becomes less of a distinguishing factor"*

This is in line with Neway and Zegeye (2022) who pointed out that gender roles in agriculture significantly influence decision-making processes, with men controlling land and financial resources, while women manage household food production and pest management. This division leads to disparities in access to information about pest management practices, hindering the adoption of effective strategies and affecting women's ability to implement them.

Results established that access to IPM inputs among the significant factor influencing the adoption of Integrated Pest Management practices among tomato farmers since the p-value was less than 0.05 ($p=0.0001$) and beta ($\beta=0.793$). This is because access to necessary IPM inputs (e.g., biopesticides, traps) strongly increases the likelihood of adoption. This implies that IPM techniques required specific inputs like biological control agents, botanical pesticides, pest traps, and resistant seed varieties. Without these, farmers could not implement recommended practices. Reliable access to IPM tools reduces dependence on chemical pesticides, aligning with IPM principles.

During an interview one of the local leaders had this to say;

> *"Improved access to IPM inputs builds farmers' trust in their effectiveness and reliability, encouraging adoption. Cost and accessibility are linked, especially in rural areas. Access to inputs complements other enablers like information, group membership, and experience, making them more accessible and effective"*

This is in line with Kabir *et al.* (2023) who pointed out that economic theory suggests farmers adopt practices to maximize profits or minimize losses, but high initial costs, limited access to affordable inputs, and biopesticides in India and Kenya deter adoption.

Results established that pest pressure level was among the significant factor influencing the adoption of Integrated Pest Management practices among tomato farmers since the p-value was less than 0.05 ($p=0.021$) and beta ($\beta=0.187$). The higher pest pressure encourages adoption, as farmers feel the need for more effective pest management strategies. Farmers face increased crop loss risk due to frequent pest attacks, prompting proactive measures like IPM. High pest pressure led to chemical ineffectiveness, increased resistance, and higher production costs.

During an interview one of the agriculture extension workers had this to say;

> *"Under high pest pressure, IPM becomes economically justifiable due to its cost-benefit ratio. Farmers who experience pest outbreaks are more likely to attend trainings, consult extension officers, and join pest control groups. Visible benefits of IPM, such as trap cropping and biological control, encourage wider adoption and reinforce word-of-mouth success stories"*

This is in agreement with Patil *et al.* (2022) who pointed out that pest pressure in tomato farming, including aphids, whiteflies, spider mites, and caterpillars, can lead to significant crop losses. A study in Maharashtra showed that farmers adopting integrated pest management practices after severe damage sought alternative strategies.

Results established that perceived effectiveness of IPM was among the significant factor influencing the adoption of Integrated Pest Management practices among tomato farmers since the p-value was less than 0.05 ($p=0.0001$) and beta ($\beta =0.455$). This implies that farmers who believe that IPM is effective were much more likely to adopt it and perception strongly drives behavior. Adoption of Integrated Pest Management (IPM) depends on trust in its effectiveness in controlling pests and improving yields. A strong belief in its success increases investment and reduces risk aversion among farmers, reducing the perceived risk of abandoning traditional methods.

During an interview one of the local leaders had this to say;

> *"Perceived effectiveness in Integrated Pest Management (IPM) influences peer behavior, encouraging consistent use of components like pest population monitoring and chemical application. This belief also supports behavior change and learning, motivating farmers to seek further training, experiment with techniques, and share experiences, reinforcing adoption and building a culture of innovation"*

This is in line with Ali *et al.* (2021) who pointed out that farmers are more likely to adopt pest management practices when the threat is higher or more noticeable, leading to increased perceived risk and economic loss. This aligns with behavior change theories and validates

IPM's role as a responsive strategy, as real-world pest challenges trigger action, making pest pressure a key driver of IPM uptake.

