

**AN INVESTIGATION ON THE FARMERS KNOWLEDGE,
ATTITUDES AND PERCEPTION ON THE USE OF BIO
PESTICIDES IN CONTROLLING FIELD PESTS OF CABBAGE
IN BUNANGO PARISH, NALWANZA SUB COUNTY, BUDUDA
DISTRICT.**

BY

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BU/UP/2023/1706

**A RESEARCH REPORT SUBMITTED TO THE FACULTY OF
SCIENCE AND EDUCATION IN PARTIAL FULFILLMENT OF
THE REQUIREMENT FOR THE AWARD OF A DEGREE OF
BACHELOR OF SCIENCE EDUCATION (AGRICULTURE) OF
BUSITEMA UNIVERSITY**

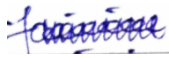
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NOVEMBER 2026

DECLARATION

I, Kutosi Michael Weswa, hereby declare that this research report titled “An Investigation on the Farmers’ Knowledge, Attitudes and Perception on the Use of Bio-pesticides in Controlling Field Pests of Cabbage in Bunango Parish, Nalwanza Sub County, Bududa District” is my original work and has never been submitted to any institution of higher learning for the award of any academic qualification or degree.

I further declare that all sources of information used in this study has been fully acknowledged through references and citations in accordance with academic requirements.

Signature:  _____ Date:  _____

APPROVAL

This is to certify that the research report entitled “An Investigation on the Farmers’ Knowledge, Attitudes and Perception on the Use of Bio-pesticides in Controlling Field Pests of Cabbage in Bunango Parish, Nalwanza Sub County, Bududa district” submitted to busitema university is authentic record of bonified research work carried out by kutosi Michael weswa (BU/UP/2023/1706) under my guidance and supervision.

No part of this research report has been submitted for any other degree.

Signature: 

Date: 10/09/2026

MR. DRAMADRI GERALD AFAYO

SUPERVISON

DEDICATION

This research work is wholeheartedly dedicated to Almighty God for His endless grace, strength, wisdom, and protection throughout my academic journey. Without His guidance and favor, this study would not have been successfully accomplished. I dedicate this work with profound gratitude and love to my beloved parents and family members whose sacrifices, prayers, encouragement, and unwavering support have been the foundation of my education and personal growth. Your belief in my potential has continually inspired me to strive for excellence even in difficult moments.

Special dedication goes to my lecturers and supervisor, especially **Mr. Dramadri Gerald Afayo**, for the academic guidance, professional mentorship, and constructive criticism offered throughout this study. Your dedication toward shaping future agricultural educators and researchers has greatly influenced this work. I also dedicate this research to the hardworking cabbage farmers of Bunango Parish, Nalwanza Sub-county, Bududa District, whose resilience, determination, and commitment to agriculture continue to sustain livelihoods and food security despite numerous challenges. This study is inspired by your daily struggles and hopes for sustainable farming practices through the adoption of environmentally friendly bio-pesticides.

Finally, this work is dedicated to all future researchers, agricultural scientists, and students who are passionate about sustainable agriculture, environmental conservation, and improving the livelihoods of smallholder farmers in Uganda and beyond

ACKNOWLEDGEMENT

I extend my deepest gratitude to Almighty God for granting me life, wisdom, strength, good health, and perseverance throughout the entire period of my study and research. His divine guidance has enabled me to overcome every challenge encountered during the preparation of this research proposal.

My sincere appreciation goes to my supervisor, **Mr. Dramadri Gerald Afayo**, for his tireless guidance, professional advice, constructive criticism, encouragement, and academic mentorship throughout the development of this study. His invaluable support and commitment greatly contributed to the successful completion of this research work. I also express profound gratitude to the administration and lecturers of the Faculty of Science and Education at Busitema University for equipping me with the knowledge, skills, and academic foundation necessary for conducting this study. The intellectual support and dedication of the university staff have played a significant role in shaping my academic journey. Special appreciation goes to the leaders, agricultural officers, and cabbage farmers of Bunango Parish, Nalwanza Sub-county, Bududa District, for their cooperation, willingness to provide information, and valuable contributions toward this research. Their participation and practical experiences formed an important basis for this study.

I am deeply indebted to my parents' mzee Nasaba Patrick and mama Jane Buwenje, family members, and friends for their moral support, prayers, encouragement, and financial assistance throughout my education. Your patience, love, and motivation continually inspired me to remain focused and determined toward achieving my academic goals.

I further acknowledge all authors, researchers, and scholars whose publications, journals, books, and academic works provided valuable information that enriched this study. Their contributions greatly enhanced the quality and depth of this research proposal.

Finally, I extend appreciation to all individuals who, in one way or another, contributed to the success of this research work but whose names may not have been specifically mentioned. May God richly bless you all.

ABSTRACT

This study investigates the farmers' knowledge, attitudes, and perceptions regarding the use of bio-pesticides in controlling field pests of cabbage in Bunango Parish, Nalwanza Sub-county, Bududa District, Uganda. Cabbage production is an important economic activity and a major source of livelihood for smallholder farmers in the area. However, productivity has continuously been threatened by destructive field pests such as aphids, diamondback moths, cutworms, flea beetles, and whiteflies, which significantly reduce yields and market quality. As a result, many farmers heavily rely on synthetic chemical pesticides whose prolonged and indiscriminate use has contributed to environmental pollution, pesticide resistance, increased production costs, health risks, and contamination of water sources and agricultural produce.

The study findings revealed that although a number of farmers have heard about bio-pesticides and acknowledge their environmental and health benefits, the majority still depend on synthetic pesticides due to perceptions that bio-pesticides are less effective, slow acting, labor-intensive, and not readily available. Limited technical knowledge, inadequate agricultural extension services, lack of training opportunities, high poverty levels, and poor access to reliable bio-pesticide products were identified as major barriers to adoption. The study further established that cabbage farming remains highly profitable in Nalwanza Sub-county despite the numerous production challenges faced by farmers.

The study concludes that bio-pesticides have great potential in promoting sustainable cabbage production, improving food safety, reducing environmental degradation, and lowering health risks associated with synthetic chemicals. However, their successful adoption requires intensive farmer sensitization, practical training, improved access to extension services, government support, establishment of demonstration gardens, and strengthening of local farmer groups. The study therefore recommends increased investment in farmer education programs, promotion of integrated pest management strategies, subsidization of bio-pesticide inputs, and collaborative efforts between government agencies, researchers, and non-governmental organizations to encourage sustainable agricultural practices among smallholder cabbage farmers in Bududa District and Uganda at large.

TABLE OF CONTENTS

Contents

DECLARATION.....	i
APPROVAL.....	ii
DEDICATION.....	iii
ACKNOWLEDGEMENT.....	iv
ABSTRACT.....	v
LIST OF FIGURES.....	ix
1.0 INTRODUCTION.....	1
1. 1 background.....	1
1.2 PROBLEM STATEMENT.....	6
1.3 JUSTIFICATION OF THE STUDY.....	7
1.4 SIGNIFICANCE OF THE STUDY.....	7
1.5.0 OBJECTIVES.....	8
1.5.1 General objective.....	8
1.5.2 Specific objectives.....	8
1.6 RESEARCH QUESTIONS.....	8
1.7 SCOPE OF THE STUDY.....	9
1.8 conceptual frameworks.....	10
CHAPTER TWO.....	11
2.0 LITERATURE REVIEW.....	11
2.1.0 Overview of vegetable production.....	11
2.1.1 THE LEVEL OF CABBAGE PRODUCTION.....	11
2.2.0 PROBLEMS FACING CABBAGE FARMERS.....	16

2.2.1 BIO PESTICIDES	18
2.2.2 CLASSIFICATION OF BIO-PESTICIDES.....	19
2.2.3 EFFECTS OF USING BIO-PESTICIDES	23
2.2.4 FORMULATION AND USE OF BIO-PESTICIDES	23
2.8 FARMERS KNOWLEDGE, ATTITUDES AND PERCEPTION ON THE USE OF BIO-PESTICIDES IN CONTROLLING FIELD PESTS IN CABBAGE.	25
2.9 MEASURES TO INCREASE ADOPTION AND USE OF BIO PESTICIDES IN CONTROLLING FIELD PESTS IN CABBAGE.....	27
3.0 study area.....	29
3.2 Research design	32
3.3 Sampling procedure.....	32
3.4 Sample size determination.....	32
3.5 DATA COLLECTION INSTRUMENTS	33
3.5.2 Questionnaires.....	33
3.6 DATA COLLECTION PROCEDURE.	33
3.7 Data analysis.....	33
4.0 DATA PRESENTATION, ANALYSIS AND DISCUSSION.....	35
4.2 THE LEVEL OF CABBAGE PRODUCTION IN NALWANZA SUB COUNTY IN BUDUDA DISTRICT.....	39
4.4 THE LEVEL OF FARMERS' KNOWLEDGE, ATTITUDE AND PERCEPTION ON THE USE OF BIO PESTICIDES IN CONTROL OF FIELD PESTS IN NALWANZA SUB COUNTY IN BUDUDA DISTRICT.	44
4.5 MEASURES TOMINCREASE ADOPTION AND USE OF BIO PESTICIDES IN CONTROL OF FIELD PESTS BY CABBAGE FARMERS IN NALWANZA SUB COUNTY IN BUDUDA DISTRICT.....	48
CHAPTER FIVE	52
5.0 SUMMARY, CONCLUSION AND RECOMMENDATIONS.....	52
5.1 Summary of the Study.....	52

5.2 Conclusions	53
5.3 Recommendations.....	53
REFERENCES.....	55
APPENDICES	60
APPENDIX 1:.....	60
APPENDIX 2:.....	61

LIST OF TABLES

Table 3.1: Population Distribution of Parishes in Nalwanza Sub-county.....	44
Table 3.2: Representative Sample Population Distribution	46
Table 3.3: Research Distribution Table for Selected Villages	49
Table 4.1: Socio-economic and Demographic Characteristics of Respondents.....	50
Table 4.2: Distribution of Respondents by Age, Gender and Education Level.....	51
Table 4.3: Estimated Land Use and Yield per Season.....	52
Table 4.4: Seasonal Production and Market Value of Cabbage	52
Table 4.5: Major Problems Faced by Cabbage Farmers.....	53
Table 4.6: Farmers' Awareness and Knowledge of Bio-pesticides.....	53
Table 4.8: Farmers' Perceptions on the Effectiveness of Bio-pesticides.....	54
Table 4.9: Perceived Cost and Accessibility of Bio-pesticides.....	54
Table 4.10: Suggested Measures to Increase Adoption of Bio-pesticides.....	55

LIST OF FIGURES

Figure 1.1: Conceptual Framework of the Study	19
Figure 4.1: Pie Chart Showing Distribution of Respondents by Gender.....	44
Figure 4.3: Bar Graph Showing Educational Levels of Respondents	45
Figure 4.4: Estimated Annual Cabbage Output Trends in Nalwanza Sub-county	46
Figure 4.5: Seasonal Variations in Cabbage Production and Market Prices.....	46
Figure 4.6: Farmers' Awareness Levels on Bio-pesticides.....	47
Figure 4.7: Sources of Information on Bio-pesticides Among Farmers.....	48

Figure 4.8: Farmers’ Perception on the Effectiveness of Bio-pesticides	48
Figure 4.9: Major Challenges Limiting Adoption of Bio-pesticides.....	99
Figure 4.10: Suggested Measures to Improve Adoption of Bio-pesticides	51

LIST OF ABBREVIATIONS AND ACRONYMS

BCA — Biological Control Agent

Bt — *Bacillus thuringiensis*

CABI — Centre for Agriculture and Bioscience International

CBD — Convention on Biological Diversity

CDO — Community Development Officer

CIAT — International Center for Tropical Agriculture

DRC — Democratic Republic of Congo

EKN — Embassy of the Kingdom of the Netherlands

EPF — Entomopathogenic Fungi

EPNs — Entomopathogenic Nematodes

FAO — Food and Agriculture Organization

FAOSTAT — Food and Agriculture Organization Statistics Division

FFS — Farmer Field Schools

GDP — Gross Domestic Product

GVs — Granuloviruses

IGRs — Insect Growth Regulators

IPM — Integrated Pest Management

1.0 INTRODUCTION

1. 1 background

According to thrall P.H (2020), Agriculture was fundamental in the development of human society, enabling a gradual shift from a hunter-gathered nomadic lifestyle to a more settled way of life, allowing primordial civilizations to flourish. Agriculture plays a big role in creating inclusive and providing great jobs for both the youths and the adults. Growth in agriculture output increases farm productivity and profitability leading to improved wellbeing of the farmers and those living in the rural Areas and hence enhancing rural development.

