SECURITIZATION OF DESERT LOCUST RISK MANAGEMENT AND HUMAN SECURITY IN KENYA

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A RESEARCH THESIS SUBMITTED TO THE SCHOOL OF LAW, ARTS AND SOCIAL SCIENCES IN FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF DOCTOR OF PHILOSOPHY (SECURITY STUDIES) OF KENYATTA UNIVERSITY

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DECLARATION

This thesis is my original work and has not been presented for a degree in any other University.

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DEDICATION

I wish to dedicate this research work to community members, national and county government personnel, as well as employees of regional and international non-governmental organizations who selflessly served during 2019-2022 desert locust management operations despite life-threatening risks from COVID-19.

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ABBREVIATIONS AND ACRONYMS

ASALs	Arid and Semi-Arid Lands
CRC	Central Region Commission for Controlling the Desert Locust
DCLO-EA	Desert Locust Control Organization for East Africa
DLCC	Desert Locust Control Committee
DLIS	Desert Locust Information Service
ELRP	Emergency Locust Response Program
FAO	Food and Agriculture Organization
FGD	Focus Group Discussion
FSNWG	Food Security and Nutrition Working Groups
GAP	Good Agricultural Practice
GDP	Gross Domestic Product
GIS	Geographical Information System
GOI	Government of India
GOK	Government of Kenya
GPS	Global Positioning System
HELB	Higher Education Loads Board
ICPALD	IGAD Centre for Pastoral Areas and Livestock Development
IDP	Internally Displaced Person
IGAD	Intergovernmental Authority on Development
IPC	Integrated Phase Classification
IPCC	International Panel on Climate Change
IPM	Integrated Pest Management
ITKS	Indigenous Technical Knowledge and Skills
KUERC	Kenyatta University Ethics Review Committee

LPRG	Locust Pesticide Reference Group
NACOSTI	National Commission for Science, Technology and Innovation
NDVI	Normalised Difference Vegetation Index
NGAOs	National Government Administrative Officers
PB-AHP	Patch-based Analytic Hierarchy Process
SDG	Sustainable Development Goals
SOPs	Standard Operating Procedures
SPSS	Statistical Package for Social Sciences
UAVs	Unmanned Aerial Vehicles
ULV	Ultra-Low Volume
UN	United Nations
UNDP	United Nations Development Programme
UNGA	United Nations General Assembly
VMS	Vehicle-mounted sprayer
WFP	World Food Programme
WMO	World Meteorological Organization

OPERATIONAL DEFINITION OF TERMS

Breeding is a reproductive process where one generation of desert locusts gives rise to a progeny.

Community security is the freedom from loss of traditional relationships and values due to sectarian and ethnic violence.

Corrective strategies refer to recovery programs that are done after upsurges and plagues have ended, to help in livelihood restoration and environmental rehabilitation.

Desert locust is one of the most dangerous migratory plant pests and a natural disaster whose threat spans beyond food security into all the other dimensions of human security.

Economic insecurity denotes lack of assured basic income from crop and livestock production after destruction of plants and pasture by desert locusts.

Environmental security refers to the sustainability of ecosystems due to freedom from deterioration of the natural environment or indiscriminate destruction of vegetation by desert locusts.

Food insecurity is reduction in economic and physical access to sufficient food, of acceptable nutritional value and preference due to limited crop and livestock production after desert locusts destroy plants and pasture.

Health security refers to physical and mental well-being or freedom from conditions such as malnutrition and complications resulting from hazardous pest control products.

Human security means the freedom from fear and freedom from food, economic, health, environmental, community, personal and political risks due to desert locusts or associated pest management activities.

Outbreak refers to a sudden increase in desert locust populations after sporadic rainfall that triggers an increase in vegetation in breeding areas.

Personal insecurity denotes to physical or psychosocial threats to people caused by desert locusts or associated pest management activities.

Phase polyphenism is a process facilitated by population density-dependent hormonal changes and social and meteorological factors. In this process, one genotype exhibits multiple phenotypes depicted in different colours, behaviour, and reproduction.

Plague refers to several years of widespread intra-regional infestation of desert locusts after several seasons of good rains and ineffective control.

Preventive control represents early interventions to suppress desert locust outbreaks in breeding areas, avert grangerization, and abate upsurges.

Reactive strategies are interventions to reduce desert locust population during upsurges and plagues.

Recession area refers to the native desert locust habit that covers Sahel region in the Sahara Desert, Maghreb area in the north of Africa, Arabian Peninsula and Indo-Pakistan countries.

Securitization is a process through which the government and powerful individuals use the speech act to politicize a security threat, such as desert locust invasion, elevating it from a standard agricultural production issue to a national security risk.

Surveillance refers to initiatives aimed at continuously tracing, tracking and reporting desert locust populations in affected and at-risk areas to control the spread.

Upsurge is a transnational increase in the desert locust population following successive breeding seasons in multiple places, resulting in large hopper bands and swarms.

ABSTRACT

Desert locusts, as invasive phytophagous pests, pose substantial risk to farmlands, pasturelands and rangelands, necessitating urgent, extreme and large-scale risk management practices to safeguard lives and livelihoods. However, these securitized desert locust management practices can unintentionally impact human security negatively. This study therefore sought to assess the relationship between desert locust risk management and human security in Kenya using securitization and resilience theories. Mixed methods research design using ex-post facto evaluation and cross-sectional survey which combined qualitative and quantitative methodologies, were employed. The research targeted a sample of 900 respondents who were impacted by the desert locusts. Primary data was collected using questionnaires and focus group discussions. Quantitative data was analysed using descriptive (frequencies and percentages) and inferential statistics (ordinal logistic regression) with the help of Statistical packages for social sciences and presented in tables and graphs. Qualitative data was analysed using thematic review and incorporated as narratives in the discussion. The findings revealed that desert locusts impacted food, economic, health, personal, and environmental security, contributing 27%, 19%, 19%, 18%, and 17% to the overall human security risk, respectively. Use of chemical control, recovery programs, physical control, surveillance activities, and indigenous technical knowledge, led to risk reduction rates of 43%, 16%, 16%, 15%, and 10%, respectively. Nevertheless, securitization posed inadvertent threat to economic, environmental, health, food, personal, and political security, resulting in 23%, 20%, 16%, 15%, 14%, and 12% of unforeseen risk, respectively. In addition, the research highlighted limitations in human resources, geographical difficulties, technical complexities, coordination hurdles, financial constraints, political pressure, and socio-cultural dynamics as operational challenges which led to 17%, 16%, 15%, 15%, 13%, 12%, and 12% impediment to desert locust management, respectively. Based on the results, integrated pest management, early interventions using pesticides, early interventions through physical control, and non-intervention received 34%, 28%, 24% and 14% support from respondents as preferred desert locust risk management best practices, respectively. The study concludes that although securitization of interventions had positive effects on managing desert locust risks, it also threatened human security in various ways, with the dangers being exacerbated further by challenges associated with securitized operations. The study recommends implementation of a customised integrated pest management program to efficiently manage the benefits and risks of securitizing desert locust management, while also resolving operational difficulties.

CHAPTER ONE

INTRODUCTION

1.0 Introduction

This chapter presents an overview of the study, including its background, problem statement, research aims, research questions, significance, scope, and limitations. Additionally, it highlights the importance of the study for stakeholders.

1.1 Background to the Study

Desert locusts substantially threaten food security, livelihoods, and the economy. Countries often use securitization measures to tackle these dangers, although this might inadvertently adversely affect human security. The invasion that occurred in Kenya from 2019 to 2021 emphasised the need to implement efficient risk management measures. Kenyans used strategies such as chemical spraying, physical control techniques, and surveillance activities to manage the locust population. Nevertheless, the invasion had extensive consequences for food production, economic endeavours, and the overall welfare of humans.

According to the World Meteorological Organization (WMO) and Food and Agriculture Organization (FAO), the desert locust (*Schistocerca gregaria* Forskål) is a short-horned grasshopper which is typically found in the Sahel and Maghreb areas of Africa, Arabian Peninsula, and Indo-Pakistani region of Asia (WMO & FAO, 2016; Lecoq, 2019). Desert locusts are always in a harmless solitarious phase, scattered in low numbers in their natural breeding habitats (recession area), covering about 16 million square kilometres in 30 countries (FAO, 2015).

The gregarious phase of desert locusts however can invade more than 29 million square kilometres, extending to about 60 countries during plagues (WMO & FAO, 2016). According to Geladari *et al.* (2020), countries affected by the 2019-2022 upsurge included Iran, Pakistan, Yemen, Saudi Arabia and Oman in southwest Asia. Ethiopia, Somalia, Sudan, Eritrea and Djibouti were also affected in the Horn of Africa region. In addition, South Sudan, Uganda, Tanzania and Kenya were affected in the East Africa region (Geladari *et al*., 2020).

Unlike in recession countries where desert locusts exist in a harmless solitarious phase, Kenya, an invasion country, only receives migrant swarms in their destructive gregarious phase with far-reaching effects on human security. Harmless solitarious desert locust transit to a destructive gregarious phase in what is referred to as phase polyphenism after abrupt rainfall, followed by a vegetation boom that leads to massive breeding that triggers outbreaks (Symmons & Cressman, 2001).

Phase polyphenism is a hormonal process where Serotonin causes desert locusts to change physical and physiological characteristics during outbreaks. After outbreaks, harmless solitarious desert locusts concentrate, multiply and gregarize into destructive hopper bands that develop into adult swarms (Latchininsky *et al*., 2011). The swarming desert locusts indiscriminately devastate vegetative biomass and thus threaten the survival of humans and other organisms that depend on plants for food, shelter and breeding sites (Joshi *et al.,* 2020).

Although outbreaks occur frequently, only a few result in upsurges and thus, fewer plagues occur (Lecoq, 2005). While outbreaks may happen overnight when desert locust eggs hatch, upsurges and plagues take several months to develop. As such, during major plagues, gregarious desert locusts may spread over millions of square kilometres (WMO & FAO, 2016). The threats of gregarious desert locusts are exacerbated by their versatility and ability to reproduce rapidly, migrate for long distances and forage indiscriminately on crops, pasture and other green plants (Cressman, 2016; WMO & FAO, 2016).

Desert locust invasion creates fear and exacerbates human wants through hunger or famine after the massive destruction of vegetative plant biomass (Cressman, 2016; Getabalew, 2020). The destruction of vegetative biomass, which serves as human food, livestock, wildlife feed, and habitats for many organisms, interferes with human security by threatening people and the environment. For instance, Chatterjee (2020) published that there was economic loss due to reduced yields and increased cost of agricultural production associated with the expenses of managing desert locusts in India.