4.6 The possible ways of motivating smallholder farmers to increase the adoption of Integrated Pest Management practices among tomato farmers

Smallholder tomato farmers in developing countries face pest infestations due to chemical pesticides. Integrated Pest Management (IPM) offers a safer, more sustainable solution, but adoption remains low due to factors like awareness, access, and complexity. Strategies to increase IPM adoption include improving knowledge, strengthening extension services, enhancing farmer organization, and demonstrating long-term benefits. Respondents were asked about the possible ways of motivating smallholder farmers to increase the adoption of Integrated Pest Management practices among tomato farmers and their responses were recorded in table 7 below;

Table 7: The possible ways of motivating smallholder farmers to increase the adoption of Integrated Pest Management practices among tomato farmers

The possible ways of motivating smallholder farmers to increase the adoption of Integrated Pest Management practices among tomato farmers	Mean	Std. Dev.	Chi-Square (χ^2)	p-value
Investing in building capacity development	4.30	0.78	15.62	0.003
Gender mainstreaming	3.90	0.89	12.80	0.012
Encouraging collaboration between farmer institutions	4.10	0.81	14.45	0.006
Improving access to credit	4.45	0.72	18.21	0.001
Providing incentives and market access	4.50	0.69	20.34	0.000
Improving farmer networks	4.00	0.85	13.75	0.009
Capacitating the national extension systems to respond to agriculture needs	4.20	0.79	16.12	0.004
Integration with existing practices	3.85	0.91	11.60	0.019
Strengthening the level of access to resources	4.35	0.74	17.55	0.002

Source: Field data, 2025

The study revealed that investing in building capacity development was strongly supported by respondents, with a high mean score of 4.30 and a low standard deviation of 0.78, indicating consistent agreement that capacity development is a key motivator. The chi-square value of 15.62 and a p-value of 0.003 showed a statistically significant relationship. Farmers overwhelmingly recognized training as essential for understanding and adopting Integrated Pest Management (IPM), as many smallholders previously lacked the technical skills and knowledge of pest control alternatives. Strengthening their skills through farmer field schools, extension services, or demonstration plots enhanced their confidence in applying IPM techniques. These findings implies that both government and NGOs needed to invest in well-tailored training programs focused on IPM for tomato farmers to promote adoption and reduce dependence on harmful chemical pesticides.

During an interview one of the local leaders confirmed this when she said that;

> "*Smallholder tomato farmers in developing countries face pest infestations due to chemical pesticides. Integrated Pest Management (IPM) offers a safer, more sustainable solution, but adoption remains low due to factors like awareness, access, and complexity. Strategies to increase IPM adoption include improving knowledge, strengthening extension services, enhancing farmer organization, and demonstrating long-term benefits*"

This is in agreement with Kassie *et al.* (2019) who pointed out that smallholder farmers can be motivated through education and training programs on Integrated Pest Management (IPM) principles. A Kenyan study found that farmer field schools (FFS) improved knowledge about pest management among tomato farmers, leading to increased confidence in implementing IPM practices.

The findings showed that gender mainstreaming was generally supported by farmers, with a mean score of 3.90, indicating agreement on its importance, though the relatively higher standard deviation of 0.89 suggested varied perceptions among respondents. The chi-square value of 12.80 and p-value of 0.012 indicated a statistically significant relationship. While gender mainstreaming was acknowledged as important, some farmers appeared to have limited understanding of its value. Women, despite playing vital roles in tomato farming, often faced unequal access to training and agricultural inputs. Promoting their inclusion was seen as essential for improving household-level adoption of Integrated Pest Management (IPM). This implies that development projects should deliberately involve women in training and decision-making processes to enhance gender equity, which would, in turn, improve overall adoption of IPM and support long-term sustainability.

During an interview one of the local leaders had this to say;

> *"Women play a crucial role in tomato farming, but often face marginalization in training and decision-making. Gender mainstreaming ensures equal participation in IPM training, resource access, and knowledge diffusion. Equitable access to information and training, including gender-sensitive programs, increases participation and adoption rates"*

This is in line with Pecenka *et al.* (2021) who pointed out that gender mainstreaming empowers women to make farm decisions, promotes inclusive extension approaches, addresses gender-specific pest management constraints, and encourages household collaboration, leading to faster, sustainable adoption of improved practices.