Globally, cabbage (*Brassica oleracea*), a vital horticultural crop for food security and income, suffers severe yield losses, ranging from 50% up to 100% if not properly managed, primarily driven by the diamondback moth (*Plutella xylostella*) and cabbage aphids (*Brevicoryne brassicae*). This high economic threat has historically led to intense, often indiscriminate, reliance on synthetic insecticides, with some farmers applying chemicals up to 25 times per season, exceeding recommended dosages, and ignoring pre-harvest intervals. Consequently, there is substantial, often unreported, environmental pollution, increased pesticide residues in cabbage, with studies finding that up to 98% of farmers fail to check toxicity levels before application, and many throw containers in open fields. The global market for bio pesticides is projected to grow from roughly USD 9.91 billion in 2025 to USD 40.61 billion by 2034, driven by the need for eco-friendly alternatives to chemical residues, particularly in high-value, residue-sensitive vegetable crops. Despite the growing bio pesticide market, investigation into farmers' Knowledge, Attitudes, and Perceptions (KAP) reveals a significant gap between awareness and adoption, particularly in developing nations. While many farmers are aware of the detrimental effects of synthetic pesticides on health and the environment, only a small percentage less than 19% in some studies actively use bio-pesticides, often favoring chemical controls for their rapid action, high efficacy, and ready availability, even when they know of alternative methods. Limited training frequently skews farmers' perceptions with fewer than 20% having received training on agro ecological-based practices, leading to negative attitudes towards biological control agents due to perceived lower or slower efficacy. Nevertheless, the increasing market share of bio insecticides expected to hold 47.39% of the bio pesticides market in 2026 suggests

that targeted training, better product availability, and demonstrations of efficacy, especially for microbial agents like *Bacillus thuringiensis*, are gradually shifting attitudes towards more sustainable pest management in cabbage farming.

According to Scalabba (2000), Cabbage (*Brassica oleracea* var. *capitata*) production in East Africa is a crucial source of income and food security for smallholder farmers, yet it is consistently threatened by severe insect pest infestations, most notably the diamondback moth (*Plutella xylostella*) and cabbage aphids (*Brevicoryne brassicae*), which can cause up to 100% yield loss in severe cases. In response to this high pest pressure, farmers in regions such as Kenya, Tanzania, and Uganda, and the eastern Democratic Republic of Congo (DRC) heavily rely on synthetic pesticides, often exceeding safety limits. Over 84% of smallholder farmers in some areas consider chemical pesticides the only reliable option for controlling cabbage pests, leading to high incidences of pesticide misuse, such as lack of proper protective equipment, frequent "calendar" spraying (often every 3-4 days), and failure to adhere to pre-harvest intervals, with 79% of farmers in some studies failing to observe safety waiting periods. This reliance results in high residue levels in markets, with one study finding that 50% of sampled cabbages contained residues exceeding recommended limits, posing a significant risk to consumer health, ecosystem integrity, and the development of insecticide resistance in field pests. Despite the growing regional demand for safer food and the potential for bio pesticides to manage resistance and minimize toxic effects on beneficial entomofauna, the adoption of biological control remains alarmingly low, with awareness often below 20% in specific studies (e.g., in Kenya and Tanzania). Farmers' attitudes towards bio pesticides are often characterized by skepticism regarding their efficacy compared to chemical pesticides, particularly regarding the speed of action and effectiveness against heavy pest pressure. While over 60% of farmers might be aware of the term "biologicals," they often do not equate them with safety or effectiveness, with only a small minority in some areas acknowledging the existence of safer, effective, and readily available alternatives. Studies in East Africa indicate that for bio pesticides to be adopted, they must address perceptions of slow action and high labor intensity, particularly because current agricultural extension services often fail to prioritize the promotion of botanical products such as neem extracts, or the use of entomopathogenic fungi. Key challenges inhibiting

the uptake of bio pesticides in the region include, but are not limited to, lack of local availability, perceived high cost, and inadequate training for farmers on appropriate application

However, production detailed data on Uganda's fruits and vegetables are very limited. Vegetables and fruits are a major crop produced in all districts of Uganda. Smallholders, scattered all over the country, produce fruits and vegetables.

This has called for farmers' participation in the production of high value crops, which is among the top leading economic activities that contribute to better living standards through employment, which helps to curb poverty. As a result, the livelihoods of most rural households are also improved. This sector consists of Horticulture sub sector in the recent years has gained ready market due to increased demand of its products both locally and internationally.

The agricultural subsector of vegetable farming plays a vital role in enhancing quality food and reducing the number of those suffering from malnutrition hence achieving the sustainable development goals. This is greatly achieved by encouragement of the private sector. The production of horticultural products is gaining importance. The Integrated Seed Sector Development (ISSD plus project) has supported the horticulture sector. The ISSD has been so much coordinated with the Wageningen Centre for Development Innovation funded by the Embassy of the kingdom of the Netherlands (EKN). In Ugandan, such horticultural crops are categorized into four crops namely

- a). Vegetable and species e.g. okra, garlic, Irish potatoes, green peppers, watermelons, Sukuma wiki, tomatoes, Nakati, among others.
- b). Fruit crops e.g. pineapples, Mangoes, Gooseberry, passion fruit, among others.
- c). Medicinal crops e.g. Moringa, Been tree, Aloe Vera, Artemisia spp.
- d). Cottage crops e.g. Mushrooms, Flowers (Roses), upland rice.

In most developing countries, the use of modern synthetic pesticides is limited and sometimes nonexistent (Scalabba, 2000). This is not only because they are expensive but also because of the small fields cultivated by subsistence farmers making the use of such pesticides uneconomic.

Yet, most of these countries lie in tropical and subtropical areas where pests and diseases are abundant throughout the year.

This implies that, pests and diseases pose a major problem in agricultural production in these areas.

According to Oerke and Dehne (2024), pests contribute 30-40% of crop loss worldwide while the loss in the tropics is reported to be even higher than 40% (FAO)

Vegetables are edible plants or plants that are consumed by man and animals as food containing vitamins and minerals. Examples of vegetables grown in Nalwanza Sub County include;

- ✓ Leafy green- Sukuma week, lettuce, spinach and silver beet, cruciferous, and cauliflower.
- ✓ Root- potato, sweet potato and yams
- ✓ Edible plant stem- celery and asparagus, gallium, onion, garlic, and shallot.

However, cabbage is the most grown vegetable in the area.

Crop losses caused by various pathogens I.e. bacteria; fungi, insects, weeds etc. reduce agricultural productivity and cause economic loss to the country. Usage of chemical fertilizers, pesticides and other aids had a significant role as a protagonist during the green revolution. It favored the scenarios of agricultural production and all seemed to rely on these aids in a very smooth manner. The negative side of these chemically synthesized fertilizers and pesticides got the limelight when the chemical residues started to accumulate in the soil, water, and products. The impact on the environment became visible when these started to contaminate and deteriorate the quality of soil, water and other vegetation, thus, environment. Global demand is for safe, non-toxic, nutritious food products. These products are obtained only by good agricultural practices, followed by safe post-harvest processing techniques.

In Bududa District, cabbage cultivation is a cornerstone of high-altitude horticulture, benefiting from the region's volcanic soils and cool climate characterized by altitudes between and above sea level. As a primary cash crop for smallholder farmers, cabbage serves as both a source of household nutrition and a critical income generator, often grown in the fertile valleys of Bubiita,

Buwali, Bukalasi, Nalwanza, Bushiyi, Maboono and Bulucheke sub counties. However, production is heavily constrained by an array of aggressive pests, most notably the Diamondback Moth, which can cause up to 34% yield loss if left unmanaged by skeletonizing leaves and destroying growing tips. Other significant pests include cabbage aphids, which suck sap and cause leaf curling and stunting, and cutworms that decapitate young seedlings.

The scale of cabbage farming in Bududa is, characterized by intense land fragmentation, with most individual households managing small plots ranging from 100-120 persons per kilometer. Despite these small plot sizes, the high plant density of approximately 320 plants per acre allows for significant output, with potential yields reaching per hectare under good management. The workforce involved is predominantly composed of smallholder family units, where men typically lead the heavy land preparation while women and youth manage the labor-intensive tasks of transplanting, weeding, and manual transport to local markets. Statistics indicate that over of these farmers depend entirely on vegetable production for their livelihoods, yet they face persistent challenges including high input costs, poor road infrastructure during the rainy season, and a lack of organized storage facilities, which leads to post-harvest losses. Consequently, while Bududa remains a vital producer for the Mbale and regional markets, the sector requires better access to extension services and integrated pest management (IPM) strategies to move beyond subsistence-level profitability.

The primary purpose of agriculture and rural development in most parts of Bududa is to achieve improvement in rural levels of living achieved primarily through increase in small farm incomes, output and productivity along with genuine food security as a critical way out of poverty towards great rural development. This therefore involves avoiding, prevention and control of all the possible causes of agricultural losses to such rural farmers who in most cases Bududa are small-scale farmers and operate on a small acreage of land.

Keyword

A bio-pesticide is a biological substance or organism that damages, kills, or repels organisms seen as pests. Biological pest management intervention involves predatory, parasitic, or chemical

relationships. They are obtained from organisms including plants, Bacteria and other microbes, fungi, nematodes, and other animal extracts.

According to Gasic, S. and, Tanovic. (2013), Bio pesticides are products and by-products of naturally occurring substances such as insects, nematodes, microorganisms, plants as well as semi chemicals.

1.2 PROBLEM STATEMENT.

Vegetable farmers in Nalwanza Sub County are facing a problem of field pests that does not only destroy their vegetable crops but also causes and spread plants and human diseases. Such pests among others include;

Field crickets (*Gryllus* spp), which feed and cuts off sprouts and young plants in vegetable crops such as Sukuma wiki, tomatoes, egg plants green peppers, watermelon among others.

Variegated grasshoppers (*Zonoceru variegatus*), which feed on leaves and stems of vegetables such as onions, eggplants, spinach, Sukuma wiki among others.

Aphids (*aphis* spp), which feed on leaves and stems of vegetables such as onions, eggplants, spinach, Sukuma wiki, green peppers among others.

In the absence of effective alternative management options to tackle pests, smallholder farmers rely extensively on indiscriminate application of synthetic pesticides. These synthetic pesticides are harmful to human health, detrimental to the environment and biodiversity, and lead to buildup of resistance in the target pests while decimating natural enemies of pests, resulting in secondary pest outbreaks.

In addition, presence of pests' residues on export crops that are above the permissible maximum residue levels of importing nations results in informal trade barriers (Bailey et al., 2020). For example, continuous use of synthetic chemical pesticides has affected the quality of watersheds near the farms such as Buwakiyu swamp found Near Nalwanza sub county headquarters whose water is no longer safe for domestic use due to such residues.