In addition, FAO and World Food Program (WFP) found that there was an increase in the proportion of households using emergency food sources from 22% to 49% between 2019 and 2020 in Amhara, Somalia, Oromia and Afar regions of Ethiopia (FAO & WFP, 2020). Emana (2002) reaffirmed that two-thirds of Sudan's farmers considered desert locusts the most dangerous crop pest that could cause up to 30% reduction in potential yield during upsurges. United States Agency for International Development (USAID) reported that 3.6 million acres in Ethiopia, Somalia, Kenya and Uganda were affected by desert locusts that threatened the livelihoods of more than 3.3 million farmers (USAID, 2021).

Because of the transnational existential threat of desert locusts to lives and livelihoods, many countries, especially those in invasion regions such as Kenya, often securitize subsequent management practices. Securitization refers to the political process of publicising an issue as an existential human security threat, which is dangerous and alarming and thus requires urgent countermeasures (Eroukhmanoff, 2018). Accordingly, the issue is securitized by people and/or organizations with social and institutional power to influence public opinion. In relation to this study, securitization of desert locust management involved framing the pest as a natural disaster.

The securitizing agencies included international, regional and local organizations such as FAO, Desert Locust Control Organization for Eastern Africa (DLCO-EA) and the government of Kenya. Due to the securitization of desert locusts, the pest was considered a national security threat that required the activation of crisis management strategies through emergency response (Ferrand, 2020). As such, the study analysed the securitized desert locust management practices used to protect human security in Kenya.

When emergency response using urgent and optimal strategies such as spraying with synthetic pesticides were initiated, there could have been limited forethought on their possible side-effects on human security. Using chemical pesticides as the first line of control at the expense of good agricultural practices (GAP) such as integrated pest management (IPM) approach can trigger unforeseen threats. For instance, Mullie *et al.* (2021a) reported that pesticides led to the mortality of birds and arthropods in Senegal.

Worku *et al.* (2022) discovered that desert locust control pesticides directly harmed worker bees in Ethiopia. This could have destabilized ecosystems as birds and bees play a critical role in pollination to sustain the reproductive function of flowering plants. Despite this realization, there was little information on the effects of securitized desert locust management activities on people and the environment in Kenya.

Nasike (2021) did a laboratory experiment in Kenya to examine the toxic effects of synthetic pesticides used to control desert locusts. The study found that Fenitrothion is toxic to humans, aquatic species and bees. Although the study elucidated the toxic effects of pesticides, the study was limited in outlining other human security threats that could have emanated from these chemicals. For example, the toxic nature of the chemicals could lead to health risks, while their effects on birds negatively impact the environment (Mullie *et al.*, 2021b). In addition, negative effects on pollinator bees could have affected food and economic security (Worku *et al.*, 2022). For example, economic insecurity is associated with poverty, which could lead to criminal behaviour (Hooghe *et al*., 2011).

As previously mentioned, the effects of desert locusts could have had both direct and indirect effects on human security. However, while there is evidence of research on the effects of desert locust management practices, the few published studies focused more on the danger of pesticides to health and environmental security. There was a gap in examining human security risks from other associated desert locust management practices in this multifaceted value chain. This study sought to address this gap by evaluating threats of securitized desert locust management practices to Kenya's food, economic, health, environmental, personal and political security.

Desert locust management as a multifaceted value chain encompasses triangulating surveillance activities, control operations and recovery programs. Each of these phases comes with some challenges that may aggravate human security risks. Although studies have identified challenges during desert locust management, they seldom evaluate their contributions to human insecurity. For instance, Showler (2021) noted that insecurity and armed conflict are significant challenges during desert locust management in Asia and Africa. The study noted that insecurity and armed conflict deter surveillance and control activities by limiting access to affected areas.

Kassegn and Endris (2021) documented that COVID-19 containment measures, especially restricted movement and social distancing, prevented group trainings in Ethiopia. Insufficient training for survey and spraying teams was identified as a serious challenge in desert locust management operations (FAO, 2014; Showler, 2018). Notably, inadequate skills on surveillance and control could lead to misreporting particularly submission of false-positive reports and poor delimitation of spraying sites. Such operational errors as aforementioned could in turn mislead aerial application of pesticides in human settlements and protected areas thus threatening people and wildlife, respectively.

Desert locusts therefore had far-reaching effects on human security. Human security in this study has been operationalized to include food, economic, health, environmental, community, personal and political dimensions. However, the aforementioned studies focused on food and economic security with little reference to other human security dimensions. In addition, although some studies identify challenges in management of desert locusts, they neither provide sufficient explanation on how these constraints can contribute to human insecurity. The study therefore established challenges during desert locust management in Kenya and provided detailed explanations on how these constraints could have exacerbated human insecurity.

Kenya had not experienced a desert locust invasion of such a devastating magnitude as the one of 2019-2021 for over seven decades. As such, the country had limited documented evidence of desert locust management best practices. In addition, the limitation of best practices in safeguarding human security had little attention in previous desert locust management publications. Despite studies publishing some desert locust risk management best practices, they were seldom explicit on universalization. For example, Showler *et al*. (2021) recommended non-intervention as a best practice where desert locust could be left to take a natural course to mortality.

The recommendation of non-intervention suggested that the insects could be allowed to breed, leading to outbreaks and transit into an upsurge, then the plague. Unfavourable weather conditions could then lead to the mortality of the pests, causing a decline, and finally, a recession would happen. Such a recommendation may, however, be impractical in Kenya, where agriculture is the most significant contributor to gross domestic product (GDP). The study, therefore, documented lessons learned to help identify and publish possible best practices that can help minimize the risks emanating from desert locust management practices, reduce securitization of operations and remedy associated challenges.

1.2 Statement of the Problem

Desert locust is one of the most dangerous plant pests that poses existential threat to several human security dimensions. The 2019-2021 desert locust invasion in Kenya was reported as the worst in over 70 years (Kenya Red Cross, 2020), and hence required rapid and extraordinary interventions. However, securitization of desert locust management by use of urgent and extreme countermeasures could trigger unforeseen human insecurities with possible unintended negative effects on people and the environment. Additionally, the challenges of managing desert locusts and threats of securitized interventions such as use synthetic pesticides could have had negative effects on human security.

Desert locust management challenges were also attributable to Kenyans having little prior experience. There was a high possibility of mishaps in pest management that could have effects on the population and ecosystems. However, limited research focused on the securitization of desert locust management in Kenya. Therefore, the problem that inspired the conceptualization of this research is that despite understanding the complexity of the 2019-2021 desert locust management in Kenya, there was little evidence of empirical studies on the securitization of desert locust management and human security. This study sought to address this gap by analysing Kenya's securitization of desert locust risk management and human security.

1.3 Objectives

There are two objectives adopted for this study the general and specific objectives:

1.3.1 General Objective

This study's goal was to analyse the relationship between the securitization of desert locust risk management and human security in Kenya.

1.3.2 Specific Objectives

i. To assess desert locust risks to human security in Kenya
ii. To analyse securitized desert locust management practices that were used to protect human security in Kenya
iii. To evaluate threats of securitized desert locust management practices to human security in Kenya
iv. To establish challenges during desert locust management that hindered the protection of human security in Kenya
v. To determine desert locust management best practices in protecting human security in Kenya

1.4 Research Questions

The study addressed the following research questions:

i. What were the risks of desert locust to human security in Kenya?
ii. Which securitized desert locust management practices were used to protect human security in Kenya?
iii. How did securitization of desert locust management practices threaten human security in Kenya?
iv. What were the challenges of desert locust management that hindered protection of human security in Kenya?
v. What are the desert locust management best practices in protecting human security in Kenya?

1.5 Justification and Significance

Although desert locusts are rare in Kenya, climate change may increase the frequency of invasions, persistence in time, spread in space and severity of impact on people, livestock and ecosystems. As such, desert locusts create fear and exacerbate human wants, thus threatening human security. This calls for urgent and extreme countermeasures to safeguard humans, animals and the environment. However, extremist efforts that are meant to manage desert locusts can, in turn, create insecurity. Understanding how securitization of desert locust management can threaten human security is important to the general public, policymakers, risk analysts, disaster managers and scholars.

This study is significant because it provides a platform for the general public to share their experiences managing desert locusts. The publication of these lessons learned could serve as a valuable guide for future pest management, benefiting all stakeholders. Policymakers can use the findings to inform strategic planning for future desert locust risk management. Risk analysts will have a solid foundation to develop early warning systems for desert locusts. Disaster managers will gain insights from best practice case scenarios for preparedness and early response. Scholars will have a rich resource for further desert locust risk management studies.

1.6 Scope of the Study

Although the 2019 to 2022 desert locust upsurge affected most parts of the Horn of Africa, this study only focused on Kenya, one of the countries that had experienced an invasion of such a magnitude after many years. This study targeted 30 counties affected by one or more of Kenya's three waves of desert locust invasions. The spatiotemporal distribution of reported desert locust incidents guided the selection of the study area.

1.7 Limitations of the Study

Desert locusts typically inhabit almost homogenous arid- and semi-arid lands (ASALs). However, as an invasion country, Kenya is a diverse and heterogeneous landscape. This study was, therefore, limited by the social, cultural, and agroecological diversity of the study area. Although desert locusts are a transnational migratory pest that poses inter-regional security risks, the findings from this study may not be universally applicable. However, they can be applied cautiously to guide policies and practices on desert locust risk management in any part of the world.

CHAPTER TWO

LITERATURE REVIEW AND THEORETICAL FRAMEWORK

2.0 Introduction

This chapter provides an explanation of desert locust biology and behaviour, offering essential context for readers unfamiliar with agricultural entomology. The foundation of human security is also elaborated, highlighting the significance of desert locusts as a transboundary threat. The section analyses relevant literature based on each of the specific objectives, and explains the theoretical and conceptual frameworks.

2.1 Desert Locust Biology and Behaviour

Desert locust is one of the more than 20,000 species of grasshoppers and one of the more than 10,000 short-horned species which is typically found in ASALs of Africa and Asia (WMO & FAO, 2016; Government of India [GOI], 2019). Desert locusts' invasion area is estimated to cover up to 31 million square kilometres during upsurges and plagues. In contrast, the recession area, where breeding occurs, is just half of that geographic space. In addition, a significant amount of land, sometimes as high as 20% of the earth's agricultural land, can be affected by desert locust invasions (GOI, 2019).