The results indicated strong agreement among respondents on the importance of encouraging collaboration between farmer institutions, with a mean score of 4.10 and a moderate standard deviation of 0.81, suggesting some variability in responses; the chi-square value of 14.45 and p-value of 0.006 confirmed a statistically significant relationship. The shows that farmer groups and cooperatives played a crucial role in facilitating knowledge sharing, accessing agricultural inputs, and promoting collaborative learning, which accelerated the adoption of Integrated Pest Management (IPM) practices and improved farmers' bargaining power in input pricing and market access. These findings implies that policy interventions and agricultural extension programs should prioritize the strengthening of farmer organizations and networks to serve as effective platforms for collective learning, information dissemination, and technology diffusion.

During an interview one of the agriculture extension workers had this to say;

> *"Collaborating farmer institutions can enhance collective bargaining, advocate for government support in IPM training, and influence local policy decisions. It can pool resources for shared IPM tools, create community centers, and lower costs. Collaborating institutions can also promote trust and social cohesion by sharing success stories, normalizing IPM practices, and reducing skepticism about alternative methods"*

This is in line with Ochieng *et al.* (2022) who pointed out that collaborating farmer institutions can improve IPM implementation by developing joint monitoring systems, providing support, and ensuring accountability. This fosters competition, innovation, and sustainability, promoting safer produce and reduced waste. Through group approaches, farmers can jointly access IPM tools and inputs, invite experts, and scale up best practices. This strong support suggests that peer learning and organized networks are effective in spreading innovations like IPM. Farmer institutions facilitate collective learning and knowledge sharing through peer-to-peer learning, promoting cross-learning and enabling farmers to benefit from each other's successes. Collaboration also improves access to training and extension services, ensuring wider outreach and reducing duplication of efforts.

The study showed that improving access to credit was viewed as highly important by farmers, reflected by a mean score of 4.45 the second highest along with a low standard deviation of 0.72, indicating strong and consistent agreement; the chi-square value of 18.21 and a p-value of 0.001 confirmed a highly statistically significant relationship. The means that while adopting Integrated Pest Management (IPM) often incurs costs such as for biocontrol inputs, traps, and labor, access to credit provided the financial flexibility needed for smallholders to adopt such practices. In the absence of affordable credit, many farmers continued to depend on cheaper, but more harmful, chemical pesticides. These findings imply the need for introducing IPM-related loan products or micro-financing schemes. Linking credit packages with IPM training and provision of appropriate tools could enhance adoption and help reduce the misuse of synthetic pesticides.

During an interview one of the local leaders had this to say;

> *"IPM adoption often requires initial investment in biological pest control agents, pest monitoring tools, protective equipment, and training materials. Improved access to credit helps farmers make these upfront investments, which may not be affordable out-of-pocket. Credit access also enables farmers to invest in knowledge acquisition and pay for extension support where public services are limited"*

This is in agreement with Singh *et al.* (2025) who pointed out that credit access enables farmer groups to purchase IPM inputs at lower costs, share resources, and establish demonstration sites, reducing chemical dependency and encouraging sustainable practices, boosting productivity and profitability. This is because IPM adoption involves initial costs (for example buying pheromone traps, protective gear, or biopesticides). Limited capital is a major constraint for smallholder farmers. With easier access to affordable credit, farmers are more likely to invest in sustainable pest control methods. The high support stresses the importance of integrating microfinance institutions and rural banks into agricultural interventions.

The findings revealed that providing incentives and market access was the most strongly supported factor among farmers, with the highest mean score of 4.50 and the lowest standard deviation of 0.69, indicating near-universal agreement; the chi-square value of 20.34 and p-value of 0.000 confirmed it as the most statistically significant variable. This emphasizes that farmers were highly motivated by financial gains and market-driven incentives, such as premium prices for IPM-grown tomatoes or contractual agreements with buyers seeking safer produce, which offered a strong economic rationale for adopting new practices. These results implies that governments and private sector actors should actively link IPM adoption to improved market access through certification schemes, eco-labeling, or price premiums, thereby encouraging widespread behavior change and promoting sustainable pest management practices. Financial incentives, tangible rewards, and improved market access can encourage farmers to adopt Integrated Pest Management (IPM), leading to long-term behavior change, sustainable practices, and improved crop quality.