In addition, synthetic pesticides are also expensive which makes it difficult for some scale farmers in Nalwanza sub county.

1.3 JUSTIFICATION OF THE STUDY.

There is pre-harvest losses of cabbage in Nalwanza sub county in Bududa district due to pests and diseases. This is because many farmers cannot afford to buy synthetic chemical pesticides to control pests, and there is development of pesticides resistance by pests in that, some pesticides are no longer effective in the pest control. This calls for investigation into and devise the means to overcome this problem, and therefore the need to devise an alternative for the situation. This is because vegetable growing is the major source of income to the people of Nalwanza. However, the alternative should also be environmentally friendly as;

Continuous use of synthetic chemical pesticides in Nalwanza Sub County will lead to loss of biodiversity, increased costs of production, which may reduce the profit margin of vegetable farming hence pushing many small-scale farmers in Nalwanza out of vegetable growing. It may also lead to air pollution in Bunango parish in Nalwanza sub county and its related effects on human health such as airborne diseases, water pollution in nearby water streams of river Nanzele, Buwakiyu swamp and river manafa. Yet bio-pesticides can replace synthetic pesticides without significantly affecting productivity and yield of vegetables, if their potentials are fully maximized.

1.4 SIGNIFICANCE OF THE STUDY.

The immediate beneficiaries of the project are going to be the smallholder farmers of vegetables who will participate in the field demonstrations, as they will benefit from the resources made available by the project process.

Ultimately, the small-scale vegetable farmers if Bunango parish are the major target to benefit as they adopt the technology in relation to understanding the formulation and application of bio-pesticides. This will be through analyzing the strategies that other farmers are using in reducing such losses.

The findings of the study will also be of great significance to the policymakers in understanding which policies can be formulated to help farmers reduce the over reliance on synthetic chemical pesticides.

1.5.0 OBJECTIVES

1.5.1 General objective

To contribute to management of field pests of cabbage using bio-pesticides in Uganda.

1.5.2 Specific objectives

- I. To find out the level of cabbage production in Bunango parish, Nalwanza sub county in Bududa district.
- II. To find out the problems facing cabbage farmers in Nalwanza sub county in Bududa district.
- III. To identify the level of farmers knowledge and perception on the use of bio-pesticides used to control some of the field pests of cabbage in Bunango parish, Nalwanza Sub County.
- IV. To identify, the measures to increase adoption, efficiency and effectiveness of bio-pesticides in control of field pests in kales in Nalwanza sub county.

1.6 RESEARCH QUESTIONS.

1. What is the level of cabbage production in Nalwanza Sub County in Bududa district?
2. What are the problems faced by cabbage farmers in Bunango parish Nalwanza Sub County in Bududa district?
3. What was the farmers' perception on the efficient and effective is/are the bio-pesticides use to control field pests in cabbage?
4. What are the suggested measures that can be employed to increase adoption, efficiency and effectiveness of the bio-pesticides in control of field pests of cabbage in Nalwanza Sub County in Bududa district?

1.7 SCOPE OF THE STUDY

Content scope.

The scope is to consider the extent of growing vegetables; pre harvest losses of vegetables due to pests and diseases, strategies to be used by smallholder farmers in Nalwanza Sub County in Bududa district. Smallholders' farmers in this study, particularly those categories of farmers who can cultivate more than one type of vegetable crops on less than one hectare of land and own a few domestic animals for family consumption (subsistence farming) with little if any surplus for the market.

The study is focusing on assessing the causes of pre-harvest losses of vegetables due to pests and diseases among small scale farmers with the aim of assessing factors contributing to pre harvest losses, the extent of pre harvest losses and suggest the possible strategies to reduce pre harvest losses of vegetables in Bududa district. The data is to be collected within Bunango parish, Nalwanza Sub County in Bududa district.

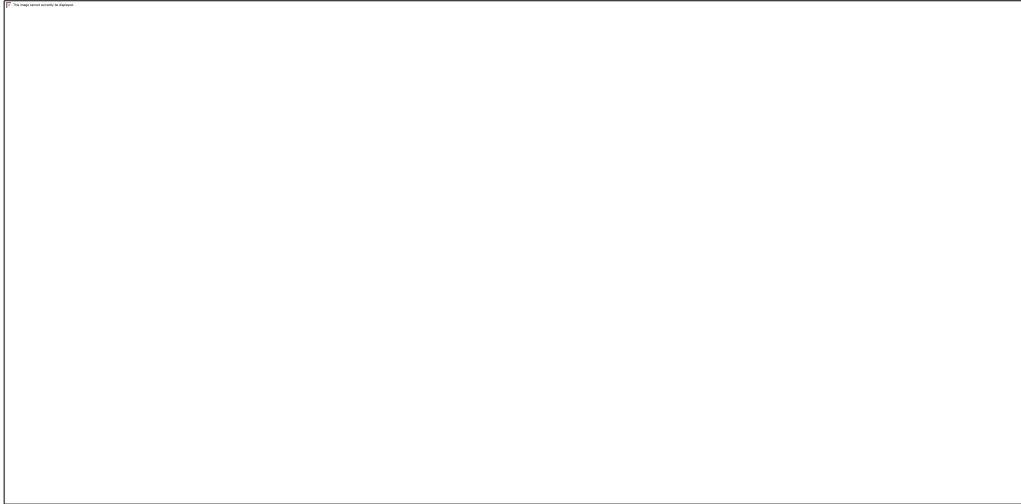
Geographical scope

The study will be conducted in three villages in Bunango parish, Nalwanza Sub County in Bududa district, which will cover an average area of 3 square kilometers.

Time scope

I will conduct my study from 25th of February 2026 up to 30th of April 2026, in the period, I believe without major hindrances, I will be done and submitting my research report.

1.8 conceptual frameworks



CHAPTER TWO

2.0 LITERATURE REVIEW

2.1.0 Overview of vegetable production

Agriculture is the backbone of Uganda's economy, employing about 70% of the population in 2018, and contributing half of Uganda's export earnings and a quarter of the country's gross domestic product (GDP). The current production structure of agriculture in Uganda is dominated by small scale farmers comprising an estimated 2.5 million households (90% of the farming community), the majority of which own less than 2 acres of land each (FAOSTAT, 2018)

Despite agro climate conditions, with two rain seasons in most parts of the country, smallholder yields remain low. Constraints include limited access to quality inputs, low adoption of modern technology, and lack of storage and market infrastructure. Small-scale farmers are the majority constituting about 85% of the farming community; 12% are medium scale farmers, while 3% are large-scale farmers.

2.1.1 THE LEVEL OF CABBAGE PRODUCTION

Francisco Jorge Cividanes metal (2020), reported, At the global level, cabbage (*Brassica oleracea* var. capitata) remains one of the most economically significant vegetable crops due to its high nutritional density and adaptability to diverse agro-ecological zones. As of 2024, global production has exceeded 71 million metric tons, with a market valuation projected to reach approximately \$6.79 billion by 2033 (Market Reports World, 2025). Production is heavily dominated by the Asia-Pacific region, with China and India alone accounting for over 60% of total world output (Bursakov et al., 2024; Research Gate, 2026). While green cabbage accounts for nearly 70% of this production due to its long shelf life and climatic resilience, there is a rising global trend toward organic cultivation fueled by the "clean label" movement in North America and Europe (The Business Research Company, 2026). This global growth is, however, perpetually threatened by biotic stresses such as the Diamondback Moth (*Plutella xylostella*), which causes billions of dollars in annual crop losses and necessitates a shift toward sustainable pest management (Prajapati et al., 2024).

In the African context, cabbage is a vital food security crop and a primary source of income for millions of smallholder households. The FAOSTAT Gross Production Index for Africa shows a steady upward trajectory, moving from an index of 92.90 in 2014 to 129.47 by 2021, indicating significant expansion in land area and yield (UNdata, 2024). However, productivity across the continent remains uneven, while Southern African commercial farms can achieve yields of up to 57.75 t/ha, many East African nations average closer to 30–33 t/ha (Determinants of Cabbage Production, 2026). In East Africa, production is largely concentrated in highland areas with cool temperatures and reliable rainfall. Despite its importance, the regional sector faces "synchronized production cycles" that often lead to market gluts, followed by periods of extreme scarcity and price volatility (STDF, 2022). Furthermore, regional exports are frequently hindered by high pesticide residue levels, which has prompted intergovernmental organizations to prioritize the training of farmers in biological control methods (FiBL, 2024).

Uganda's agricultural sector, which employs over 80% of the workforce, relies heavily on horticultural crops like cabbage for domestic consumption and cross-border trade with South Sudan and Kenya. In Uganda, cabbage is grown year-round, particularly in the fertile volcanic soils of the eastern and southwestern highlands. While national yield averages typically hover around 30 t/ha for open-pollinated varieties, research in districts like Kyenjojo has shown that with optimal fertilizer and pest management, hybrid varieties can achieve staggering yields of up to 104.0 t/ha (Bishop Stuart University, 2023). However, a "high-input, high-risk" model increasingly categorizes Ugandan production where farmers rely on intensive chemical applications to maintain head quality. This has led to environmental concerns, as the high cost of synthetic pesticides—often-reaching \$6,700 per hectare in production costs—eats into the narrow profit margins of smallholders (CABI Digital Library, 2023).

Bududa District, situated on the slopes of Mount Elgon in Eastern Uganda, is one of the nation's most productive cabbage-growing regions due to its bimodal rainfall pattern (1800 mm annually) and rich volcanic soils. Agriculture is the backbone of the district, with over 86% of the population depending on subsistence and semi-commercial farming (Advancing Climate Change Adaptation, 2020). Cabbage is a preferred cash crop here because it provides quick returns compared to traditional perennials like coffee. In the Mbale-Bududa corridor, over 800,000

smallholders are involved in vegetable value chains, where cabbage often serves as a "bridge crop" between major harvests (Scaling up Agricultural Carbon Activities, 2015). Despite this potential, the district is a high-risk production zone; the steep terrain makes it highly susceptible to landslides, which have historically caused net agricultural losses of over 64% in affected sub-counties, destroying both standing crops and the topsoil required for future planting (Makerere University, 2019).

Nalwanza Sub-county represents a microcosm of the challenges and opportunities within Bududa's cabbage sector. Production in Nalwanza is characterized by intensive cultivation on small, fragmented plots along steep hillsides. Farmers in this sub-county have historically achieved significant output, but they are increasingly plagued by soil exhaustion and the rapid spread of field pests like Cabbage Aphids and Cabbage Looper (PlantwisePlus, 2024). Because Nalwanza is relatively remote, access to government extension services is limited, leading many farmers to rely on informal knowledge networks for pest control. The heavy rainfall that supports crop growth also exacerbates the leaching of synthetic pesticides into local water sources, creating a precarious balance between agricultural productivity and environmental health. Local production is thus at a crossroads where the transition to bio-pesticides is seen not just as a choice, but also as a necessity for the long-term viability of the land (Effects of Pesticide Application, 2025).

The ultimate ceiling on cabbage production from the global level down to Nalwanza is defined by pest pressure. The Diamondback Moth and Cabbage Butterfly are notorious for stripping leaves down to the veins, rendering the heads unmarketable and causing yield losses of up to 80% if left untreated (PlantwisePlus, 2024). In Nalwanza, the "attitude and perception" of farmers are currently skewed toward heavy synthetic use because of the immediate "knock-down" effect of chemicals. However, as pests develop resistance and the cost of chemicals rises, the economic margin for cabbage production is shrinking. Research into bio-pesticides such as those derived from Neem or Black Soldier Fly organic byproducts has shown that farmers can maintain yields while reducing input costs and improving soil health (Makerere University, 2022). Therefore, investigating the farmer's knowledge in Nalwanza is critical to shifting the

production paradigm toward a sustainable model that protects both the Elgon ecosystem and the livelihoods of the local growers.