Desert locusts can sometimes invade over 29 million square kilometres, extending to about 60 countries across the globe (WMO & FAO, 2016). In North Africa, the Middle East, and southwest Asia, as well as West and East Africa, desert locust is considered a serious agricultural pest in more than 50 countries. (Lecoq, 2019). Unlike other species of locusts, the desert locust exhibits polyphenism (transition from solitary to gregarious phase). This plastic reaction to population density is linked to transformations in morphological, behavioural, physiological and anatomical traits (Sultana *et al*., 2021).

The biology, behaviour and migratory patterns of desert locusts are influenced by environmental factors, especially precipitation, temperature, vegetation condition, wind direction and speed, soil texture, moisture and composition (Retkute *et al*., 2021). These ecological factors inhibit or stimulate desert locust breeding, gregarization and migration. For instance, sudden high amounts of precipitation contribute to vegetation boom; moist sandy soil is necessary for oviposition, while convergence of winds influences gregarization (Sharma, 2014; Ellenburg *et al.*, 2021).

Desert locusts can change their behaviour and physiology, especially colour and shape in response to age and weather conditions (GOI, 2019). When the numbers of desert locusts are low, the pest exists as harmless solitarious insects, and when the population is high, they behave as very destructive gregarious swarms that pose a severe threat to human security (Lecoq, 2005; Latchininsky *et al.,* 2011). The transition from harmless solitarious to destructive gregarious insects starts with an outbreak within a limited area. This phase transition is triggered by a sudden high rainfall that leads to increased green vegetation, which in turn causes the rapid breeding of desert locusts (Kumar & Rahman, 2020).

Under optimal conditions, the lifespan of gregarious desert locusts is about three months during upsurges; hence, 3 to 4 progenies can emerge annually (Sultana *et al*., 2021). Young adults of the gregarious desert locust can remain immature for several months, awaiting conducive breeding conditions. Typically, 20–25 mm of rainfall is required for sexual maturity and oviposition (Lecoq, 2019). After oviposition, hatching of eggs can take place within two weeks, hoppers can fledge in 6 weeks and adults can mature sexually in 4 weeks on average (WMO & FAO, 2016). This rapid reproduction can lead to plague and cause an imminent threat of famine, thus causing human insecurity.

Outbreaks can happen undetected, and geospatiotemporal trends of invasions are challenging to predict with precision. For example, desert locust oviposition commences within two days after copulation (Lecoq, 2005). The pest has three distinct development stages of incomplete metamorphism: egg, nymph/hopper and adult (Latchininsky *et al*., 2011). The female desert locusts lay eggs at an interval of 7-10 days in pods placed 10-15cm into moist sandy soil, and one insect oviposits typically in 2-3 pods of 60-80 eggs each, with up to 20% survival rates on average (Latchininsky *et al*., 2011; Lecoq, 2005; GOI, 2019).

Egg development takes approximately two weeks but highly depends on soil moisture content and temperatures. Below the temperature of 15°C, no egg development occurs. At optimum temperatures of 32–35°C, the incubation period takes 10–12 days (Latchininsky *et al*., 2011; GOI, 2019). After incubation, each successful egg hatches into a wingless nymph/hopper, which undergoes 6 or 5 instars during solitary and gregarious phases, respectively, each having a growth and colour change.

Gregarious hoppers are black at instar 1-2 and turn yellow with black colouration from instar 3. Solitary hoppers are green in colour throughout their development stages. Young, sexually immature, gregarious desert locusts are pink, while older ones are dark red or brown and turn bright yellow after maturity. Solitary adults are brown/beige in colour, and thus, they can easily be confused with tree locusts and some giant grasshoppers.

As mentioned earlier, the gregarious phase takes approximately 6 weeks from hatching to fledging. However, hopper development depends on prevailing temperatures. As such, it takes 22 days at about 37°C and may lag for up to 70 days at temperatures below 22°C (Latchininsky *et al*., 2011). The 5th instar nymph moults/fledges into an adult desert locust with soft wings; hence, it cannot fly. The wings harden in a few days, ready to fly for long distances. This is the most injurious stage of desert locusts to green vegetation, even though they are sexually immature.

Generally, it takes about 4 weeks before an adult desert locust is sexually mature, but the development is again highly dependent on temperatures and rainfall. Under warm and wet conditions, an adult desert locust may become sexually mature within 3 weeks. Under cooler and drier conditions, it takes longer and can take up to 8 months (Lecoq, 2005). This delayed maturity provides desert locust management teams ample time for responsive control through pesticide spraying. Male desert locusts mature before females, and bright yellow colouration is an indicator of this maturity.

If vegetation dries out, the adults leave an area and fly downwind in search of food and favourable conditions for breeding. This migratory behaviour leads to more destruction of crops and pastures in new areas. Desert locust swarms can migrate about 16-19 kilometres per hour depending on the wind speed and direction and can travel 150-200 kilometres daily (Symmons & Cressman, 2001). Before embarking on a migratory journey, a desert locust swarm warms up by basking in the sun shortly after sunrise to benefit from thermodynamics. The solar energy allows desert locusts to fly throughout the day. At about sunset, desert locusts land and remain settled on the ground, feeding on vegetation throughout the night (GOI, 2019).

Desert locusts can feed on an equivalent of their weight, which is, on average, about 2 grams per locust per day. In 24 hours, a small swarm containing 40-80 million locusts on a 1 square kilometre farm can consume approximately 80 metric tonnes of vegetative biomass (Symmons & Cressman, 2001). In one day, a 1 square kilometre swarm of desert locusts can destroy vegetation estimated to be sufficient food for 35,000 people and feed 20 camels or 6 elephants (Symmons & Cressman, 2001; WMO & FAO, 2016). The sheer scale of this destruction is staggering and poses significant human security risks. Recognition of such a disaster creates panic worldwide, calling for securitization of Dessert locust management.

2.2 Human Security Concept in Desert Locust Management

The expanded understanding of security pioneered by the Copenhagen School scholars permitted threats other than inter-state war to emerge (Buzan *et al*., 1998). Human security is made up of two concepts: human and security. Security is considered in the "traditionalists" and the "wideners" perspectives. The traditional perspective, as borrowed from realists, defines security in military terms as a threat to the survival of States in an anarchic international system (Collins, 2006). For the traditionalists, security is considered a natural science subject and is perceived in terms of territorial integrity and State survival in an international self-help system (Bjork, 2015).

This traditional understanding of security is associated with the realist paradigm that perceives States as continuously engaging in perpetual competition for survival in anarchic world order (Dalby, 2003). In traditional realism, security is linked to factors that directly influence the structure of the nation-state. Therefore, the sovereignty of the States as members of the world system is at the centre of traditional security discourse. The realists' sense of security revolves around national threats, control and military force (Bjork, 2015).

The traditional understanding of security therefore conveys security as granted by the State and, as such, equal to her selfish interest. Traditional security is considered from the perspective of threats and insecurity applicable to the Nation-State. This view dominated the aftermath of World War II and the Cold War periods until the late 1980s. However, the Copenhagen School, closely linked to Buzan, Weaver and De-Wilde, championed a new understanding of security that dis-aggregated security aspects by redefining human security as a broader and deeper concept (Buzan *et al*., 1998).

Focusing on what constitutes a security issue, the “wideners” defined human security as a state of being free from threats, focusing on an individual person rather than the State (Holliday & Howe, 2011). This Copenhagen understanding of security perceived security as a relative concept that is conceived and defined from the perspective of an individual human being. Defining security at the individual level means that human security is only said to exist when one feels free from threats. In this way, Wolfers (2008) argued that human security is potentially ambiguous, although it is undoubtedly unlimited to territorial integrity, military might and States’ survival.

Human security is however not a self-enclosed and isolated object but a subject of complex relationships. Therefore, human security is associated with the extended perspective of threats. The concept of human security was given the limelight by the 1994 United National Development Program Human Development Report (UNDP-HDR). The UNDP-HDR emphasized “freedom from want and freedom from fear” in addressing global security challenges (UNDP-HDR, 1994). The former United Nations Secretary-General (UNSG), Boutros Boutros-Ghali, in the 1992 United Nations Agenda for Peace, cited human security as one of the proposed approaches to sustainable global security in addition to peace-making, peacekeeping, post-conflict recovery, transformation and preventive diplomacy.

The Human Security Now Report 2003 by the UN Commission on Human Security Conference defined human security as protecting people's fundamental freedoms that support life. This understanding of human security implies that people need protection from severe threats and challenging conditions. This expanded and human-centric understanding of security has come to define the concept of human security. Therefore, while human security focuses on protecting the individual human being from fear and want, security in the conventional understanding relates to protecting the State and her survival (Holiday & Howe, 2011).

Human security, therefore, entails utilizing available processes that enhance people's aspirations and strengths and creating social, cultural, political, environmental and economic systems that ensure support for dignity, livelihood and survival (Holiday & Howe, 2011). The "narrow" and the "broad" categories of human security have always been considered for integration in a reinforcing strategy to protect and empower people (UNDP-HDR, 1994). While the "narrow" view focuses on freedom from fear, the "broad" view entails "freedom from want" (Holiday & Howe, 2011). However, the "freedom from want" perspective is integrated in the 1994 UNDP-HDR and the 2003 Human Security Now publications.

In 2021, the United Nations General Assembly (UNGA) adopted Resolution 66/290, which recognized human security as an approach that links the three pillars of the UN (human rights, development, peace, and security (FAO, 2013)). According to Human Security Research Group (HSRG), the "broad" understanding of human security brings to the fore security aspects that have been neglected, such as diseases, natural calamities, hunger, environmental disasters and other socio-economic issues (HSRG, 2021). From this backdrop, desert locusts can be considered an important human security threat to people, animals and ecosystems. It is within this broadened and more in-depth understanding of human security that this study was anchored to analyse how the desert locust risks influence human security.

2.3 Desert Locust Risks to Human Security

There is research evidence that desert locusts are one of the most dangerous plant pests whose effects span several human security dimensions (Bradshaw *et al*., 2016). For instance, upsurges and plagues cause famine due to desert locusts' indiscriminate devastation of green vegetation. It is important to note that one adult desert locust can feed on an equivalent of its weight, which is, on average, about 2 grams per day (WMO & FAO, 2016). In 24 hours, 40-80 million desert locusts, occupying only 1 square kilometre, can consume approximately 80 metric tonnes of vegetative biomass (Symmons & Cressman, 2001).