During an interview one of the local leaders had this to say;

> *"Integrative pest management (IPM) helps reduce the risk of rejection and loss for farmers exporting tomatoes due to strict regulations on pesticide residues. It also enhances profit margins and farm income by boosting tomato prices due to high quality, organic certification, and consumer preferences. Incentives like public procurement programs can stimulate local demand for eco-friendly produce, encouraging more farmers to adopt IPM practices"*

This is in line with Gómez-Guzmán *et al.* (2022) who pointed out that market incentive and certification schemes can motivate smallholder farmers to adopt sustainable practices. For example, the Rainforest Alliance certification in Latin America has encouraged tomato producers to adopt Integrated Pest Management (IPM) by offering better market access and premium prices. Financial support through subsidies or grants can also encourage farmers to invest in IPM technologies, as demonstrated in Greece and Kenya.

The results indicated that improving farmer networks was generally supported by respondents, with a mean score of 4.00 showing agreement and a standard deviation of 0.85 reflecting some variation in perceptions; the chi-square value of 13.75 and p-value of 0.009 confirmed statistical significance. The shows the value of informal learning avenues such as peer-to-peer interactions, farmer WhatsApp groups, and cooperative-based training, which facilitated the adoption of Integrated Pest Management (IPM) by leveraging trust and shared experiences among farmers. Since farmers often trusted and emulated their successful peers more than external experts, the findings implies that extension services should strengthen community-based farmer networks and adopt lead-farmer models to enhance peer learning, promote knowledge exchange, and close information gaps in IPM adoption.

During an interview one of the local leaders had this to say;

> *"IPM adoption is facilitated by strong farmer networks, which facilitate peer-to-peer learning, on-farm demonstrations, and mentorship. This enhances awareness and confidence in IPM practices. Collective access to information and extension services is also possible through farmer groups, cooperatives, or associations, which invite and organize training sessions and share up-to-date information"*

This is in agreement with Diaz *et al.* (2020) who pointed out that social networks significantly influence agricultural practices among smallholders. Farmers who see successful IPM techniques are more likely to adopt them. Community-based approaches, leveraging local leaders, can create a ripple effect. In Uganda, shared experiences and collective problem-solving led to increased IPM adoption. This is because networks serve as platforms for experience sharing, collective action, and social learning. Farmers who are part of vibrant networks are more likely to learn about new technologies, including IPM, and observe their results in nearby farms. The response supports the idea of forming or strengthening local farmer groups, cooperatives, or knowledge-sharing platforms.

The study found strong consensus among respondents on the importance of capacitating the national extension system, as reflected by a mean score of 4.20 and a standard deviation of 0.79, with a chi-square value of 16.12 and a p-value of 0.004 confirming statistical significance. This implies that many farmers lacked adequate support for Integrated Pest Management (IPM) due to overstretched and under-trained extension personnel. Enhancing the extension system through updated curricula, improved logistics, and targeted IPM training was seen as essential for effectively supporting farmers. Therefore, governments should prioritize investing in the recruitment, training, and equipping of more extension workers particularly those knowledgeable in IPM and capable of leveraging digital tools to improve outreach and service delivery.

During an interview one of the local leaders confirmed this when he said that;

> *"Extension services are crucial for technical knowledge in Integrated Pest Management (IPM), involving techniques like biological control, crop rotation, and pest scouting. A capacitated national system provides regular field visits, demonstrations, and accessible explanations, building farmers' confidence and bridging the knowledge gap between scientific knowledge and farmer practice"*

This is in line with Desneux *et al.* (2022) who pointed out that extension agents promote integrated pest management through on-farm trials, behavioral change, and support, strengthening capacity, improving coverage, and enhancing training, benefiting farmers, marginalized groups, and reducing workload.