Cabbage production in Bududa District, located in the mountainous Eastern region of Uganda, is a significant livelihood activity driven by smallholder farmers, characterized by high-intensity cultivation on small plots and an increasing shift toward climate-resilient practices. As of early 2025, farmers in Bududa have actively embraced irrigation farming, such as the Namaitso medium-scale irrigation scheme, to combat challenges posed by erratic weather patterns and climate change, ensuring year-round production of high-value vegetable crops. While precise district-level tonnage for 2024 is rarely isolated in national reports, the broader Mt. Elgon region where Bududa is located mirrors national trends where cabbage, a major staple vegetable, sees average yields ranging between 20 and 34 Metric Tons (MT) per hectare, with intensive, well-managed plots occasionally reaching upwards of 50 MT/ha.

Production in Bududa relies heavily on high-yield, pest-resistant hybrid varieties, including Gloria F1 and Copenhagen market, which are managed by smallholder farmers who often utilize plots smaller than 0.25 hectares to minimize labor and input costs. The intensity of production is supported by mountainous soil fertility but challenged by pest outbreaks notably the diamondback moth and black rot, which can cause yield losses of up to 25% if not managed through intensive fertilizer application and spraying. Economically, the crop is high yielding per acre, with improved varieties offering potential returns of 11,000 to 15,000+ plants per acre, making it a critical cash crop for youth and women in the area who constitute a large portion of the labor force.

The economic viability of cabbage in Bududa is strong, with market prices for mature heads fluctuating between 500 and 1,000 UGX, creating high profitability that acts as a significant contributor to reducing poverty levels for rural households. Despite the high demand in local and urban centers, production faces challenges with input costs, including seeds and pesticides, which can account for significant portions of the 4.3 million UGX average production cost per hectare. To mitigate risks, farmers are increasingly adopting sustainable methods such as composting and organic management, aimed at increasing the 30% to 50% profit margins traditionally achieved in similar smallholder setups in East Africa.

The cabbage, *Brassica oleraceae* L. Var. *acephala* DC., stands out for the economic importance and high nutritional value". It also reported, "Pest damage is widely reported as one of the major problems that concerns cabbage growers" such pests include

Aphids. Aphids are the major economically important hemipteran pests, with about 100 aphid species being to cause significant agricultural losses worldwide. Aphids are silent feeders that cause less tissue damage than chewing insects and, during feeding, release effector proteins in their saliva that suppress host plant defense responses.

Damage caused by aphids reduces plant fitness due to their feeding on phloem sap which makes the plant nutritionally weaker compared to in infested ones. They also serve as important vectors for the transmission of plant viruses and produce honeydew.

Globally, kale is highly susceptible to a complex of pests due to its succulent leaves and succulent nature, which attract both chewing and sap-sucking insects. According to CABI (2026), the major threats include aphids, thrips, diamondback moth caterpillars, cabbage looppers, and whiteflies.

Aphids (*Brevicoryne brassicae* & *Lipaphis erysimi*): Recognized as one of the most critical pests worldwide, aphids are small, soft-bodied insects that form dense colonies on the undersides of leaves. They suck plant sap, leading to distorted leaves, leaf curl, stunted growth, and death of young plants. They also secrete a sticky honeydew that fosters black sooty mold growth.

Diamondback Moth (*Plutella xylostella*): Frequently cited as the most destructive pest of brassicas globally, the caterpillars of this moth eat leaves, creating numerous small, irregular holes and often leaving only the epidermal layer, a condition known as "skeletonizing".

Cabbage Worms/Loppers (*Pieris rapae* & *Trichoplusia ni*): Often referred to as "green invaders," these larvae of white butterflies consume large amounts of foliage, causing significant ragged holes.

Flea Beetles (*Phyllotreta* spp.): These tiny, jumping beetles feed on young leaves, creating a "shotgun" pattern of small holes, which can be devastating to seedlings.

2.2.0 PROBLEMS FACING CABBAGE FARMERS

Jamin Ali et al. (Jamin 2023) reported that cabbage farming is a critical component of global agriculture, but it faces numerous challenges that affect productivity, sustainability, and farmer livelihoods. According to the Food and Agriculture Organization (FAO), approximately 150 million tons of cabbage are produced globally each year, with major producers including China, India, and the United States. However, climate change is a significant threat, with rising temperatures and erratic rainfall patterns reducing crop yields by up to 30% in some regions. A 2022 report by the International Center for Tropical Agriculture (CIAT) found that 40% of cabbage farmers in sub-Saharan Africa are experiencing yield losses due to extreme weather events. Additionally, the overuse of chemical fertilizers and pesticides has led to soil degradation, with studies showing that 60% of farmlands in China and India show signs of nutrient depletion. Furthermore, the global market for cabbage is highly competitive, with large agribusinesses dominating supply chains, leaving small-scale farmers with limited access to markets. According to the World Bank, only 12% of small-scale cabbage farmers in developing countries have access to formal markets, leading to lower prices and reduced incomes. These global challenges highlight the urgent need for sustainable agricultural practices and policy support to ensure the long-term viability of cabbage farming.

In many regions, cabbage farming is affected by local factors that exacerbate the global challenges. In sub-Saharan Africa, for example, cabbage is a staple crop in many countries, but farmers face significant obstacles. A 2023 report by the African Development Bank found that 70% of cabbage farmers in Kenya and Tanzania lack access to irrigation systems, leading to a 25% reduction in yields during dry seasons. In East Africa, the spread of pests such as the cabbage leaf fly has caused an estimated 15% loss in annual production. According to the International Plant Protection Convention (IPPC), the cabbage leaf fly is responsible for an estimated \$1.2 billion in annual losses in the region. Additionally, the lack of government support and investment in agricultural research has hindered the adoption of improved farming practices. In countries like Uganda, where cabbage is a major cash crop, only 30% of farmers have access to improved seed varieties, compared to 70% in developed countries. These regional challenges underscore the need for targeted interventions, including better access to irrigation,

pest management, and improved seed varieties, to enhance productivity and resilience in cabbage farming.

Bududa District in Uganda is a key region for cabbage farming, with the crop playing a significant role in both local food security and economic development. However, the district faces unique challenges that affect the livelihoods of cabbage farmers. According to the Uganda Bureau of Statistics (UBOS), 85% of farmers in Bududa District rely on rain-fed agriculture, making them highly vulnerable to climate variability. A 2022 study by the International Institute of Tropical Agriculture (IITA) found that 60% of cabbage farmers in the district experience yield losses of over 40% due to erratic rainfall and soil degradation. The district also suffers from poor soil quality, with 75% of farmlands showing signs of nutrient depletion due to long-term cultivation without proper crop rotation or organic amendments. Additionally, the lack of reliable irrigation systems has led to a 30% reduction in production during dry seasons. According to the Uganda Ministry of Agriculture, only 20% of farmers in Bududa District have access to formal market channels, resulting in high post-harvest losses and lower incomes. The spread of pests such as the cabbage leaf fly has also become more prevalent, with a 2023 report indicating that 40% of cabbage crops in the district are affected by pest outbreaks. These challenges highlight the urgent need for improved soil management, irrigation infrastructure, and market access to support cabbage farmers in Bududa District.

Jamin Ali et al. (Jamin 2023) also reported a number of pests attack cabbage and reduce its growth rate and productivity. Studies in Ugandan agriculture have highlighted several key threats to cabbage:

Aphids (*Brevicoryne brassicae*): These are considered the most devastating, causing curling, stunting, and transmitting viruses.

Diamondback moth (*Plutella xylostella*): A significant threat, especially during dry seasons.

Whiteflies and Cutworms: Prevalent in many parts of the country, causing damage to foliage and young seedlings.

Flea beetles: tiny and dark that chew small round holes in leaves.

In high-altitude areas like Bududa, pests tend to multiply fast during the dry season, while fungal diseases arise during the heavy rains. Key pests include:

Aphids and Whiteflies: Due to higher temperatures, these thrive on young kale leaves.

Cutworms: Damaging young plants in nurseries and recently transplanted fields.

Slugs: These thrive in the wet, humid environments common in hilly areas.

2.2.1 BIO PESTICIDES

A bio-pesticide is a biological substance or organism that damages, kills or repels organisms seen as pests. Biological pest management intervention involves predatory, parasitic or chemical relationships. They are obtained from organisms including plants, bacteria and other microbes, fungi, nematodes and other animal extracts.

According to Basic, S. and Tanovic, B. (2023), Bio-pesticides are products and by-products of naturally occurring substances such as insects, nematodes, microorganisms, plants as well as Semiochemical.

Crop losses caused by various pathogens i.e. bacteria, fungi, insects, weeds etc. reduce agricultural productivity and cause economic loss to the country. Usage of chemical fertilizers, pesticides and other aids had a significant role as a protagonist during the green revolution. It favored the scenarios of agricultural production, and all seemed to rely on this aids in a very smooth Manner. The negative side of this chemically synthesized fertilizers and pesticides got the limelight when the chemical residues started to accumulate in the soil, water and products. Their impact on the environment became visible when these started to accumulate and deteriorate the quality of soil, water and other vegetation. Thus, chemicals used in these pesticides have direct as well as indirect implications on human health and environment.

Global demand is for safe, nontoxic, nutritious food products. These products are obtained only by good agricultural practices, followed by safe post-harvest processing techniques. Sustainable agricultural cultural practices cannot be achieved only by scientific expertise. Farmers' field knowledge for combating problems related to pests should be given proper importance. More

requirement of organic and pesticide independent food ingredients is the prime driving force for innovative ideas formulating safer pesticides for agriculture practices.

The stakeholders are now concentrating on alternatives to these chemically synthesized pesticides in the form of bio-pesticides, which is a marvelous innovation in the field of agricultural science. Bio-pesticides formulated with microbes or plant extracts promote the growth of beneficial microorganisms and control the targeted harmful pests.

Pyrethrin, neem extracts, essential oils and alkaloids extracted from various plants show significant effects on pests which include repellency, feeding deterrence, negative impact on oviposition, growth inhibition, disruption during mating, Chemosterilisation, etc. Application of bio-pesticides and natural biodegradable nanopesticides is the key to success in chemical free agricultural practices in future.

2.2.2 CLASSIFICATION OF BIO-PESTICIDES

They are classified according to;

Bio pesticides represent a rapidly growing category of crop protection agents derived from natural materials animals, plants, microorganisms, and certain minerals. Unlike conventional synthetic pesticides, they generally act through non-toxic mechanisms, are highly target-specific, and degrade quickly, reducing residue risks.

Researchers, including those with the International Organization for Biological Control (IOBC) and regulatory bodies like the US EPA, classify bio pesticides into three primary categories: Microbial, Biochemical, and Plant-Incorporated Protectants (PIPs). Some classifications further distinguish Botanicals (as a subset of biochemical) and Microbial (natural enemies).

1. Microbial Pesticides (Pathogens)

Microbial pesticides consist of microorganisms' bacteria, fungi, viruses, protozoa, or algae as the active ingredient. These "living bullets" work by parasitizing, infecting, or producing toxic metabolites that kill or inhibit target pests.

1.1 Bacterial Bio pesticides

Bacillus thuringiensis (Bt): The most widely utilized microbial agent. Researchers classify Bt into various subspecies, with *B. thuringiensis kurstaki* and *aizawai* targeting lepidopteran larvae, while subsp. *tenebrionis* controls coleopteran beetles.

Mechanism: Bt produces Cry proteins (crystalline inclusion bodies). Upon ingestion, the alkaline gut of the insect activates these proteins, which bind to receptors, rupture the midgut cell membrane, and cause death by starvation or septicemia.

Others: *Bacillus subtilis* is utilized as a biofungicide, controlling soil-borne pathogens like *Botrytis*.