Desert locusts, therefore, pose a severe risk to human security. With specific reference to the relationship between health insecurity and desert locusts, Le and My (2022) sought to investigate the impact of locust upsurges on child health in Asia and Africa between 1990 and 2018. The study found that childhood exposure to desert locust upsurges and plagues in the prenatal stage affected child height-for-age, weight-for-size and weight-for-height z-scores by 0.159, 0.155 and 0.148, respectively, compared to unexposed children. The study concluded that prenatal exposure to desert locust upsurges and plagues on height-for-age cannot be recovered.

Chatterjee (2020) established an association between economic insecurity and desert locusts due to reduced yields and increased cost of agricultural production that could be linked directly with expenses of managing the pest in India. In addition, Sultana *et al.* (2021) found approximately 3.4-10.21 billion US dollars' worth of losses resulting from desert locust infestation in Pakistan. In addition, it was reported that more than 3 million Pakistanis were facing food insecurity, and about 34,000 households needed emergency food and livelihood assistance due to crop losses occasioned by desert locusts in Pakistan between 2019 and 2020 (Sultana *et al.*, 2021). These may seem like farfetched examples from Asia, but examples of the risk of desert locusts to human security can be traced within Africa.

In north-western Africa, economic loss from the 1866 invasion in Algeria was estimated to be equivalent to about 52 million euros and 4.5 million pounds in the 1954-1955 Morocco invasion (Lecoq, 2003). In addition, Lecoq reported that Mauritania lost approximately 60% of its 200,000 hectares of rangeland, 70% of its 200,000 ha of rain-fed crops and 50% of its 400,000 hectares of irrigated crops to desert locusts. In Niger, the losses were estimated at 50% of range or grazing land, while in Mali, it was as high as between 65-90% (Lecoq, 2003).

De-Vreyer *et al.* (2015) evaluated the impact of desert locusts on education in Mali. The study found that the 1986–1989 plague reduced enrolment of boys in school as they were actively involved in desert locust control activities. Despite the clear indication of human security risk that desert locusts could cause, these examples only paint a grey picture of the existential threat emanating from the pest. This is because the examples focus on a few of the human security dimensions. The examples are also biased towards countries in recession area; where desert locust breeding occurs.

With a focus on the greater Horn of Africa region, FAO (2020b) reported that over 20 million people were facing acute food insecurity in eight Intergovernmental Authority on Development (IGAD) countries between January – December 2020. In addition, the report indicated that approximately 1 million ha of land was affected, and at least

138 million US dollars was needed for rapid livelihood protection to at least 110,000 households. As such, in early 2020, over 20 million people were already experiencing food insecurity in the east and horn of Africa, especially Kenya, Uganda, Tanzania, Ethiopia, Somalia and South Sudan, due to desert locusts (IGAD, 2020; FAO, 2020b; WFP, 2020).

Emana (2002) examined the socioeconomic implications of desert locust infestation in Sudan and reaffirmed that two-thirds of farmers considered the insect the most dangerous crop pest that could cause a 20-30% reduction in potential yield during upsurges. Yuga and Wani (2022) assessed the impact of desert locust infestation on crops, pasture and livestock health in South Sudan. Despite these examples being closer to Kenya, they still focused on recession regions where desert locust always exists in a solitary phase.

Moreover, USAID (2021) reported that 3.6 million acres in Ethiopia, Somalia, Kenya and Uganda were affected by desert locusts, risking the lives and livelihoods of 3.3 million farmers. The assessment reported that more than 19 million individuals had become food insecure. According to the IGAD Food Security and Nutrition Work Group (FSNWG) alert of December 2019 and FAO Locust Bulletin No. 495 of 6th January 2020, the desert locust invasion was the worst in 25 years for Ethiopia and Somalia. The FSNWG (2021) report found that approximately one-third of cropping households were affected by desert locusts, and half of livestock-rearing households were affected.

FAO and WFP (2020) established that the proportion of households reporting poor food consumption had increased from 37% to 41% between August 2019 and February 2020 in Ethiopia. In addition, household diet quality had deteriorated due to food insecurity. The study also found that the proportion of households using emergency support as a coping strategy increased from 22% to 49% between 2019 and 2020 in Amhara, Somalia, Oromia and Afar regions. The study also noted that there were stagnant livestock prices and a limited supply of cereal foodstuffs, especially barley, a month after harvest due to limited supply as a result of desert locust infestation. As such, there were reports that 25% of households relied on markets for food and a 50% increase in prices of cereals.

With a unique focus on the effects of desert locusts on environmental security, Worku *et al.* (2022) found that desert locust swarms and hopper bands destroyed plants, resulting in pollen and nectar loss. As a result, honeybees in the infested areas produced less brood suffered poor health, produced less honey and eventually disappeared from their resident apiaries. In Somalia, the pest infested 180,000 hectares, affecting approximately 30,000 pastoral and agropastoral households (FAO, 2020a), and this led to a dire impact on the food and economic security. Based on the review, it is evident that these studies focused on recession areas where desert locusts are an all-time challenge. Therefore, the findings may not be generalizable invasion countries such as Kenya, where the desert locust problem is rare.

The FSNWG (2021) report found that 35% of desert locust-affected households in Kenya had high to very high losses in crop production, while 34% expected the harvest of their most important crops to be below average. In addition, the study reported that 52% of respondents had high or very high livestock losses, 63% said that livestock was either in fair conditions, or 21% said livestock were in poor condition. Respondents indicated that desert locusts increased food insecurity, malnutrition, anxiety and emotional stress. While the study was done in Kenya, it had limited scope, focusing more on food and health insecurity. As such, there was a need to carry out a more comprehensive study to assess the effect of desert locusts on all the other human security dimensions.

Desert locust is an indiscriminate polyphagous forager that targets all vegetation types (WMO & FAO, 2016). As such, during desert locust upsurges and plagues, all types of plants are likely to be destroyed. However, more importantly, perennial and annual, rain-fed, irrigated crops and trees are damaged (Lecoq, 2019). Lassa (2017) reported that in the eastern Sumba region of Indonesia, corn and paddy were severely damaged by desert locusts in 2017. In the Middle East, vegetables and wheat were the most affected. Wheat and sugarcane were the most affected in the eastern regions of India and Pakistan (GOI, 2019). A study by Retkute *et al.* (2021) found that the top five crops that were affected by desert locusts in East Africa included sugarcane, maize, sorghum, wheat and root crops, all of which are a source of staple food for many communities.

With such an impact on staple food being reported, WFP estimated that more than 40 million people in 9 countries within the greater East and Horn of Africa region were likely to be food insecure by mid-2020. Other agencies such as IFRC, IGAD and FAO have estimated that more than 10 million people in Ethiopia, Kenya, and Somalia who were already facing severe food insecurity were in areas already affected by desert locust infestations (IFRC, 2020). Further estimates indicated that over 3 million more individuals faced a similar threat in Uganda and South Sudan. According to FAO (2020b), approximately 20.2 million people in the eight IGAD countries of Kenya, Tanzania, Djibouti, Ethiopia, South Sudan, Somalia, Uganda and Eritrea were facing severe food insecurity as a result of the 2019-2022 desert locust upsurge.

The FSNWG (2021) conducted a study in the aftermath of the 2019–2021 desert locust invasion in Kenya, Somalia and Ethiopia and sampled 7,871 agricultural respondents. The study revealed that about half of livestock farming and a third of cropping households experienced crop and pasture-related losses as a result of desert locusts. According to IPC, nearly 250,000 people faced food insecurity in Somalia, especially in the desert locust affected areas of Gedo, Mudug, Bay, Galgaduud, Hiraan and Bakool (Cosgrove, 2020). In addition, IPC had projected that nearly 8.5 million people in the Oromia, Somali, Afar, Amhara and Tigray regions of Ethiopia were expected to be food insecure.

A joint assessment report by FAO and other agencies reported huge crop losses in Somali regions and Oromia estimating that up to one million people were facing severe food insecurity due to desert locust infestation. According to USAID (2022) economic and food insecurity deteriorated as the cropping season for the year 2020 coincided with invasion by desert locust swarms. The 2019 desert locust invasion in the horn of Africa played into the persistent perennial food insecurity. For instance, in Ethiopia, 8.5 million people were already facing acute food insecurity (USAID, 2022). Out of those, 6 million were in areas that experienced the 2019-2022 desert locust upsurge.

In Kenya, IPC estimated that more than 1 million people were estimated to be in food security crisis especially in counties that were most infested with desert locust such as Mandera, Wajir, Garissa Marsabit, Isiolo, Laikipia, Samburu and Turkana (Cosgrove, 2020). In April 2020, the next generation of desert locust began swarming, which coincided with the long rain planting season. By November 2020, preliminary estimates indicated that desert locusts had destroyed an estimated 175,000 hectares of rangeland and cropland, threatening economic security of close to 164,000 households

(World Bank, 2020a). By late 2020, desert locusts had been reported in 28 out of the 47 counties in Kenya. In April 2021, the Government of Kenya announced that 1.4 million Kenyans risked starvation, hunger and acute food insecurity due to desert locusts (MoALF&C, 2021).

According to FAO's Locust watch report, as of February 2022 when the upsurge was starting to decline, more than 3,000,000 hectares of farmland had been invaded by desert locust in Kenya. While the invasion had mostly affected the northern part of Kenya, it had spread to new areas posing a severe threat to human security. The invasion was also unique in that desert locusts were reported in Kipini on the Indian ocean coast (MoALF&C, 2021). This study therefore sought to comprehensively assess desert locust risks to human security in all the affected counties of Kenya, with expanded focus to food, economic, health, environmental and personal security dimension.

2.4 Desert Locust Management Practices that Protect Human Security

Desert locust is one of the most destructive plant pests and hence it poses a significant threat to human security. Given the destructive nature of desert locusts, most nations apply a comprehensive risk management approach. This incorporates preventive strategies in the form of surveillance and reactive measures to reduce the pest population through control and corrective methods in terms of recovery programs. However, due to the rare occurrence of invasions in countries such as Kenya, there is limited studies that comprehensively analyse risk desert locust management activities that are carried out in each of the three aforementioned phases. This study attempted to address this gap.