The findings indicated moderate agreement among farmers on the importance of integrating IPM with existing farming practices, with a mean score of 3.85 and the highest variability reflected by a standard deviation of 0.91; the chi-square value of 11.60 and p-value of 0.019 confirmed the statistical significance of this variable. The shows that some farmers were uncertain about how easily IPM could be incorporated into their current practices, noting that adoption tended to be higher when new methods complemented familiar activities such as composting or crop rotation. This implies that extension services should promote IPM as an enhancement rather than a replacement of existing techniques, emphasizing incremental changes tailored to the local context to facilitate smoother adoption among farmers.

During an interview one of the agriculture extension workers had this to say;

> *"IPM aligns with existing practices, facilitating extension and farmer training. It enhances practicality, encourages peer learning, and tailors solutions to local contexts. It avoids a one-size-fits-all approach, promoting relevance and practicality in farming communities with unique pest challenges"*

This is in line with Wang *et al.* (2014) who pointed out that Integrated Pest Management (IPM) integrates into traditional farming practices, promoting sustainability, soil health, eco-friendly alternatives, innovation, long-term adoption, and improved productivity and profitability.

The study demonstrated strong and consistent agreement on the importance of strengthening access to resources, with a high mean score of 4.35 and a low standard deviation of 0.74; the chi-square value of 17.55 and p-value of 0.002 indicated high statistical significance. This emphasizes that farmers' adoption of Integrated Pest Management (IPM) was often constrained by limited access to essential inputs such as botanical pesticides, traps, and resistant seeds, with factors like distance to suppliers and high costs further discouraging uptake. This implies that improving rural agro-input supply chains and providing subsidies for IPM-related products would enhance resource accessibility, thereby promoting greater adoption of IPM and reducing dependence on synthetic pesticides.

During an interview one of the local leaders had this to say;

> *"IPM adoption is cost-effective in the long term, but initial investment may involve purchasing improved tools, attending training, and adopting new infrastructure. Access to financial resources, land, water, and infrastructure support IPM success, as certain practices require these resources"*

This is in line with Pecenka *et al.* (2021) who pointed out that access to resources like financial support, quality seeds, and pest management tools is crucial for successful implementation of Integrated Pest Management (IPM). Incentives like subsidies can encourage farmers to invest in IPM technologies. Access to financial, informational, technological, and social resources can lead to the adoption of innovative agricultural practices by smallholder farmers. Access to resources like biopesticides, protective gear, and pest monitoring tools is crucial for effective IPM application in smallholder farmers.

CHAPTER FIVE

SUMMARY OF THE FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.0 Introduction

This chapter presents the summary of the findings, conclusions and recommendations derived from the major findings of the study.

5.1 Summary of the findings

Summary of the findings were based on the study objectives as listed below;

5.1.1 The level of knowledge of Integrated Pest Management practices among tomato farmers

The study findings revealed varying levels of knowledge and practices related to Integrated Pest Management (IPM) among tomato farmers. The highest awareness was observed in the understanding of IPM principles and objectives followed by proper application of chemical pesticides, and knowledge of common tomato pests. Farmers also demonstrated good understanding of pest-environment relationships and moderate knowledge of cultural control methods. However, their ability to distinguish between harmful and beneficial insects, confidence in field-based pest management decisions, and knowledge of biological pest control were comparatively lower. Regular use of non-chemical methods and access to IPM training were the lowest, highlighting the need for enhanced training, demonstrations, and support to promote holistic IPM adoption.

5.1.2 The factors influencing the adoption of Integrated Pest Management practices among tomato farmers

Results established that the adoption of Integrated Pest Management (IPM) practices among tomato farmers was significantly influenced by several factors, with education, extension contact, access to information, group membership, experience in tomato farming, access to IPM inputs pest pressure level and perceived effectiveness of IPM showing strong positive and statistically significant influence. This means that farmers, who were more educated, managed larger farms, had regular contact with extension services, belonged to farmer groups, experienced in tomato farming, and believed in the effectiveness of IPM were more ably to adopt these practices. Notably, access to IPM inputs and extension contact had the highest positive coefficients. Conversely, factors such as age, access to credit, market access, and gender were not statistically significant. These results emphasized the importance of improving education, extension services, group engagement, and input availability to enhance IPM adoption among tomato farmers.