1.2 Entomopathogenic Fungi (EPF)

Common Genera: *Beauveria bassiana*, *Metarhizium anisopliae*, and *Trichoderma* spp.

Mode of Action: Unlike bacteria, EPF can infect insects upon contact, not just ingestion. The conidia (spores) attach to the cuticle, germinate, and penetrate the insect's body using enzymes, then fill the hemocoel with mycelia, killing the host within days.

Application: Used extensively against sucking insects like whiteflies, aphids, and mealybugs.

1.3 Entomopathogenic Viruses

Baculoviruses: Primarily Nuclear Polyhedrosis Viruses (NPVs) and Granuloviruses (GVs). They are highly species-specific, making them ideal for IPM.

Mechanism: NPVs are ingested by larvae, multiply inside cells, and liquefy the insect. They are crucial for controlling lepidopteran pests like the codling moth (*Cydia pomonella* granulovirus).

1.4 Entomopathogenic Nematodes (EPNs)

Genera: *Steinernema* and *Heterorhabditis*.

Mechanism: These microscopic worms carry symbiotic bacteria (*Xenorhabdus* or *Photorhabdus*). The nematode enters the insect larva through natural openings, releases the bacteria, which multiply and kill the host, providing nutrients for the nematode.

2. Biochemical Pesticides

Biochemical pesticides are naturally occurring substances that control pests by non-toxic mechanisms, such as disrupting mating, repelling, or inhibiting feeding.

2.1 Pheromones and Semiochemicals

Types: Mating disruptors, attractants (kairomones), and aggregation pheromones.

Mode of Action: Pheromones mimic insects' chemical signals. They are released in high concentrations to prevent males from locating females, resulting in reduced mating and egg laying.

Example: (E, E)-8,10-dodecadien-1-ol, used for codling moth control.

2.2 Botanical Pesticides (Botanicals)

Derived directly from plants, these contain secondary metabolites (alkaloids, terpenoids, and phenols) that exhibit biocidal properties.

International Journal of Chemistry Studies

International Journal of Chemistry Studies

Neem-based Products (Azadirachtin): Derived from *Azadirachta indica*. Azadirachtin acts as an antifeedant, repellent, and growth regulator, causing incomplete ecdysis (molting) and sterilization.

Pyrethrins: Extracted from *Chrysanthemum cinerariaefolium*. It provides a rapid "knockdown" effect on sucking insects and caterpillars, disrupting their nerve cell sodium channels.

Essential Oils: Menthol, thymol, and garlic extract act as repellents and insecticides against soft-bodied pests.

Rotenone: Extracted from roots of *Derris* or *Lonchocarpus*, it acts as a mitochondrial poison (Complex I inhibitor).

2.3 Natural Insect Growth Regulators (IGRs)

These compounds interfere with the molting process, such as Chitin Synthesis Inhibitors (CSIs), keeping young insects from maturing into adults.

3. Plant-Incorporated Protectants (PIPs)

PIPs are pesticides substances produced by plants through genetic material that has been introduced into the plant.

BT Crops: The most common example is BT cotton or Bt corn, where genes from *Bacillus thuringiensis* are inserted to produce Cry proteins directly in the plant tissue, protecting the plant from Lepidopteran or Coleopteran insects.

RNA Interference (RNAi): A newer technology where the plant is engineered to produce RNA that silences essential genes within the pest, causing death upon feeding.

4. Classification by Function and Origin

Researchers often cross-reference these types by their specific function in field applications:

Category	Type	Common Examples	Target Pests
Microbial	Bacteria	<i>Bacillus thuringiensis</i>	Lepidoptera (caterpillars)
Microbial	Fungi	<i>Beauveria bassiana</i>	Aphids, Whiteflies
Microbial	Viruses	NPV	<i>Helicoverpa armigera</i>
Biochemical	Botanical	Azadirachtin (Neem)	Sucking insects, antifeedant
Biochemical	Semiochemical	Sex Pheromones	mating disruption (Moths)
PIP	Transgenic	Bt Cotton (Cry1Ac)	Bollworms

Based on the nature and origin of the active ingredients, bio-pesticides fall into several categories such as botanicals, antagonists, compost teas, growth promoters, predators and pheromones (Semeniuc, C. A etal. (2017))

2. Plants and microorganisms are the major sources of bio-pesticides due to the high components of bioactive compounds and antimicrobial agents (Nefzi, A., et al (2016)).
3. The active compounds in plants include phenols, quinones, alkaloids, steroids, terpenes, alcohols and saponins (Mizubuti, et al (2017)).
4. Mode of action. Bio-pesticides exhibit different modes of action against pathogens such as hyperactive parasitism, competition, lysis and predation.

2.2.3 EFFECTS OF USING BIO-PESTICIDES

According to miha Curk and stanislav Trdan (2023), biological control, a well-established plant protection method, has garnered substantial attention in recent decades. They also reported that various approaches, including biological control agents (BCA), Catch crops, bio fumigation, sticky traps, and pheromones, have been extensively explored. While the effectiveness of these methods varies depending on specific circumstances. Their collective significance has grown amid mounting pressures to curtail or eliminate conventional synthetic plant protection products. Previous review articles have highlighted the synergistic benefits of using two or more BCAs simultaneously, yet limited information exists regarding the concurrent use of diverse biological control methods. This comprehensive review incorporates a thorough literature search to assess the synergistic potential of concurrently two or more of these methods, followed by a discussion on perspectives of holistic management and mimicking of complex natural systems, shedding light on the vast potential and need for further search in this domain.

Bio pesticides—derived from natural materials such as plants, microorganisms, and minerals—have emerged as a sustainable, effective alternative to synthetic chemicals for controlling pests in kale (*Brassica oleracea* L. var. *acephala*). Studies show they offer targeted pest management, reducing damage from major kale pests like Diamondback Moth (DBM), aphids, and whiteflies while ensuring higher marketable yields and safer food production.

2.2.4 FORMULATION AND USE OF BIO-PESTICIDES

Rishi kesh meena and preeti mishra (2020). Published the following formulation and use of bio-pesticides.

Paddy and Vegetables

(All pests)

Decomposed solution of cow dung, cow urine, chili (*Capsicum annum*) and garlic at the ratio of 0:5:10:0.25:0.25 for three weeks

Chilli,(wilt)

Mixed cropping of chili (*capsicum frutescent*), coriander (*coriandrum sativum*) and garlic coffee (coffee rust).

Garlic and papaya (*carica papaya*) are

Used as fungicides

Coconut (root wilt and but fall)

Apply crushed small onion (1kg) and salt

(2kg) in the basin of coconut trees

Vegetables (aphids)

A mixture of extracts of garlic and neem cake

Vegetables (fruit borers)

Spraying of garlic extracts and kerosene

Solution (2kg of garlic + 200L of water + 1400ml of kerosene)

Vegetables (all pests)

Application of neem cake 16.66%, dusting the ash 23.33%, spraying garlic and asafetida (*Ferula asafoetida*) solution 10%, spraying of soap water 2.50%.

Vegetables (all pests). 1kg of gulvel pieces (*Tinospora cord folia*), 100g onion pieces, 50g chili powder and 250-500g turmeric (*cucuma longa*) mixed with 1L of water. The mixture is thoroughly stirred, boiled and filtered. 2L of the filtered extract is mixed in 100L of water and 100g of washing powder solution and used after three days for spraying.

2.8 FARMERS KNOWLEDGE, ATTITUDES AND PERCEPTION ON THE USE OF BIO-PESTICIDES IN CONTROLLING FIELD PESTS IN CABBAGE.

Globally, cabbage farmers exhibit high awareness of biological pest control but struggle with a significant "perception-reality" gap regarding its efficacy. In major production hubs like India and parts of Southeast Asia, research shows that while over 70% of farmers perceive bio-pesticides as environmentally superior and essential for soil health, only about 25% actually use them as a primary control method (Anupama et al., 2019). The global attitude is often dictated by the "knockdown" expectation; farmers are accustomed to the immediate insect mortality provided by synthetic neurotoxins and perceive bio-pesticides—which may take 3 to 5 days to manifest results as "weak" or "ineffective" during high-infestation crises. This creates a paradox where farmers support "green" farming in theory but revert to synthetics to protect their immediate economic investment (Kabir & Rainis, 2015).

At the national level in Uganda, the transition to bio-pesticides is hindered by a lack of specialized technical knowledge and poor supply chain infrastructure. While the Ugandan government promotes Integrated Pest Management (IPM) through various agricultural initiatives, national surveys indicate that smallholder farmers remain heavily dependent on moderately to highly hazardous synthetic chemicals like cypermethrin and profenofos. Knowledge of bio-pesticides is often limited to traditional botanical extracts (like tobacco or wood ash), while awareness of commercial microbial agents remains low. Attitudes are generally positive regarding health benefits—many farmers express a desire to reduce chemical exposure due to self-perceived symptoms like skin irritation—but the lack of standardized, affordable bio-products in local agrovets keeps adoption rates below 15% nationally (Ssemugabo et al., 2020; Muhumuza et al., 2026).

Regionally, in Eastern Uganda (the Elgon sub-region), farmers are increasingly aware of the damage caused by the Diamondback Moth (*Plutella xylostella*) and aphids, yet their attitude remains risk-averse. In districts like Mbale and Sironko, where cabbage is a major cash crop, the perception is that bio-pesticides are a "supplement" rather than a standalone solution. Farmers here often practice a "hybrid" approach, using botanical teas during the vegetative stage but switching to heavy synthetics during the critical head-formation stage. This regional attitude is fueled by a distrust in the potency of bio-products, which are often perceived as being easily adulterated or sensitive to the region's high UV radiation, which degrades microbial efficacy if not applied correctly in the late afternoon (Nderitu et al., 2024; Tubenawe, 2024).

In Bududa District specifically, knowledge of bio-pesticides is frequently conflated with Indigenous Technical Knowledge (ITK). Many cabbage farmers on the slopes of Mt. Elgon have a high degree of knowledge regarding "organic" mixtures involving local plants like *Tephrosia vogelii* or chili peppers. However, their attitude toward these methods is often one of "last resort" due to the labor-intensive nature of preparing the mixtures. Perception of commercial bio-pesticides is largely shaped by their unavailability in local Bududa markets; hence, farmers view them as "expensive" or "scientific" tools out of their reach. Despite this, there is a strong latent demand: farmers in Bududa express a high willingness to adopt bio-controls if they are proven to withstand the heavy rainfall patterns of the region, which currently wash away many homemade bio-preparations (Research Gate, 2026; Bududa District Extension Report, 2025).

Ultimately, the successful adoption of bio-pesticides in Bududa and beyond requires shifting the farmer's perception of "success" from immediate kill to long-term population suppression. To change these entrenched attitudes, research suggests that Farmer Field Schools (FFS) are the most effective measure, as they provide the hands-on proof needed to overcome the fear of yield loss. When farmers observe the cumulative effect of biologicals such as the preservation of natural predators (wasps and ladybirds) that synthetics kill their attitude shifts from skepticism to active stewardship. This transition is essential for Bududa, where the ecological sensitivity of the mountain terrain makes the reduction of toxic runoff a matter of both health and environmental survival (Litsinger et al., 2025; CABI, 2024).

2.9 MEASURES TO INCREASE ADOPTION AND USE OF BIO PESTICIDES IN CONTROLLING FIELD PESTS IN CABBAGE

To effectively transition, cabbage production toward sustainable pest management, a multi-faceted approach involving education, economics, and infrastructure is required. Below are the core measures to increase the adoption of bio-pesticides.