2.4.1 Surveillance of Desert Locusts

Surveillance refers to the initiatives that aim to trace, track, monitor and report desert locust populations for the purpose of forecasting breeding, assessing spatiotemporal distribution, issuing early warning and controlling the spread of the pest (Gay *et al.,* 2018, 2020; Showler *et al.,* 2021). Tabar *et al.* (2021) reported that the global strategy for desert locust management involves manual surveillance of potential breeding areas for early detection of outbreaks. In addition, Kumar and Rahman (2020) reported that forecasting of gregarization mainly involves occasional manually conducted inspections, which are both time-consuming and labour-intensive.

Lecoq (2001) acknowledged that technology-enabled surveillance systems can either complement or even supplement manual scouting. According to Cressman (2008), there have been dramatic improvements in surveillance using advanced technologies such as geographic information system (GPS) technology and global positioning system (GIS). Sharma (2014) recognizes the critical role of GIS tools, GPS, Satellite imagery, elocust2 and Reconnaissance and Management System of the Environment of Schistocerca (RAMSES) in desert locust surveillance, forecasting and early warning.

In addition, Matthews (2021) examined the use of GPS-enabled unmanned aerial vehicles (UAVs) such as drones and affirmed they could complement manual surveillance in harsh geographical terrains. For instance, studies in the Sahel and Ethiopia found that remote sensing using UAVs could supplement manual surveillance in areas where armed conflict was ongoing (Alemu & Neigh, 2022). However, there was limited analysis of surveillance tools, their securitization and potential risks during desert locust management in Kenya.

In the Sahel region, Showler (2003) found that remote sensing was an important surveillance technology that could support effective surveillance in challenging to access areas. Maiga *et al.* (2008) recommended satellite remote sensing to support surveillance, monitoring and forecasting using normalized difference vegetation index (NDVI) data in Senegal. However, he noted that NDVI could give false-positive early warning where areas with invasive evergreen species such as *Prosopis juliflora* were identified as potential locust breeding areas. Such misinformation could easily cause resource-use inefficiency amidst scarcity. Alemu and Neigh (2022) examined the different approaches to predicting breeding grounds and migration paths of desert locusts in Ethiopia and recognized the key role of satellite remote sensing.

It was discovered that use of satellite forecasting techniques to predict breeding and gregarization based on weather patterns and soil data was effective (Kumar & Rahman, 2020). In addition, the study found that recent improvements in deep learning and computer vision algorithms had enabled spotting of swarm formation with up to 83% accuracy. Tabar *et al,* (2021) also documented the potential use of predictive models to forecast desert locust movement using machine learning algorithms, artificial intelligence and deep learning. This helped to predict future patterns of migration at high temporal and spatial resolution thus augmenting and assisting human expertise. Modelling big data alongside remote sensing can therefore help to identify potential desert locust migration routes and breeding sites (Geng *et al.,* 2020; Gómez *et al.,* 2021; Kimathi *et al.,* 2020).

Geng *et al.* (2020) explored a model for examining multi-temporal MODIS and Landsat images that integrated habitat factors and landscape structure to analyse desert locust ecosystem in Tianjin China. The study found that Patch-based Analytic

Hierarchy Process (PB-AHP) could monitor desert locust habitat and breeding zones as influenced by vegetation coverage and growth status, soil moisture and salinity as well as land cover and surface temperature. While remote sensing is useful as an earth observation tool that is capable of detecting static images, it may be difficult for multispectral sensors to capture flying swarms. Despite this realization there is limited assessment of securitization of remote sensing tools and their effectiveness especially in geographically and ecologically heterogeneous topographies such as in Kenya.

The population of desert locust diminish by either migration or through mortality. As such, continuous real-time surveillance and geospatial interpolation of meteorological and agroecological data onto satellite images can offer invaluable early warning indicators to support ground scouting. The GIS and RS offer this very important component of integrating various datasets which are required for situation analysis and informed, data-driven decision making (Cressman, 2008). Geospatiotemporal (space and time) analysis therefore plays a central role in the evaluation of desert locust outbreak, hotspots analysis, assessing patterns of migration during invasions as well as planning of survey and control activities.

Since 1978, FAO Desert locust Information Service (DLIS) has been operating an early warning system that monitors weather, ecological conditions, and locust infestations in the potential breeding and affected area to prevent plagues in Africa and Asia (FAO, 2015). In the past three decades, the system has shifted from surveillance on camels to four-wheel drive vehicles, from telex to email, from map reading and navigation to GPS, from written narratives to handheld data loggers, from manual plotting to GIS, and from weather station reports to satellite-based rainfall estimates and remote sensed greenness maps.

In addition, GPS, SWARMS (Schistocerca Warning and Management System) and RAMSES applications, the Internet and eLocust3 (Android-based tablet) have been successful in replacing traditional paper-based survey/control forms, coloured marker pencils, paper-maps, pushpins and analogue telephone (Cressman, 2008). In Kenya, a mobile application (eLocust3m), a handheld satellite gadget (eLocust3g) and cloud computing with EarthRanger were used to support real-time surveillance, forecasting and early warning during the 2019-2021 desert locust invasion (FAO, 2021b).

The GIS technology allows linkage among pest densities, sociocultural, economic and environmental characteristics of certain areas thus facilitating identification of factors related to prevalence and virulence (Kimathi *et al*., 2020). As such, GIS has the ability to perform spatial analysis and hence allows leaders to make accurate and effective decisions when addressing desert locust problems. Learning about desert locust distribution patterns in a location via mapping of incidents can be extremely helpful in improving the effectiveness and efficacy of management operations (Gómez *et al.,* 2021). In addition, modelling desert locust incidents together with sociocultural, economic and environmental data can also be used to prioritise target areas for control programs, thus providing an objective guide to field teams (FAO, 2021b).

The weather-dependent life cycle of desert locusts greatly interferes with the effectiveness of uncoordinated pest management programs (Showler *et al.,* 2022). This results in a continuous need for reactive countermeasures, especially synthetic pesticide application. To reduce the effects of pesticide residues on people and the environment, there is a need for a robust early warning system to guide preventive control of desert locusts. This dilemma to balance risk and benefits makes the effectiveness and efficiency of desert locust management programs a knowledge-intensive and evidence-based operation. Desert locust management, therefore, demands continuous collection and analysis of valid and reliable data to understand pest characteristics, their distribution and environmental dynamics.

2.4.2 Desert Locust Control Strategies

The control phase of desert locust management either involves containing outbreaks to prevent upsurges or reducing the pest population during upsurges and plagues to prevent breeding and migration. However, Lecoq (2001) assessed the progress of desert locust management in Africa and doubted the feasibility of preventive actions due to geographical remoteness that limits surveillance. Desert locust control involves multiple approaches that include physical, chemical and biological methods. Retkute *et al.* (2021) also assessed desert locust control operations between 2019 and 2021 in East Africa, Middle East and Eastern Asia regions. Although the study enumerated the nature of operations undertaken in Kenya, Ethiopia and Somalia. However, there was still limited documentation and analysis of indigenous and traditional knowledge (ITK) nor cultural practices of managing desert locusts by different communities.

2.4.2.1 Physical Control of Desert Locusts

Sharma (2014) examined desert locust management activities in India and mapped the progression of control methods from traditional to new technologies. According to Sharma, physical methods that had been used to control desert locusts included burning roosting locusts at night, digging trenches to bury hoppers and ploughing pod-infested fields to deter breeding. Moharana *et al.* (2020) also assessed the status of desert locust control strategies in India and reported that farmers used garlic spray to repel them, ploughing fields where pods were oviposited to expose them, baiting the pest with wheat bran and used fire to destroy the insects.

Thompson and Miers (2002) reported that farmers in Eritrea relied on digging ditches to trap hopper bands. Ethiopia Ministry of Agriculture (2020) documented the following physical control methods: digging trenches to bury hoppers, excavation of breeding areas to expose eggs and mechanical killing of adult locusts in Ethiopia. Although Thompson and Miers (2002) considered physical methods of desert locust management as not only ineffective but also time-wasting, there is limited evidence of whether it was effective in Kenya.

While most of the physical methods of desert locust management aim at killing the pest, some of them are geared towards scaring the pest away. For instance, Chitre (2020) documented the practical use of police sirens to scare away desert locusts in India. In addition, Yuga and Wani (2022) found that 80% of affected communities in Sudan used noisemaking as a control measure against desert locusts. Peng *et al.* (2020) recommended the use of green technologies, such as sound and light simulation, to scare desert locusts. However, scaring desert locusts away with noise only transfers the threat to neighbouring areas rather than addressing the risk. There was, however, limited publication on the effectiveness of scare tactics for desert locust management in Kenya.

Apart from the mechanical destruction of desert locusts, other physical control methods have attempted to create economic and health gains from the pest. According to Kietzka *et al.* (2020), desert locusts can produce human food and livestock feed. The study examined the dietary and ecological value of desert locusts and found that they are nutritious sources of protein and carbohydrates. Stanford *et al.* (2021) found that other than being raw material for food and feed, the pest can also be used as organic fertilizer.

Acknowledging the potential of harvesting desert locusts, Kinyuru (2021) established that a sample of 100 insects contained 450Kcal energy, 32g fat, 4g fibre and 46g protein in addition to traces of calcium, iron, a-tocopherol. Mass harvesting of desert locusts as raw material and processing them into food, feed, and compost can, therefore, be considered a safe management practice (Huis, 2021). However, the use of desert locusts as raw material for human food, livestock feed and organic fertilizer may not be sustainable due to the seasonal nature of upsurges and plagues and transnational migration of the pest.

There are other physical control measures that are aimed at salvaging crops rather than directly targeting the pest. For example, Mamo and Bedane (2021) suggested that early harvesting reduced the vulnerability of mature crops to desert locust attacks. In addition, Peng *et al.* (2020) found that farm enterprise diversification could help people cope with and mitigate the impact of desert locusts. Yuga and Wani (2022) also reasserted the need to diversify crop production as a means of creating resilience against desert locusts in agricultural enterprises in Sudan. However, Kenya being an invasion country, there is inadequate evidence of either the application or effectiveness of harvesting desert locusts and resilience-building as pest management practices.

2.4.2.2 Biological control of desert locusts

Biological control is lauded as one of the most environmentally friendly methods of controlling desert locusts using predators, parasites, parasitoids and entomopathogens (Matthews, 2021). Peng *et al.* (2020) found that the use of micro-organisms, birds and insects can help to manage desert locusts. In China, Vosshall (2020) reported that aggregating pheromone, which is sensed by an odorant receptor, could be harnessed to prevent the gregarization of desert locusts. Bio-pesticides such as *Metarhizium* *anisopliae* and *Beauveria bassiana* have also been recommended for desert locust control (USAID, 2020; Githae & Kuria, 2021; Wakil *et al.,* 2022). Nonetheless, biological control methods are considered to have slow action, and their production and storage are challenging (Retkute *et al.,* 2021).