5.1.3 The possible ways of motivating smallholder farmers to increase the adoption and utilization of Integrated Pest Management practices among tomato farmers

The findings reveal that all the proposed strategies to motivate smallholder tomato farmers to adopt Integrated Pest Management (IPM) practices were positively rated, with mean scores ranging from 3.85 to 4.50. The highest-rated strategy was providing incentives and market access with a mean of 4.50, standard deviation 0.69, chi-square value 20.34, and a highly significant p-value of 0.000, indicating strong consensus among respondents, followed by improving access to credit, strengthening access to resources, capacity development and capacitating extension systems were also strongly agreed upon, while integration with existing practices received the lowest mean score with the highest response variability, though still statistically significant. All variables had p-values below 0.05, confirming statistically significant differences in respondent opinions, thus suggesting that a multifaceted approach combining incentives, financial access, training, and institutional support is essential for enhancing IPM adoption among tomato farmers.

5.2 Conclusions

The study demonstrated that while tomato farmers exhibited high awareness of IPM principles, pest identification, and chemical pesticide application, their knowledge and consistent use of cultural, biological, and non-chemical pest control methods remained moderate to low.

Results established that the adoption of Integrated Pest Management (IPM) practices among tomato farmers was influenced by socioeconomic, institutional, and perceptual factors. Factors like education, farm size, extension contact, information access, group membership, farming experience, pest pressure, and perceived effectiveness positively affect IPM adoption. Targeted interventions are needed to enhance sustainable practices.

Results also showed that smallholder tomato farmers strongly support a multifaceted strategy to enhance Integrated Pest Management (IPM) adoption, emphasizing incentives, market access, credit, and resource strengthening. Capacity building, extension support, and collaborative farmer institutions are also recognized as enablers. Gender mainstreaming and integration are important, suggesting comprehensive policies and interventions for sustainable uptake.

5.3 Recommendations

Government and development partners should invest in strengthening agricultural extension services, including on-farm demonstrations, farmer field schools, and farmer-to-farmer training, to close knowledge gaps in areas like biological control and safe pesticide use.

Targeted awareness campaigns should be implemented to address low knowledge on biological control and safe pesticide use, utilizing various media such as radio, TV, agro-input dealers, and community meetings.

The study recommends investing in agricultural extension services and farmer training to increase IPM adoption, highlighting the significant influence of extension contact and information access on farmers' adoption.

Stakeholders should enhance access to IPM inputs and promote group membership to increase adoption rates. Ensure availability and affordability of materials like biopesticides and resistant seeds, and support farmer group formation for collective input procurement.

The government should strengthen and equip the national agricultural extension systems with adequate resources, trained personnel, and logistical support to effectively disseminate IPM knowledge and provide hands-on guidance to smallholder tomato farmers, ensuring sustained capacity building and adoption.

The government and NGOs should improve access to affordable credit and critical farm resources such as IPM tools, biological control agents, and improved seed varieties by establishing farmer-friendly loan schemes and input subsidies, enabling farmers to overcome financial barriers and implement IPM practices effectively.

5.4 Areas for further research

Examining the socioeconomic impact of IPM adoption on farmers' income, productivity, input costs, and livelihoods to determine its long-term economic benefits in tomato farming.

Exploring the role of gender in influencing access to IPM knowledge, resources, and decision-making among tomato farmers, and how gender-responsive strategies can enhance adoption rates.

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Appendices

Appendix I: Questionnaire for tomato farmers

Dear Respondent,

My name is **Acola Harriet** a student of Uganda Martyrs University pursuing Master of Science in Agroecology. I am carrying out research on assessing the socioeconomic factors influencing the adoption of Integrated Pest Management practices among tomato farmers in Amuru district. The information given here shall be kept confidential and serve for academic purpose only.