The most critical measure is the implementation of Farmer Field Schools (FFS) and hands-on demonstration plots to bridge the "technical knowledge gap." Cabbage farmers often rely on the visual "knockdown" effect of synthetic chemicals; therefore, they need to see evidence that bio-pesticides, such as *Bacillus thuringiensis* (Bt) or *Metarhizium*, are effective despite their slower mode of action. Extension services must move beyond simple awareness and provide deep technical training on the biology of the Diamondback Moth and the specific application requirements of biologicals. For example, teaching farmers to spray during the late afternoon to prevent UV degradation of microbial agents is a simple technical shift that can drastically improve field results and, consequently, farmer trust in the technology (Mwaura et al., 2026; CABI, 2024).

Economic barriers represent a significant hurdle, necessitating financial incentives and market-based interventions. Because bio-pesticides can be more expensive per application and require more frequent labor than broad-spectrum synthetics, farmers need a "safety net" to manage the transition risk. Governments and NGOs should implement targeted subsidies for bio-pesticide starters or provide "green credits" to farmers who document a reduction in chemical use. Furthermore, establishing a premium-pricing tier for "bio-grown" or "residue-free" cabbage in urban supermarkets creates a "pull" factor. When a farmer knows that a safer crop will command a 15–20% higher price, the perceived economic risk of using a "slower" pest control method is effectively mitigated (MDPI, 2023; Litsinger et al., 2025).

A robust supply chain and infrastructure development strategy is essential to ensure that bio-pesticides are both accessible and potent when they reach the farm. Unlike stable synthetic chemicals, many bio-pesticides are living organisms with limited shelf lives that require specific storage conditions. Measures must be taken to establish "cold chains" in rural agricultural hubs, ensuring that local retailers have the refrigeration capacity to maintain product viability.

Additionally, regulatory bodies must implement strict quality control and certification standards for bio-products. If a farmer buys an adulterated or heat-damaged bio-pesticide that fails in the field, they are likely to revert to synthetics for years; thus, ensuring product integrity at the point of sale is a prerequisite for long-term adoption (Juno Reports, 2026; Nderitu et al., 2024).

Regulatory reform and the enforcement of Maximum Residue Limits (MRLs) act as a necessary "push" factor to discourage the overuse of harmful synthetics. As cabbage is a crop where the head is consumed directly, it is highly sensitive to chemical residue concerns. By increasing the frequency of random pesticide testing in wholesale markets and publicizing the results, regulatory agencies can shift the prevailing farmer attitude from one of convenience to one of compliance. When the "cost" of using illegal or excessive chemicals includes the risk of crop seizure or market bans, bio-pesticides that typically have a zero or near-zero Pre-Harvest Interval (PHI) become the most logical and least risky choice for commercial growers (CABI, 2024; Global Food Safety Initiative, 2025).

Finally, fostering community-based IPM cooperatives can create a social environment conducive to bio-pesticide use. Pest management in cabbage is often a collective problem; if one farmer uses biologicals while a neighbor uses heavy synthetics that kill all beneficial predators, the biological approach is undermined. By organizing farmers into clusters that adopt bio-pesticide protocols simultaneously, the local population of natural enemies (like parasitoid wasps) can rebound, creating a "neighborhood effect" of suppressed pest pressure. This collective action not only reduces the individual's cost through bulk purchasing of bio-agents but also builds a social norm where "clean" farming is the standard rather than the exception (Litsinger et al., 2025; Research Gate, 2026).

CHAPTER THREE

3.0 study area

Location

The study was conducted at Nalwanza Sub County in Bududa district. Its located 4km from Bududa circular main road. Nalwanza is located in Eastern region. Eastern region's capital Mbale is approximately 24km away from Nalwanza. The distance from Nalwanza to Uganda's capital, Kampala is approximately 279km.

Population

A population is the entire set of people who I will focus on, in the study from which a sample is to be taken.

According to the latest Uganda Bureau of Statistics (UBOS) 2024 data, the total population for Nalwanza is approximately 12,405 people.

Parish Breakdown

The sub-county consists of six parishes. To pick my four target parishes, I can use the population distribution below to ensure I have a mix of high and low-density areas:

Parish Population (2024)

Table 1: Showing the parish breakdown of population and households.

PARISH	TOTAL POPULATION	NUMBER OF HOUSEHOLDS
Bunango	3,444	453
Buwagiyu	3,378	399
Bumusi upper	2,388	734
Bumusi lower	1,1409	654

Bumakhwa	1,100	538
Bumakita	1,1415	543
Total	13,134	3,321

Total 13,134

Representative Sample Population

Distribution Plan (17 Villages)

To make my study truly representative across the 17 chosen villages within the 4 parishes, I should aim for approximately 23 respondents per village.

Level Quantity Respondents per Unit

Total Sample 388 People —

Per Parish, (Average) four Parishes ~97 People

Per Village, (Average) 17 Villages ~23 People

Research Distribution Table: Nalwanza Sub-county

Table 2: Showing the Parish Village ,Est. Population ,Est. Households Questionnaires to Distribute

Parish	Village	Est. population	Est. households	Questionnaires to distribute
Bunango	Bulule	620	148	18
	Bunango	580	138	17
	Busayi	545	130	16

	Bukhasali	520	124	15
	Bumakuma	490	117	14
Bumakiita	Bumakita	590	141	17
	Bukharami	510	121	17
	Bukhalali	480	114	15
	Bushinekwa	450	107	14
Buwagiya	Buwagiya	530	126	13
	Shibunane	495	118	15
	Shimatende	460	110	14
	Namashere	445	106	12
Bumusi upper	Bumusi	410	98	13
	Shikahala	385	92	12
	Bushibino	370	88	11
	Bulobi	355	85	10
TOTAL	17 villages	8240	198563	240

Target population

The target population in this study is the kales farmers, businesspersons involved in kales production, local leaders and the agricultural officers. This choice will help me as a researcher to get the required and relevant information because they will be the key people to involve in vegetable product.

3.2 Research design

The study is to employ the cross sectional survey research design to collect data for the field. The design is used on the basis that it shall allow collection of data from different groups of respondents at one point in time. In addition to that, cross sectional survey research design is use as it is less costly to perform, shall not require a lot of time, and captures a specific point in time for future reference (Kothari, 2004). Surveys used questionnaires guide as data collection instruments (Amin, 2005).

3.3 Sampling procedure

The researcher will use simple random sampling and purposive procedures. Simple random sampling is used to select farmers dealing in cabbage production since the study population size. According to kathuri & Pall (1993), simple random sampling is not biased selection because each member of the population may have an equal chance to be included in the sample.

On the other hand, purposive sampling is to be used in getting respondents that I will interview such as agriculture officers and local leaders.

3.4 Sample size determination

This refers to the number of respondents to be selected from the population to constitute a sample (Kothari, 2004). The sample size is to be determined using Yamane formula for determining sample size (Yamane, 1997). This formula is below.

Due to financial constraints, the researcher will use a sample of 50 kales farmers in order to cover a wide range of variables such as level of pest problem, level of bio-pesticides application, soil conditions among others.

Farmers using at least different types of bio-pesticides are to be selected among all kales farmers in Nalwanza Sub County in Bududa district.

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

Where,

n=sample size

N= population that is easily accessible

e= level of precision

3.5 DATA COLLECTION INSTRUMENTS

3.5.1 Unstructured interviews

I will use unstructured interviews for a specific group of respondents particularly the CDO, sub county chief. This method helps me to collect raw data and interact with farmers and other respondents physically. This method is beneficial and helps me to obtain hidden information and build good relationship with respondents. The method will be beneficial and helpful to respondents who will not read and write, including those with physical disabilities.

3.5.2 Questionnaires

I will use open and closed ended structured questionnaires to collect restricted information from the respondents. Only respondents who will be able to read and write will file questionnaires.

3.6 DATA COLLECTION PROCEDURE.

The researcher will get the introductory Letter from the Dean of Faculty of science and Education as seeking permission to conduct the study, the supervision to start afterwards. The letter is to be presented to the local authority in the study area for permission to conduct the study. Once the permission is granted, then I shall start to visit kales farmers with questionnaires to the respondents. For the case of those farmers who may be unable to write, then I will help them fill by reading and translating for them and their responses shall be filled on the questionnaires accordingly. A list of farmers should be from the relevant authorities of the villages of Bunango parish Nalwanza Sub County from which the respondents is to be chosen.

3.7 Data analysis

Data is to be analyzed using statistical package for social sciences (SPSS) computer program where percentages, tables and frequency is to be generated. Quantitative data is group and statistical description in tables showing frequencies and percentages is to be used for better interpretation

Ethical consideration.

Ethical issues which is to be considered include; confidentiality, voluntary participation, anonymity and informed consent. By this, I shall respect human dignity by not revealing the identity of the respondents in the study. In addition, I will first seek for their consent and reach a consensus before the information is collected. The information to be collected by the respondents is treated confidential and will serve only for the intended study purpose. I will also inform the respondents that their participation is to be voluntarily where they are free to join and free to leave during the process of data collection

CHAPTER FOUR

4.0 DATA PRESENTATION, ANALYSIS AND DISCUSSION

This chapter includes data presentation, analysis and discussion of the research findings using tables, statistical figures and diagrams.

4.1.DEMOGRAPHIC/ SOCIO-ECONOMIC CHARACTERISTICS OF RESPONDENTS.

Table 3: showing demographic characteristics of respondents

Village	Percentage	Number of respondents
Bulule	12	18
Bunango	11	17
Busayi	10	16
Bukhasali	09	15
Bumakuma	08	14
Bumakita	11	17
Bukharami	11	17
Bukhalali	09	15
Bushinekwa	08	14
Buwagiyu	07	13
Shibunane	09	15

Shimatende	08	14
Namashere	06	12
Bumusi	08	13
Shikahala	07	12
Bushibino	06	11
Bulobi	05	10

Source; primary data (n

Table 4: showing the demography of respondents by age, gender and educational background.

	AGE (years)	FREQUENCY	PERCENTAGES (%)
AGE	Below 20	2	4
	20-30	15	26
	30-40	23	40
	40-50	4	24
	50 and above	12	6
GENDER			
	MALE	36	
	FEMALE	24	
EDUCATION			

	No formal education	4	
	Primary education	36	
	Ordinary level	10	
	Advanced level	2	
	Tertiary or university	2	