The effectiveness and efficacy of biopesticides are greatly influenced by the timing of the application during the desert locusts' life cycle, making this option less adaptable. For example, Wakil *et al.* (2022) examined the efficacy of four distinct entomopathogenic fungal formulations that included Green muscle, Green guard, *Metarhizium anisopliae* and *Beauveria bassiana* against nymph and adult desert locusts. The study discovered that the susceptibility of desert locusts to entomopathogens was greatest at the instar 3 hopper stage. At this opportune stage, entomopathogenic fungi caused behavioural changes such as reduced faecal production, minimal food consumption, and minimized weight gain. As a result, the effects caused mortality of the desert locust hoppers.

Following an FAO Orthopterist's Society workshop in Sally Senegal, the use of biopesticide *Metarhizium anisopliae* var. acridum (Green muscle) was formally introduced in Yemen to manage desert locust outbreaks. In 2009, Green muscle was used to control the Red locusts in Tanzania and was later used against desert locusts in Mauritania and Senegal (Lecoq, 2010). In 2009, the Rome-based Desert Locust Control Committee (DLCC) recommended the use of the Green muscle in the control of desert locusts in other parts of the world.

Wakil *et al.* (2022) explained that desert locusts were exposed to *Metarhizium anisopliae* conidia through at least three methods. These options include directly spraying them, secondary contact with conidia on treated vegetation, or through horizontal transmission by already-infected desert locusts during copulation or aggregation. The usefulness of entomopathogens has been witnessed in at least three effects. These effects include a reduction in feeding among acrid insects and a decrease in fecundity among other insects (Blanford & Thomas, 2001; Wakil *et al.,* 2022). FAO (2021a) found that *Metarhizium acridium* was efficacious against desert locusts at a rate of 50 g/ha (2.5 x 10^{12} spores/ha). In Niger, Mullie *et al.* (2021a) established that Green muscle had 80% efficacy 21 days after application and had no side effects on avian predators such as Lanners and Kestrels.

Blanford and Thomas (2001) sought to examine the reproduction, maturation and survival of adult desert locusts after infection with *Metarhizium anisopliae*. The study showed that adult desert locusts that were infected with the entomopathogen showed either high or rapid mortality at relatively constant temperatures. The findings also revealed that the mortality rate varied from less than 90% after 10 days under constant temperature to 66% after 70 days under optimal temperatures.

Studies on the efficacy of *Metarhizium anisopliae* against desert locusts, however, indicated sub-lethal effects on the pests' overall status, especially during the adult stage when the exoskeleton is already hardened (Blanford & Thomas, 2001). Even though the trials in Somalia during the 2019–2022 upsurge yielded positive outcomes, pesticides with more severe ecological impact, such as organophosphate-based Fenitrothion, were used in Kenya (Retkute *et al.,* 2021). There was, therefore, little research evidence of the effectiveness of the use of biopesticides during desert locust management in Kenya due to limited opportunities for field trials owing to the few invasions that are far apart in time.

2.4.2.3 Control of desert locusts using synthetic pesticides

Chemical control using synthetic pesticides is the most widely used method of managing desert locusts. Tabar *et al.* (2021) noted that the overarching strategy for desert locust outbreak control involved spraying pesticides in breeding areas. Since the 1980s, the principal control strategy for dealing with desert locus has been spraying hopper bands and swarms with pesticides. As such, control of desert locusts highly depends on the use of chemical insecticides (Wakil *et al*., 2022).

The USAID estimated that desert locust control using aircraft to spray affected areas with pesticides prevented the loss of 2.9 million metric tonnes of crop and pasture in 2020 (USAID, 2022). The report indicated that aerial spray operations safeguarded the food security of at least 19.6 million individuals and protected grazing areas for livestock belonging to 1.4 million households. It is good to note that desert locust control using pesticides has been a common practice among affected regions. For example, during the 1993-94 desert locust management campaign, about 834,400 ha of landmass was sprayed with pesticides by ground and aerial teams in Mauritania (Thompson & Miers, 2002).

During the 1986-1989 desert locust plague, about 26 million ha of land was sprayed with pesticides (Walsh, 1988; Showler & Potter, 1991). During the 1992-1994 upsurge, about 4 million ha of landmass was also sprayed with pesticides (Showler, 2003). The USAID (2020) published pesticide classes used for desert locust management as organophosphates (Malathion and Fenitrothion, carbamates (Bendiocarb), and pyrethroids (Deltamethrin and Lambda-Cyhalothrin). The efficacy of Lambda-cyhalothrin 2.5EC and Chlorpyrifos 40EC has also been confirmed (Ahmad *et al.,* 2020). Pesticides that are recommended to control desert locusts can be grouped into five pesticide classes. These categories of pesticides were used to combat the desert locust invasion in Kenya, Ethiopia and Somalia (Table 2.1).

Table 2.1 Recommended desert locust control pesticides

Pesticide class	**Active ingredients**
Biopesticide	*Metarhizium Anisopliae* Var Acridum
Insect growth regulators	Diflubenzuron, Teflubenzuron, Triflumuron
Pyrethroids	Deltamethrin, Lambda-Cyhalothrin
Carbamates	Bendiocarb
Organophosphates	Malathion, Fenitrothion

(Source: USAID – 2020)

Ahmad *et al.* (2020) studied the effectiveness of seven insecticides (Malathion 57EC, Lambda-cyhalothrin 2.5EC, Chlorpyrifos 40EC, Buprofezin 25WP, Deltamethrin 2.5EC, Pyriproxyfen 10.8EC, Metarhizium 100g/l) against desert locust. The study reported the efficacy of Lambda-cyhalothrin 2.5EC and Chlorpyrifos 40EC and recommended their use in desert locust control. A report by the FAO Locust Pesticide Reference Group (LPRG) on the efficacy of insecticides found that organophosphates (Fipronil, Diazinon and Malathion) proved efficacious against desert locusts in medium and higher dose rates but did not recommend the use of Fipronil irrespective of dosage (FAO, 2021a).

Most desert locust management pesticides can be formulated using either water as emulsifiable concentrates (EC) or using petroleum oil as ultra-low volume (ULV) formulations. Showler *et al.* (2022), while assessing the status of integrated desert locust management, documented that control operations in Pakistan depended on conventional synthetic insecticides, especially ULV and EC formulations, applied with specialized terrestrial vehicle-mounted sprayers (VMS). Sharma (2014) reported the successful use of ULV pesticide spraying in desert locust control. The use of low-depletion pesticides such as ULV formulation reduces evaporation, decreases transportation costs, and lowers handling and storage risks in addition to preventing environmental contamination (Mamo & Bedane, 2021). The FAO LPRG recommends the use of ULV to address the logistics challenges of treating large areas (FAO, 2021a).

Although there are several approved active ingredients, formulations and application platforms, Showler *et al.* (2022) reported that their selection depends on availability, cost-effectiveness, safety and environmental suitability. For example, Story *et al.* (2008) studied the optimal pesticide application rate for desert locust control in Australia. The study results revealed that, at low temperatures, with low wind speed, and in the absence of rainfall, the effective dosage ranged between 0.261 to 0.307 kg of active ingridient per ha. In addition, other than normal sprayers, Matthews (2021) found that Drones can be fitted with special nozzles that can spray pesticides.

The use of pesticides is however not only expensive but also hazardous. For example, Fipronil and Chlorpyrifos, although they have been approved by FAO's LPRG, have been rejected by USAID due to associated risks (USAID, 2020). In addition, Chlorpyrifos was associated with the decline of honey production in Ethiopia (Mullié *et al.,* 2023). Before 1980, organochlorines such as Dieldrin had been effectively used to control desert locusts. However, organochlorines were associated with persistence and hazardous consequences on humans, animals, and the environment. Recognizing the detrimental effects, the use of organochlorines was discontinued when organophosphates and carbamates were adopted to control desert locusts.

Organophosphates and carbamates are fast-acting and comparatively non-persistent (Retkute *et al.*, 2021). This minimizes their effects on non-target organisms since they dissipate quickly and do not remain biologically active for long. Nonetheless, organophosphates and carbamates are broad-spectrum compounds comprising of and exhibiting toxic effects on other insects, especially arthropods (Retkute *et al.,* 2021). They, therefore, have been linked to unintended ecological damage by interfering with biodiversity.

Mullié *et al.* (2023) expressed concerns that future procurement of organophosphates could become difficult due to environmental safeguards put in place by the European Union. In addition, Carbamates' low persistence makes them less effective, especially against adult desert locusts (Wakil *et al.,* 2022). Despite this evidence on potential harm and limitations of pesticides in controlling desert locusts, there was limited publication on their effectiveness and adverse effects in Kenya.

2.4.2.4 Integrated pest management in desert locust control

The IPM strategy entails identifying possible and effective management practices, prioritising the suitable ones, and their application at different pest thresholds. The global GAP recommends that IPM ensure conformity with phytosanitary standards that encourage the judicious use of chemical pesticides in farming. As such, physical/cultural practices always come first due to their cost-effectiveness, biological control, and judicious use of pesticides. Cultural practices such as ploughing breeding sites, trapping hoppers using trenches and burning the pest can be part of IPM against desert locust outbreaks (Sharma, 2014).

The second line of defence against desert locusts could be the use of biopeptides such as Metarhizium anisopliae and predators such as birds and ants. In contrast, synthetic pesticides, especially pyrethroids, can be used as a last resort strategy. Moharana *et al*. (2020) reported that desert locust IPM combined the use of fire with the application of chemicals by farmers in India. There is, however, a limited recommended IPM procedure that can cut across recession areas where desert locusts are always present and invasion countries where pests are seasonal.

2.4.3 Recovery Programs after Desert Locust Upsurges and Plagues

In the aftermath of upsurges and plagues, devastation by desert locusts leaves affected communities vulnerable, calling for restitution through recovery programs. When reacting to security threats such as desert locust invasion, damage should have been confirmed, necessitating restoration measures to correct the situation or rehabilitate livelihood and environmental losses. Therefore, Corrective strategies are implemented when preventive strategies are unsuccessful.