All responses will be kept confidential and anonymous.

Section A: Demographic characteristics

1. Gender

   (a) Male ☐ (b) Female ☐

2. Age

   (a) 18 - 25 ☐ (b) 26 - 35 ☐ (c) 36 - 45 ☐

   (d) 46 - 55 ☐ (e) 56 and above ☐

3. Education level

   (a) No formal education ☐ (b) Primary school ☐ (c) Secondary school ☐

   (d) Diploma/certificate ☐ (e) Bachelor's degree or higher ☐

4. Marital status

   (a) Single ☐ (b) Married ☐

   (c) Widowed ☐ (d) Separated ☐

Section B: The level of knowledge of Integrated Pest Management practices among tomato farmers

5. How many years have you been engaged in tomato farming?

(a) Less than 1 year ☐ (b) 1-5 years ☐

(c) 6-10 years ☐ (d) More than 10 years ☐

6. Have you heard about Integrated Pest Management (IPM)?

(a) Yes ☐ (b) No ☐

7. From which source did you first learn about IPM practices?

(a) Agricultural extension officers ☐ (b) Fellow farmers ☐

(c) Media (radio/TV/newspapers) ☐ (d) Training programs/workshops ☐

(e) Others (specify)…………………………………………………………………...

8. What do you understand by Integrated Pest Management (IPM)?

(a) The use of synthetic pesticides only ☐

(b) Combining different methods to manage pests sustainably ☐

(c) Allowing pests to grow naturally ☐

(d) Unsure ☐

9. Which of the following methods do you think is part of IPM? (Choose all that apply)

(a) Use of resistant tomato varieties ☐

(b) Proper crop rotation ☐

(c) Overuse of chemical pesticides ☐

(d) Use of biological pest control (e.g., natural enemies) ☐

Section C: Level of knowledge of Integrated Pest Management practices among tomato farmers

10. In this section you are requested to indicate the level of agreement to the statements given guided by; 1-srongly disagree (SD), 1 Disagree (D), 3 Not sure (NS), 4 Agree (A) and 5-strongly agree (SA).

Level of knowledge of Integrated Pest Management practices among tomato farmers	**1**	**2**	**3**	**4**	**5**
I am aware of the principles and objectives of Integrated Pest Management (IPM).					
I know how to identify common pests that affect tomato crops.					
I understand how to use cultural methods (e.g., crop rotation) to manage pests in tomatoes.					
I can distinguish between harmful and beneficial insects in my tomato field.					
I am knowledgeable about the safe use of biological pest control methods.					
I know how to correctly apply chemical pesticides as part of an IPM strategy.					
I have received training or guidance on IPM practices in tomato farming.					
I understand how environmental conditions influence pest outbreaks in tomato farming.					
I am confident in making pest management decisions based on field monitoring or scouting.					
I regularly use non-chemical methods (e.g., mulching, trap crops) to reduce pest damage.					

Section D: The factors influencing the adoption of Integrated Pest Management practices among tomato farmers in Amuru District

11. What are the factors influencing the adoption of Integrated Pest Management practices among tomato farmers in Amuru District? (Choose all that apply)

Factors influencing the adoption of Integrated Pest Management practices among tomato farmers	**Agree**	**Not sure**	**Disagree**
Knowledge and awareness			
Market demand for sustainable products			
Economic incentives			
Input costs			
Farm income			
Farm size			
Farming experience			
Gender			
Education level			
Access to extension services			
Government policy			
Age			
Cultural Beliefs and Practices			

Section E: The possible ways of motivating smallholder farmers to increase the adoption and utilization of Integrated Pest Management practices among tomato farmers

12. What are the possible ways of motivating smallholder farmers to increase the adoption and utilization of Integrated Pest Management practices among tomato farmers? (Choose all that apply)

In this section you are requested to indicate the level of agreement to the statements given guided by; 1-srongly disagree (SD), 1 Disagree (D), 3 Not sure (NS), 4 Agree (A) and 5-strongly agree (SA).