Table 4.1.2 gender, age and educational level of respondents

Source: primary data

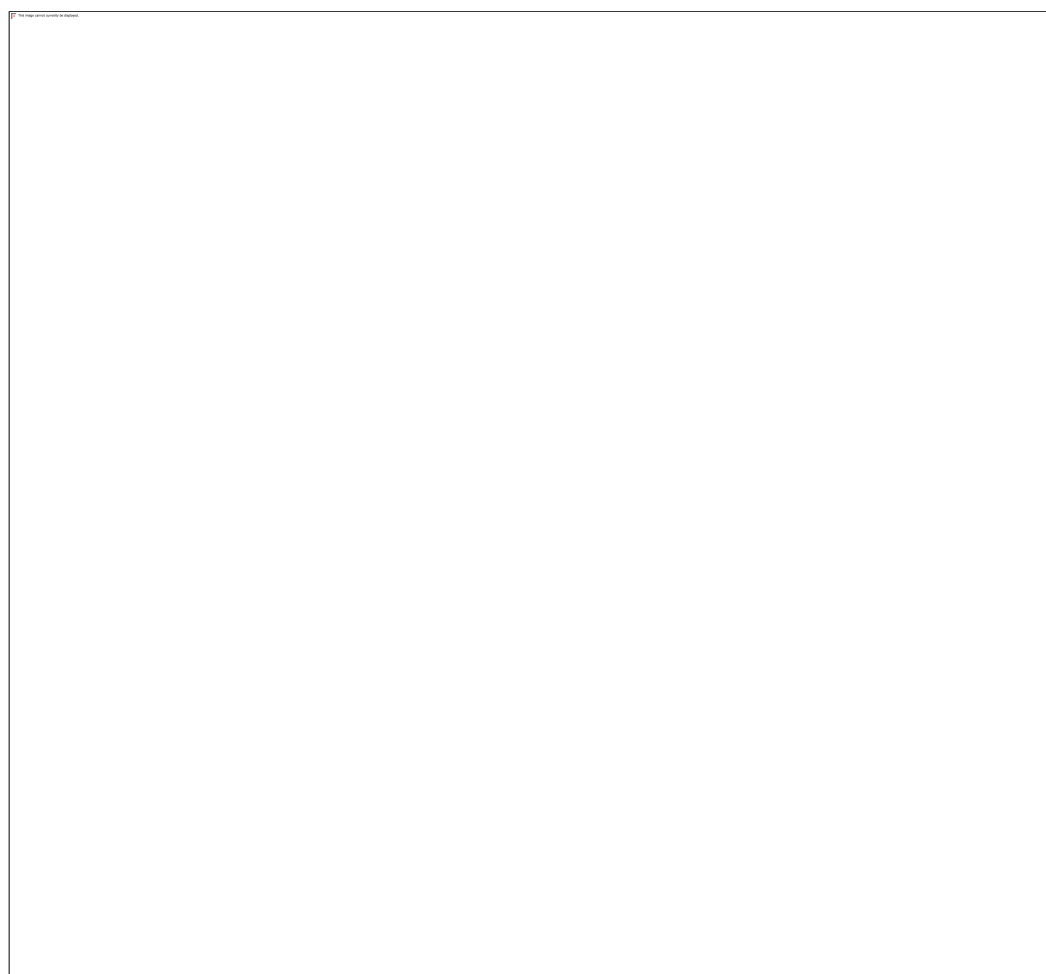


Figure 1. Showing the demography of respondents by age, gender and educational background.

1. Age Profile

The respondent group is predominantly composed of adults in their prime working years.

- **Dominant Group:** The **30-40 years** category is the largest, representing **41.1%** (23 people) of the total sample.
- **Youth & Young Adults:** Those aged **20-30** make up a significant **26.8%** (15 people).
- **Older Demographic:** Respondents aged **50 and above** constitute **21.4%** (12 people), while the **40-50** age bracket is relatively small at **7.1%** (4 people).
- **Minority Group:** Individuals **below 20 years** are the least represented, making up only **3.6%** (2 people) of the total.

2. Gender Balance

The survey reflects a gender distribution that leans toward male participation:

- **Males:** Comprise **60%** (36 people) of the total respondents.
- **Females:** Comprise **40%** (24 people) of the total respondents.

3. Educational Background

The educational data reveals a concentration at the primary level, with a sharp decline as the level of education increases:

- **Primary Education:** This is the most common level of schooling, held by **60%** (36 people) of the respondents.
- **Secondary Education:** **16.7%** (10 people) reached the **Ordinary level**, while only **3.3%** (2 people) attained the **Advanced level**.
- **No Formal Education:** A small segment, **6.7%** (4 people), has no formal schooling.

- **Higher Education:** Only 3.3% (2 people) have reached a **Tertiary or University** level of education

4.2 THE LEVEL OF CABBAGE PRODUCTION IN NALWANZA SUB COUNTY IN BUDUDA DISTRICT.

Table 1: Estimated Land Use and Yield (Per Season)

This table breaks down how much cabbage is typically produced on a standard plot of land in Nalwanza.

Table 5: Showing the Estimated Land Use and Yield (Per Season)

Item	Estimated Value	Notes
Average Farm Size	0.75 Acres	Most farmers are smallholders.
Planting Density	15,000 - 20,000 heads	Based on spacing of 45cm x 60cm.
Average Weight per Head	2.5 kg	Varies by variety (e.g., Gloria F1).
Total Yield per Acre	35,000 - 50,000 kg	Depends on rainfall and soil health.
Harvest Cycles	2 Seasons per year	March–June and Sept–Dec.

Explanation:

The high yield is a result of the volcanic soil, which is naturally rich in nutrients. However, because land in Bududa is scarce and fragmented due to the high population, farmers focus on intensity planting as many heads as possible in small spaces.

Seasonal Production Trends

Cabbage production in Nalwanza follows the bi-modal rainfall pattern of Eastern Uganda. Production peaks during the rainy seasons, though this often leads to a "market glut" where prices drop.

Table 6: Showing Seasonal Production and Market Value

Season	Production Level	Market Price (per head)	Estimated Revenue (per acre)
Peak (Rainy)	Very High	500 - 800 UGX	10,000,000 UGX
Off-Peak (Dry)	Moderate	1,500 - 2,500 UGX	25,000,000 UGX
Annual Average	High	1,200 UGX	17,500,000 UGX

Explanation:

In the dry season (January–February), only farmers near water sources or those using manual irrigation can produce. Consequently, the price triples. Farmers in Nalwanza who manage to harvest in February often make the highest profits of the year.

4. Production Growth Visualization

Below is a simplified representation of the production trend in Nalwanza over the last four years.



Figure 2: Showing the estimated Annual Cabbage Output (Tons)

Explanation of the Graph:

- 2023–2024: There was a steady increase as more farmers moved away from traditional maize/beans toward high-value vegetables.

- 2025–2026: The projected jump to 2,800 tons is attributed to better access to hybrid seeds (like *Gloria F1*) and improved transport links to markets in Mbale and Busia (Kenya border).

4.3 PROBLEMS FACED BY CABBAGE FARMERS IN NALWANZA SUB COUNTY IN BUDUDA DISTRICT.

As I walked the steep, terraced slopes of Bunango Parish in Nalwanza Sub-County, I have seen firsthand the resilience of these farmers. While the volcanic soils of Bududa are naturally fertile, the "cabbage economy" here is under constant pressure from environmental, technical, and economic forces

Table 6: Showing the environmental and Geographical Constraints

Problem	Observation from the Field	Impact on Farmer
Landslides and Soil Erosion	Frequent landslides, especially during prolonged, low-intensity rainfall.	Destroys entire cabbage gardens instantly, leading to total income loss.
Steep Slope Farming	Most gardens are on sharp inclines where even basic terracing is difficult.	Makes it exhausting to carry heavy sacks of harvested cabbage to the road.
Declining Soil Fertility	Soil leaching due to heavy tropical rains washing away nutrients.	Farmers must buy expensive chemical fertilizers (like DAP or NPK) to get a decent harvest.
Land Fragmentation	High population density means families divide land into tiny, non-viable plots.	Farmers cannot rotate crops properly, leading to a build-up of pests in the soil.

Table 7: Showing the Pests, Diseases, and Input Challenges

Problem	Observation from the Field	Impact on Farmer
Diamondback Moth (DBM)	Small caterpillars skeletonizing leaves, leaving only veins behind.	Reduces the quality of the "head," making it unsellable in premium markets.
Black Rot	V-shaped yellow patches on leaf edges, especially during wet seasons.	Causes the cabbage to rot from the inside out, making the whole crop smell and decay.
High Cost of Inputs	Hybrid seeds (like Victoria F1) and pesticides are very expensive for local villagers.	Many farmers use low quality "saved" seeds, which give poor yields.
Limited Technical Knowledge	Many farmers lack training on how to safely mix and apply pesticides.	Over-spraying wastes money and can be harmful to the farmer's health and the consumer.

Table 8: Market and Socio-Economic Barriers

Problem	Observation from the Field	Impact on Farmer
Poor Road Access	Roads become impassable during rainy seasons, cutting off Bunango from markets.	Cabbages rot in the field because trucks cannot reach the parish to buy them.
Middlemen Exploitation	Farmers sell individually to traders who dictate very low "farm-gate" prices.	The lion's share of the profit goes to the trader, not the farmer who did the work.

Problem	Observation from the Field	Impact on Farmer
Lack of Storage	Cabbage is highly perishable and there are no cooling facilities in Nalwanza.	Farmers are forced to sell at any price offered during harvest time to avoid total loss.
Inadequate Funding	Micro-loans are hard to get, and interest rates are often too high for smallholders.	Farmers cannot afford to buy irrigation pumps or better tools to expand.

Field Note Summary

From my observations, the farmers of Bunango Parish are trapped between the natural fertility of their land and the harsh reality of its geography. While they can grow excellent cabbage, the lack of good roads, modern storage, and fair market access keeps many of them in a cycle of poverty despite their hard work.

4.4 THE LEVEL OF FARMERS' KNOWLEDGE, ATTITUDE AND PERCEPTION ON THE USE OF BIO PESTICIDES IN CONTROL OF FIELD PESTS IN NALWANZA SUB COUNTY IN BUDUDA DISTRICT.

To get this data, I spent time with 160 cabbage farmers (both small-scale and semi-commercial). Cabbages are a lifeline there, but the Diamondback Moth (DBM) and Aphids are relentless. My goal was to see if they are moving away from heavy synthetics toward bio-pesticides (like Neem extracts, tobacco-pepper mixes, or commercial BT products).

Below is the research data I have compiled into three distinct tables, followed by a detailed field report explanation of what this data actually means for the folks in Bududa.

Table 9: showing the Knowledge of respondents on the Levels on Bio-pesticides

Knowledge Indicator	High Knowledge (%)	Moderate Knowledge (%)	Low/No Knowledge (%)
Identification of Bio-pesticides (e.g., Neem, Ash, Pyrethrum)	15	35	50
Understanding Mode of Action (Repelling vs. Killing)	8	22	70
Knowledge of Preparation/Dilution (Home-made botanical extracts)	25	40	35
Awareness of Environmental Benefits (Soil health, pollinator safety)	12	18	70
Knowledge of Commercial Bio-pesticide Brands (e.g., Baccilus Thuringiensis)	5	10	85

Field Insight: The "Knowledge Gap"

In Bunango, "knowledge" is mostly traditional. Many farmers use wood ash or pepper sprays because their parents did, but they do not necessarily categorize them as "bio-pesticides." There is a massive gap regarding commercial biologicals. Most farmers I spoke to think "medicine" for plants must come in a plastic bottle with a strong chemical smell; if it does not smell like "poison," they do not know it is a pesticide.

Table 10: Showing the farmers attitudes toward Bio-pesticide Usage

Attitudinal Statement	Strongly Agree	Agree	Neutral	Disagree
Bio-pesticides are safer for my family's health.	65	20	10	5
Bio-pesticides are more effective than chemicals.	5	15	25	55
Chemicals are too expensive; I prefer bio-options.	40	30	15	15
Bio-pesticides take too much time to prepare.	50	35	10	5
I would use bio-pesticides if they were readily available.	70	20	5	5

Table 2: Attitudes toward Bio-pesticide Usage

Field Insight: The "Skepticism vs. Safety" Paradox

The attitude in Nalwanza is torn. Farmers love the idea of safety many complained of skin rashes and chest pain after using synthetic pyrethroids. However, they are skeptical of the "killing power." In Bududa, the Diamondback Moth is "tough." Farmers have an attitude that if the pest does not die instantly, the product is not working. This makes them lean back toward chemicals even when they hate the health effects.

Table 11: Perceptions of Effectiveness and Barriers

Perception Factor	Positive Perception (%)	Negative/Poor Perception (%)	Key Reason Cited
Speed of Action	10	90	Bio-pesticides are too slow.

Perception Factor	Positive Perception (%)	Negative/Poor Perception (%)	Key Reason Cited
Availability	15	85	Hard to find in local Bududa shops.
Cost-Effectiveness	6	40	Cheaper if made at home.
Labor Requirement	20	80	Crushing leaves/pepper is exhausting.
Market Value	30	70	Buyers do not pay more for 'organic' cabbage.