Corrective strategies entail livelihood recovery and farm-enterprise reestablishment or environmental rehabilitation. Recovery programs aim to help farmers revert to their previous economic status by providing food relief, cash transfers, or insurance in the short term and restoring crop and livestock enterprises in the long run. After the 2016-2017 desert locust invasion in Indonesia, the government implemented a strategy that involved local authorities distributing 100 megatons of stockpiled rice as emergency food relief (Lassa, 2017).

Thompson and Miers (2002) state that insurance is one of the most economically efficient corrective strategies for addressing desert locust risks. In addition, risk management analysis suggests that taking an insurance policy is an appropriate measure to protect against an event that has a low probability of occurring but has severe damage when it occurs, such as desert locust invasions (Hardeweg, 2001).

However, Showler (2018) acknowledges that insurance is impractical in countries where subsistence agriculture prevails because financial quantification of crop damage and livestock losses from desert locust invasion is difficult. Despite an attempt to document potential recovery measures after desert locust infestations, few studies were done outside Kenya and are limited in exploring other disaster recovery strategies.

2.5 Threats of Desert Locust Management Practices to Human Security

Given the destructive nature of desert locusts, risk management incorporates surveillance, control, and recovery programs. However, these ensuing management practices may threaten people and the environment (Githae & Kuria, 2021; Nasike, 2021). Limited published information exists on the threat of desert locust management practices, and hence, the proposed study sought to address this knowledge gap.

2.5.1 Threat of Desert Locust Surveillance to Human Security

Tabar *et al.* (2021) reported that the global strategy for desert locust management involves manual surveillance of potential breeding areas for early detection of outbreaks. In addition, Kumar and Rahman (2020) reported that surveillance involves manual inspections of suspected breeding areas. These human activities could, however, lead to land degradation through soil erosion, thus reducing crop productivity and threatening food, environmental and personal security. Despite an understanding that scouts' movement could threaten human security, few studies have examined the potential risks with reflection on desert locust management.

Lecoq (2001) acknowledged the important role of GPS and GIS technology in complementing manual scouting. In addition, studies in the Sahel and Ethiopia found that remote sensing using UAVs could support surveillance in hard-to-access areas (Alemu & Neigh, 2022). However, like other technological devices, malfunctions of

UAVs can cause injuries to people or cross aviation routes and cause fatal accidents. In addition, while remote sensing reduces environmental risks, it also introduces espionage risks, thus violating privacy. Despite evidence pointing to remote sensing having unintended security threats, few studies have examined the potential risks concerning desert locust management.

2.5.2 Threat of Desert Locust Control Measures to Human Security

Desert locust control involves multiple physical, chemical and biological approaches. Retkute *et al.* (2021) assessed desert locust control operations between 2019 and 2021 in East Africa, Middle East and Eastern Asia. Although the study enumerated the nature of operations undertaken in Kenya, Ethiopia and Somalia, it did not evaluate the effects of these operations on human security. The study therefore sought to address this gap reflecting on probable risks emanating from physical, biological and chemical control of desert locusts in Kenya.

2.5.2.1 Threat of physical control of desert locust to human security

Physical methods that have been used to control desert locusts include burning them while roosting at night, digging trenches to bury hoppers and ploughing pod-infested fields to deter breeding in India, Eritrea and Ethiopia (Thompson & Miers, 2002; Sharma, 2014; Ethiopia Ministry of Agriculture, 2020; Moharana *et al.,* 2020;). Although physical methods of controlling desert locusts are somewhat effective against low-level infestations, they can threaten people and the environment.

For instance, Thompson and Miers (2002) found that fire may destabilize ecosystems by interfering with biodiversity through burning vegetation cover, killing non-target organisms or even injuring people. In addition, digging desert locust breeding sites would loosen topsoil and expose it to erosion, causing land degradation and subsequently lowering the fertility of agricultural farms. Maiga *et al.* (2008) also reported that crowd-chasing of desert locusts in Senegal caused direct crop damage, exacerbating food insecurity. There is, however, limited evidence of the probable risks that physical control of desert locusts could have posed to human security in Kenya.

While most of the physical methods of desert locust management aim at killing the pest, some, such as beating objects, blowing whistles, and activating sirens and gunshots, are geared towards scaring the insects away (Chitre, 2020; Wani, 2022). However, using noise may cause fear, sound pollution, and personal security threats. Apart from mechanical destruction of locusts and scare strategies, other physical control methods have attempted to harvest the pest for food, feed and fertilizer (Huis, 2021; Kinyuru, 2021; Stanford *et al*., 2021).

Mass harvesting of desert locusts as raw material and processing them into food, feed and fertilizer can be considered a safe management practice (Huis, 2021). However, Kenya being an invasion country, migrant swarms could have been sprayed with pesticides, thus posing health security risks to people, livestock and the environment if used as raw material for food, feed or fertilizer. There was, however, limited empirical evidence of whether the collection and processing of desert locusts happened in Kenya and if this could have been hazardous.

2.5.2.2 Threat of biological control of desert locust to human security

Biological control is lauded as an environmentally friendly method of controlling desert locusts (Peng *et al.,* 2020; Vosshall, 2020). However, Githae and Kuria (2021) found that despite biopesticides being fronted as the best option in terms of safety, entomopathogenic ultra-low volume (ULV) formulations resulted in adverse effects on non-target organisms and hence threatened biodiversity in ecosystems. This study, therefore, sought to assess whether biological control was used in Kenya and the potential threats it might have caused.

2.5.2.3 Threat of chemical control of desert locust to human security

There is always a challenge in balancing the benefits and risks of using synthetic pesticides in desert locust management (FAO, 2005). Tabar *et al.* (2021) noted that the overarching desert locust outbreak control strategy involves spraying pesticides in breeding areas. However, the use of pesticides as the first line of control at the expense of IPM can trigger unforeseen health and environmental security threats, especially when safety precautions and application rates are ignored. For instance, Abou-Ali and Belhaj (2008) found that more than 1000 people involved in desert locust spraying were removed from operations for illness in Morocco, Sudan and Eritrea.

In addition, Showler (2021) documented the adverse effects of anti-locust insecticides on human health among pesticide applicators and handlers. Emana (2002) found that farmers became contaminated after applying pesticides, working in recently treated fields, consuming pesticide-contaminated water, having contact with polluted air or soil, and consuming crop or animal products with chemical residues. Despite this realization, little information was available on the effects of desert locust pesticides on personnel, community members, and the environment in Kenya.

Tingle *et al.* (2003) recounted that field-based evidence indicated that control of desert locusts with synthetic pesticides posed a risk to fish, birds and aquatic animals. Mullie *et al*. (2021a) reported that desert locust pesticides led to the mortality of birds and arthropods in Senegal. In addition, Worku *et al.* (2022) documented that desert locust control pesticides harmed worker bees in Ethiopia. Mamo and Bedane (2021) also published that high-level depletion of synthetic pesticides has severe environmental hazards and health risks. However, there was limited information on the effects of desert locust management pesticides on non-target organisms and the environment in Kenya.

Showler (2021) documented the dilemma of disposing of large stocks of residual, unusable, expired and obsolete pesticides that accumulate in countries affected by desert locusts. The study also noted the severe problem of handling empty pesticide containers as the public has a high demand for reusing them for water and food storage, posing health security risks. Despite this evidence on the potential danger of expired pesticides and resultant empty containers to humans and the environment, there was limited publication on their human security threats in Kenya.

2.5.3 Threat of Desert Locust Recovery Programs to Human Security

Recovery programs were meant to help affected farmers restore their livelihoods after crop and livestock losses. Recovery programs could, however, have created unforeseen risks such as corruption, favouritism, nepotism and even sexual exploitation and abuse. Although the Emergency locust response program had a grievance redress mechanism, there was limited publicly accessible information on human security risks that emerged during desert locust recovery programs. The study, therefore, sought to evaluate the potential threats that could have emanated from recovery programs during desert locust management in Kenya.

2.6 Challenges During Desert Locust Management

Upsurges and plagues are complex due to biological, meteorological and geographical factors that play different roles, in either facilitating breeding and migration of desert locusts, or disrupting surveillance and control operations. Due to the complexity, desert locust management, as a national disaster response operation, is therefore not only resource-demanding but also labour-intensive (Belayneh, 2005). Challenges usually experienced during desert locust risk management can be clustered into financial, human, technical and physical limitations.

It was observed that insufficient funding for desert locust control operations is a major challenge (GOK, 2022; Showler, 2003). Thompson and Miers (2002) reported that most affected countries rely on international assistance to facilitate desert locust management programs financially. In most cases, this international assistance comes in the form of loans that have to be repaid with interest and hence pose economic security threats to affected countries. Even with possible support from international partners, the economic downturn occasioned by the COVID-19 pandemic made donor countries' financial independence difficult.

On average, desert locust management activities are estimated to cost approximately 38 million US dollars annually (Babah & Sword, 2004). For example, the famous 1986-1989 desert locust plague had an expenditure of over 300 million US dollars (Showler & Potter, 1991; Walsh, 1988). In addition, from 1992-1994, more than 19 million US dollars were spent on desert locust management activities (Showler, 2003). The total cost of Mauritania's 1993-1994 desert locust management was approximately 9,565,900 US dollars (Thompson & Miers, 2002).

The initial assessment by FAO (2020b) showed that financial support equivalent to at least 138 million US dollars was needed for desert locust management and livelihood protection for about 110,000 households. In addition, USAID (2021) reported that more than 38.8 million US dollars were needed for emergency intervention to manage desert locusts. Without a desert locust upsurge, this money could have gone towards economic development, thus improving many people's lives. Desert locust emergency, therefore, affects economic security indirectly. This study, therefore, aimed at assessing how these challenges prevented interventions from protecting human security in Kenya.

Rugged terrain is documented as one of the challenges during desert locust management (Showler *et al.,* 2022). Showler (2021) also documented geographical remoteness and expansiveness as other challenges. For example, some of the most critical breeding habitats, such as the "Empty Quarter" in the Arabian Peninsula, are geographically inaccessible for continuous surveillance and early intervention for preventive control (Hardeweg, 2001). This makes the area an essential epicentre of many outbreaks as it facilitates spring breeding in the interior of Yemen and Oman.

Besides complicating spray operations, hilly landscapes may also increase the risk of aircraft accidents. Ground and aerial spraying can also be made difficult by obstacles such as isolated stands of trees or forested areas, power lines, property boundaries and administrative borders (Story *et al.*, 2008). Gay *et al.* (2018) found that geographical remoteness could deter surveillance and control. Besides personal security threats regarding accidents, these obstacles slow down desert locust management and hence facilitate outbreaks, upsurges and plagues.