The possible ways of motivating smallholder farmers to increase the adoption and utilization of Integrated Pest Management practices among tomato farmers	**1**	**2**	**3**	**4**	**5**
Enhancing education and Training Programs					
Access to resources					
Enhancing peer influence and social networks					
Enhancing incentives and market access					
Integration IPM with existing practices					
Improving farmer networks					
Improving on Policy and institutional support					

Thanks for your responses

Appendix II: Interview for key informants

Dear Respondent,

My name is **Acola Harriet** a student of Uganda Martyrs University pursuing Master of Science in Agroecology. I am carrying out research on assessing the socioeconomic factors influencing the adoption of Integrated Pest Management practices among tomato farmers in Amuru district. The information given here shall be kept confidential and serve for academic purpose only.

All responses will be kept confidential and anonymous.

1. What is your role in supporting tomato farmers in Amuru District?
2. How familiar are you with Integrated Pest Management (IPM) practices?
3. In your opinion, how widespread is the adoption of IPM practices among tomato farmers in this district?
4. How would you assess the level of awareness of IPM practices among tomato farmers in this area?
5. What sources of information about IPM practices are most accessible to farmers here?
6. Are there any training programs or workshops on IPM practices for tomato farmers? If yes, how effective are they?
7. What specific IPM practices are commonly adopted by tomato farmers in Amuru District?
8. What percentage of tomato farmers in this area do you estimate have adopted IPM practices?

9. Are there any particular groups (e.g., women, youth, large-scale farmers) that are more likely to adopt IPM practices? Why?
10. What factors encourage the adoption of IPM practices among tomato farmers?
11. What barriers do tomato farmers face in adopting IPM practices?
12. How do social factors, such as peer influence or membership in farmer groups, affect IPM adoption?
13. What role do extension services play in promoting IPM practices among tomato farmers?
14. Are there any government or non-governmental programs that support IPM adoption in this district? If yes, how effective are they?
15. Do input suppliers provide products and advice related to IPM practices?
16. In your view, how has the adoption of IPM practices affected tomato production in this area?
17. Have farmers reported any challenges or successes after adopting IPM practices? Can you provide examples?
18. What strategies would you recommend to increase the adoption of IPM practices among tomato farmers in Amuru District?
19. What additional support do you think farmers need to adopt and sustain IPM practices effectively?
20. How can different stakeholders (e.g., government, NGOs, input suppliers) collaborate to promote IPM adoption?

Thanks for your responses

Appendix III: Consent form for research participants

Assessment of the socioeconomic factors influencing the adoption of Integrated Pest Management practices among tomato farmers in Amuru district.

Principal Investigator: **Acola Harriet**

Research Institution: **Uganda Martyrs University**

Dear Participant,

You are being invited to participate in a research to study the socioeconomic factors influencing the adoption of Integrated Pest Management practices among tomato farmers in Amuru district.

Participants will be asked to participate in an interview or group discussion, conducted by a trained researcher, with the intention of gaining insights into the level of adoption of Integrated Pest Management practices among tomato farmers in Amuru District so as to inform strategies to improve the adoption and use of IPM.

The study has minimal risks, such as discomfort or emotional stress, but will ensure a safe and supportive environment during data collection. Participants will receive 2000 Uganda shillings to cover their time and contribute to the generation of knowledge that may inform future projects.

If you agree to participate, you will be asked to take part in an interview or group discussion. The interview will be conducted by a trained researcher and will last approximately 30 minutes.

The discussion will focus on your experiences, knowledge, and opinions regarding the level of adoption of Integrated Pest Management practices among tomato farmers in Amuru District so as to inform strategies to improve the adoption and use. The interview or discussion may be audio or video-recorded for accurate transcription and analysis purposes, with your explicit consent.

By signing this form, you are indicating that you have read and understood the information provided above, and that you voluntarily agree to participate in this study. You understand that your participation is entirely voluntary, and that you may withdraw from the study at any time without penalty.

Please sign below to indicate your agreement to participate in the study.

Participant Signature: ………………………………… Date ……………………………