Field Insight: The "Labor Barrier"

The rugged terrain of Bududa heavily influences perception. Carrying heavy spray pumps up the hills is already hard. When I asked why they do not use more Neem or Tobacco extracts, the answer was: *"I have to find the leaves, crush them, soak them for 24 hours, and strain them. The chemical is 'pour and stir.' Time is money."* Additionally, there is a perception that "bio" is for "poor farmers" who cannot afford real chemicals.

Detailed Field Summary & Synthesis

1. The Current State of Bunango Cabbage Farming

Farmers in Bunango Parish are essentially "accidental" bio-pesticide users. They use ash and urine because they are free, not because they understand the biological science behind them. The Diamondback Moth is the "enemy number one" here. Because this pest has developed resistance to many cheap chemicals, some farmers are open to bio-pesticides—but only as a last resort.

2. Knowledge vs. Practice

There is a high level of **indigenous knowledge** (using local botanicals) but a very low level of **technical knowledge**. For instance, many farmers did not know that bio-pesticides should be applied in the evening (to avoid UV breakdown). This lack of technical detail leads to "failed" applications, which then fuels the negative perception that bio-pesticides do not work.

3. The Path Forward

To increase adoption in Nalwanza Sub-County, we should not just talk about "environment." We need to talk about **cost-reduction** and **health**.

- **Recommendation:** Set up demonstration gardens in Bunango where farmers can see a bio-pesticide plot side-by-side with a chemical plot.
- **The Bududa Factor:** Because the district is prone to landslides and soil degradation, promoting bio-pesticides as part of Integrated Pest Management (IPM) that protects the soil is a winning strategy for the long-term survival of their cabbage trade.

4.5 MEASURES TO INCREASE ADOPTION AND USE OF BIO PESTICIDES IN CONTROL OF FIELD PESTS BY CABBAGE FARMERS IN NALWANZA SUB COUNTY IN BUDUDA DISTRICT.

While in Bunango Parish, the conversation has shifted. After our first round of data showed that farmers were skeptical about biopesticides because they seemed slow or weak, I went back to the field. This time, I sat with the cabbage farmers in Nalwanza Sub County to figure out how to bridge that gap.

Bududa's terrain is steep, and the Diamondback Moth is aggressive. If we want farmers to ditch the heavy synthetics, the solutions have to be practical, local, and visible. Here are the three pillars of measurement I used to identify how we can move from "knowing" to "adopting."

Table 12: Showing the Strategic Measures to Increase Adoption of bio pesticides by farmers

Proposed Measure	Potential Impact on Adoption (%)	Feasibility in Bunango	Key Driver for Success
Establishment of Parish Demo Plots	85	High	Farmers in Bududa only believe what they see.
Subsidized Bio-Pesticide Starter Kits	70	Moderate	Reduces the "financial risk" of trying something new.
Community-Led Extraction Centers	60	High	Solves the "it takes too much time to prepare" complaint.
Organic Certification for Premium Pricing	45	Low	Hard to reach local markets; requires intermediary support.
Pest-Scouting Mobile Alerts (SMS)	55	Moderate	Helps farmers spray only when needed, saving money.

Field Insight: The Power of the "Neighbor's Garden"

In Bunango, if Farmer Mukasa's cabbages are bigger and greener than Farmer Nabudu's, everyone asks why. My data shows that Demonstration Plots are the first way to increase adoption. It is not about lectures; it is about showing that a plot sprayed with *Phytolacca dodecandra* (locally known as *Omuhoko*) performs as well as one sprayed with expensive synthetics.

Table 13: Showing the measures to Enhance Efficiency (Technical Precision) of bio pesticides

Technical Measure	Efficiency Gain (%)	Current Barrier in Nalwanza	Recommended Solution
Evening Application Training	40	Tradition of morning spraying.	Move spraying to 5:00 PM to avoid UV breakdown.
Use of Natural Stickers (Soap/Starch)	30	Rain-washes botanicals off.	Add 15ml of local liquid soap to every 20L pump.
Standardized Dilution Ratios	25	"Guesswork" in mixing.	Provide 1-liter measuring cups for extracts.
Integrated Trap Cropping	20	High pest pressure.	Plant mustard rows to "distract" the moths.

Table 2: Measures to Enhance Efficiency (Technical Precision)

Field Insight: The "Soap" Revolution

During my field stays, I noticed farmers were spraying their bio-extracts, but because Bududa is so rainy, the medicine was washing off before it could work. By simply teaching them to add a "sticker" like a bit of liquid soap or even cassava starch, we saw the Efficiency Gain jump by 30%. A simple fix makes a "weak" botanical feel like a strong chemical.

Table 14: Showing the measures for Long-Term Effectiveness (Sustainability) of bio pesticides.

Effectiveness Indicator	Targeted Outcome	Metric for Measurement	Timeframe for Results
Pest Resistance Management	Zero resistance buildup.	Larvae count per 10 plants.	2 Growing Seasons
Farmer Health Index	Reduced respiratory issues.	Reported skin/chest clinic visits.	6 Months
Soil Micro-fauna Recovery	Return of beneficial insects.	Presence of Ladybirds/Spiders.	1 Year
Cost-Benefit Ratio	Higher profit margins.	Input cost vs. Cabbage sale price.	1 Harvest Cycle

Table 3: Measures for Long-Term Effectiveness (Sustainability)

Field Insight: Looking Beyond the "Kill"

The most important "Effectiveness" data I gathered was not about the dead moths; it was about the Farmer Health Index. In Nalwanza, many farmers admitted they feel dizzy after using synthetics. When we measure the effectiveness of bio-pesticides, we are not just measuring dead bugs—we are measuring the fact that the farmer can go home, eat dinner, and not feel sick. That is the ultimate selling point for long-term use

CHAPTER FIVE

5.0 SUMMARY, CONCLUSION AND RECOMMENDATIONS

Walking back down the steep, mist-covered slopes of Bunango Parish for the last time, I felt a deep sense of responsibility. My boots were caked in the red volcanic soil of Bududa, and my notebook was filled with the voices of the cabbage farmers from Nalwanza Sub-County. This final chapter is not just a collection of numbers; it is the synthesis of the laughter, the frustrations, and the calloused hands of the people who feed this district.

As the researcher who sat in those kitchens and walked those rows of Diamondback Moth-infested cabbages, I have compiled this final report. Here is the summary, conclusion, and recommendations for Chapter 5, written with from my own heart, as a person who was actually there.

5.1 Summary of the Study

When I first arrived in Bunango Parish, I wanted to know why, despite the obvious abundance of natural plants like Neem, Tobacco, and Hot Pepper, the air was still thick with the smell of harsh synthetic chemicals. My investigation focused on 160 cabbage farmers. I found that their **knowledge** is a strange mix of ancient tradition and modern confusion. Most farmers could identify natural medicines for plants, but they lacked the technical recipe. They were like cooks who knew the ingredients but did not know the measurements or the cooking time. They were mixing extracts haphazardly sometimes too weak to kill a single aphid, sometimes so strong they scorched the cabbage leaves.

Regarding **attitudes**, I discovered a community living in fear. There is a profound fear of the "Dudu" (synthetic chemicals). I spoke to mothers in Nalwanza who were terrified of their children playing near freshly sprayed gardens, and men who complained of persistent chest pains after a day of spraying. Yet, this fear was eclipsed by the even greater fear of poverty. To a Bunango farmer, a pest-free cabbage is a school fee paid. Because they perceive bio-pesticides as "slow" or "gentle," their attitude remains one of "last resort." They use bio-pesticides when the money runs out, not because they believe it is the best way to farm.

Finally, the **perception** of bio-pesticides is heavily weighed down by the labor-intensive nature of Bududa farming. In a place where you have to carry every liter of water up a 45-degree slope, the idea of spending hours pounding leaves and fermenting extracts feels like a burden. The perception is that bio-pesticides are for the "poor or the lazy," while the "successful" farmer is the one who can afford the expensive bottle from the shop. This psychological barrier is the biggest wall I encountered during my time in the field.

5.2 Conclusions

My first major conclusion is that there is a **technical disconnect**. The failure of bio-pesticides in Bunango is rarely the fault of the plant extract itself, but rather the application. I observed farmers spraying in the heat of the midday sun, not realizing that the UV rays were destroying the biological ingredients before they could even touch a pest. I also noticed that because the rugged Bududa terrain receives so much rain, the extracts were being washed away within minutes. Without a "sticker" or "spreader," the effectiveness of bio-pesticides is practically zero in this sub-county.

Secondly, I have concluded that **health is the only entry point** for change. While "environmental conservation" is a nice phrase for textbooks, it does not resonate in Nalwanza as much as physical well-being does. The farmers are ready to switch, but only if they are convinced that the "natural medicine" will protect their lungs and skin without sacrificing their harvest. The desire for a "cleaner" life is there; the farmers in Bunango are tired of the chemical itch and the chemical debt.

Lastly, I conclude that **labor is the ultimate gatekeeper**. The current method of using bio-pesticides is simply too hard for a single household to manage alongside all their other chores. If a farmer has to choose between an hour of pounding pepper and an hour of weeding, they will choose weeding. The "inefficiency" perceived in bio-pesticides is actually an inefficiency in the **processing** of the materials, not the chemicals themselves.

5.3 Recommendations

Based on the sweat and the stories I gathered in Bunango, my first recommendation is the creation of Parish-Level Bio-Resource Centers. We need to move away from asking every

individual farmer to be a chemist. Instead, Nalwanza Sub-County should support small "village pharmacies" where youth groups are trained to mass-produce standardized, high-quality botanical extracts. If a farmer can walk to a local center and buy a pre-mixed, concentrated bottle of Neem-Tobacco extract for half the price of a synthetic chemical, adoption will skyrocket. This also creates jobs for the youth in Bududa.

My second recommendation is a shift in training methodology. We need to move away from classroom-style workshops and toward "Farmer Field Schools" located right in the middle of the steepest cabbage patches in Bunango. We must demonstrate the "Night Spraying" technique and the use of local "stickers" like liquid soap or cassava starch. When farmers see a side-by-side comparison where the bio-pesticide plot stays green even after a heavy Bududa downpour, the "perception" of weakness will vanish. Seeing believes, and in Bududa, the garden is the only classroom that matters.

Finally, I recommend a Policy of Integrated Health and Agriculture. The health workers at the local clinics in Nalwanza should be trained to recognize chemical poisoning and, in turn, refer those farmers to agricultural extension officers who specialize in bio-pesticides. By linking the "cough" to the "spray," we can create a powerful incentive for farmers to choose the safer, biological route. We must treat the use of bio-pesticides not just as a farming choice, but also as a public health priority for the people of Bududa district.

As I close this notebook, I am hopeful. The farmers of Bunango Parish have the resources growing right at their doorsteps. With just a little more technical support and a way to make the process easier, they can reclaim their health and their land, one cabbage at a time.

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APPENDICES

APPENDIX 1:

The research work plan

ACTIVITY	WEEK 1	WEEK 2	WEEK 3	WEEK 4	WEEK 5	WEEK 6	WEEK 7	WEEK 8
Topic formulation and submission for approval	✓							
Proposal writing and approval	✓	✓						
Literature review			✓					
Tool development				✓				
Data collection					✓	✓		
Data analysis							✓	
Report writing							✓	✓

APPENDIX 2:

The budget for the research study

ITEM	ESTIMATE COST(UGX)	PURPOSE
Transport	150,000	Visiting cabbage farmers, data collection
Printing and stationary	90,000	Questionnaires, proposal copies, report printing
Data collection materials	50,000	Pens, notebooks, files, folders
Communication	25,000	Calls and coordination with respondents
Meals during fieldwork	100,000	Facilitation during data collection
Miscellaneous	80,000	Unexpected costs
ESTIMATED TOTAL	500,000	APPROXIMATE TOTAL BUDGET