The FAO LPRG recommended using ULV-formulated pesticides to address the challenge of remoteness and expansiveness of desert locust-infested areas (FAO, 2021a). However, Showler (2021) documented poor pesticide handling skills, improper maintenance of equipment and wrong pesticide application rates as challenges that threaten health security. In addition, Mamo and Bedane (2021) also reported that ULV formulations cut transportation costs and lower handling and storage challenges. However, Githae and Kuria (2021) found that ULV formulations resulted in adverse effects on non-target organisms, thus threatening environmental security, mainly if Diesel is used instead of plant-based oils.

Showler (2003) noted that insecurity and armed conflict posed a challenge when managing desert locusts in Asia and Africa. In addition, it was essential to recall that Kenya had a serious desert locust invasion during the wars of self-determination against colonial governance in Africa. In addition, the most recent invasion in Kenya coincided with post-election violence in 2007-2008. The recent upsurge also happened during the war in Yemen, which could have prevented active assessment surveys to identify potential outbreak areas for early intervention (FAO, 2021b). Moreover, insecurity and armed conflicts create leeway for the use of security forces and UAVs that pose personal security risks as they create fear among community members.

Showler (2021) found that the activation of emergency response instead of a preventive approach was due to limited funds, unpreparedness, competing interests, inaccessibility of breeding areas, ill-defined responsibilities and armed conflict in parts of Ethiopia, Somalia and Sudan. In addition, COVID-19 containment measures significantly restricted movement and social distancing, prevented group training and hence exacerbated the risks in Ethiopia (Kassegn & Endris, 2021).

The highlighted studies documented various challenges of managing desert locusts in other parts of the world, especially the recession areas. However, there was inadequate documentation of challenges that Kenya experienced during desert locust management and how they could have exacerbated human insecurity. This study intended to address this gap.

2.7 Desert Locust Management Best Practices to Protect Human Security

Faced with the paradox of securitization of desert locust management, this study sought to determine best practices that could help to balance the benefits and costs of rapid and extreme interventions. Cost-benefit considerations could have helped to safeguard human security by reducing the chances of introducing unintended threats. In addition, the principal of do no harm of security risk management demands de-securitization (Holliday & Howe, 2011), to ensure response to and recovery from desert locust infestations does not trigger unintended insecurities. Some published best practices in desert locust management included non-intervention, early intervention and integrated pest management.

2.7.1 Non-Intervention to Desert Locust Upsurges and Plagues

Showler *et al.* (2021) observed that from a global perspective, agricultural loss due to desert locusts was usually too small to warrant huge investment in control operations. Recognizing this fact, one of the desert locust management approaches could be to permit outbreaks to develop into upsurges or plagues and run the full cycle, ending up in natural mortality, then initiate recovery. Recovery programs would then compensate farmers for crop and livestock losses through food relief during the infestation or restitution using cash transfers or insurance.

The rationale behind non-intervention approach is that recovery programs such as food relief, cash transfers, and insurance are cheaper than early intervention and emergency response through pesticide application. Since agriculture is the most significant contributor to Kenya's GDP, evaluating non-intervention against other desert locust management options is crucial. According to Thompson and Miers (2002), insurance is an economically efficient strategy for managing desert locusts. Risk management analysis suggests appropriate measures to protect against an event that has a low probability of occurring but has severe damage when it occurs, such as desert locust invasions, is to adopt an insurance policy (Hardeweg, 2001).

Insurance against natural events, such as desert locust-related crop damage, is however still relatively rare in developing countries such as Kenya (World Bank, 2020b). In the absence of any examples that would give estimates of the administrative costs of desert locust insurance schemes or farmers' willingness to pay, it would be difficult to assess the feasibility of such a scheme. In addition, it can be hard to determine if insurance would be more economically efficient than reactive strategies where desert locusts are sprayed with expensive pesticides.

2.7.2 Early Intervention to Desert Locust Outbreaks

Preventive strategy through early intervention is lauded as a best practice in desert locust management because it hastens rapid return to recession status by averting the advancement of outbreaks to upsurge (Gay *et al*., 2018, 2020). In Australia, Magor *et al*. (2008) noted that outbreak control within recession areas through early intervention could help contain infestation before gregarization. However, preventive management of desert locusts depends on the efficiency of outbreak suppression in breeding areas (Showler, 2018; Showler *et al.*, 2021).

The preventive intervention through early action assists in hastening the return to the recession status and averts the graduation of outbreaks to upsurges and plagues. For example, preventive control thwarted a potential upsurge in 2007-2016, during which possible outbreaks were controlled within five months (Showler, 2018). In contrast, the absence of preventive intervention facilitated the 2003-2005 upsurge (Belayneh, 2005). However, early intervention through preventive control happens within a very limited window of opportunity.

To maximize outcomes from preventive control, the timing of chemical interventions through spraying insecticides on early incidents of outbreaks is important. To detect early incidents of outbreaks, surveillance should be adequate to enable the identification of the onset of gregarization. Showler *et al.* (2021) reported that it is not yet clear how effective surveillance can be achieved to enable early detection of outbreaks for early action. Showler (2003) documented the importance of remote sensing in forecasting desert locust presence to trigger early intervention.

Latchininsky *et al*. (2011) lauded the increasing use of remote sensing and GIS as potentially effective means to enhance the detection of potential outbreak areas for targeted early interventions. One practice that has facilitated early intervention is an effective early warning system (Mamo & Bedane, 2021). Early warning enables prediction and determination of areas that provide desert locusts with favourable breeding grounds, which are prone to outbreaks. Early warning translates into early action through effective ground monitoring, timely preventive control and reactive recovery measures.

Early warning also enables governments, communities and other stakeholders to prepare for desert locust management. Latchininsky *et al*. (2011), therefore, lauded the increasing use of GIS and remote sensing of weather variability as critical means for enhancing the effectiveness of desert locust surveillance, forecasting and early warning. However, Showler *et al.* (2022) noted that despite clear weather-based forecasts, India and Pakistan ignored FAO's early warnings leading to low preparedness to respond to the recent upsurge. In Australia, Magor *et al*. (2008) noted that early intervention to control outbreaks in recession areas helped to contain infestation before gregarization thus preventing upsurges.

Reliable forecasting however requires surveillance in recession areas to be continuous, strategic and effective to enable early detection of initial incidents of gregarization. Early detection to support precise and prompt early interventions against desert locusts is therefore not only difficult but is also a complex process (Gay *et al*., 2020; Ferrand, 2020; Showler *et al.,* 2021). This is because surveillance of desert locust ecology is highly fluid as it can change rapidly based on weather variability, vegetation greenness and resource availability (FAO, 2001b).

Surveillance has, however, benefited from technological advancement, and therefore, predictive modelling can progressively be achieved. For instance, several technological innovations support desert locust surveillance, such as remote sensing imagery, helicopters, unmanned aerial vehicles, GPS equipment and satellites (Cressman, 2008; Sharma, 2014). However, technology alone cannot solve surveillance, forecasting and early warning needs. As such, automated surveillance should also be complemented by trained scouts from the ground to identify where prevailing conditions favour outbreaks (FAO, 2021b). Surveillance data can also be obtained from local farmers, military personnel, administrative authorities, tourists and nomads (Symmons & Cressman, 2001).

Preventive control of desert locusts can be summarised as preventing outbreaks, slowing down upsurges and abating plagues (Joffe, 1997). If preventive control is successful, risks from desert locusts can be reduced. However, preventive control is seldom 100% successful (Thompson & Miers, 2002). This is because monitoring sparsely populated solitarious desert locusts in remote areas is difficult. In addition, in the past, human crises such as the war in Yemen have prevented the effective implementation of prevention control measures (FAO, 2021a).

The alternative to prevention control has been to wait until gregarization has occurred and swarms have emerged, and hence, a targeted response is possible through reactive strategies. At such a stage, reactive strategies through ground and aerial spraying of pesticides become inevitable. Early intervention, therefore, happens within a very limited window of opportunity, and hence, it may only be practical in recession areas. It is, therefore, critical to maximize outcomes through the proper timing of targeted chemical interventions. However, chemical control poses health and environmental security threats. The study, therefore, aimed at determining the next best practice faced with this normative dilemma.

2.7.3 Integrated Pest Management in Desert Locust Control

The IPM approach is cited as a best practice for many plant pests and diseases. The IPM entails identifying possible management practices, prioritising the most practical approaches and their application at different pest thresholds. The global GAP recommends that IPM comply with phytosanitary standards that encourage the judicious use of chemicals in agriculture. As such, physical/cultural practices always come first due to their cost-effectiveness, biological control, and judicious use of pesticides. Lecoq (2001) found that the existing desert locust control activities included IPM approach and precision spraying.

In Pakistan, Showler *et al.* (2022) noted that IPM involved application of oil-based pesticides in combination with non-conventional control methods. In India, Sharma (2014) recognized the role of ITKs in desert locust IPM where traditional methods are practiced in combination with chemical control. In spite of evidence on IPM for desert locust in other parts of the world, limited research had assessed desert locust IPM practices in Kenya to contribute to the existing pool of knowledge. This study sought to use field experiences from practitioners and the general public to determine desert locust management best practices in Kenya.

2.8 Theoretical Framework

This section highlights the study's theoretical foundation. The study used propositions of securitization and resilience theories. Securitization theory was used to explain the consideration of desert locust invasion as a human security issue. The theory also expounds on the threat of securitization of desert locust management. Resilience theory was used to explain mitigative and adaptive measures to absorb internal and external shocks from desert locusts and securitized interventions.

2.8.1 Securitization Theory

Securitization theory is attributed to scholars of the Copenhagen school, especially Barry Buzan, Ole Weaver and Jaap De-Wilde (Buzan *et al.*, 1998). Securitization is the theoretical perspective that emerged in response to, what was considered, realism's narrow conceptualization of security. The constructivists and post-constructivists challenged realism for not appreciating the social construction of security threats. As such, securitization theory is considered one of the perspectives that emerged to draw attention to other aspects of security that were not directly linked to threats to the State.

The main proposition of securitization theory was the social construction of security through speech act and the notion that any issue could be securitized. Securitizing actors are politicians and decision-makers such as ministers with social and institutional power to elevate an issue beyond normal politics (Stritzel, 2007). Securitization of issues is, therefore, the act of elevating a threat such as desert locust invasion from a low-priority agricultural concern to a high-priority political issue with a national security profile. A securitized issue is framed as an existential threat to people (Balzacq, 2011).

Securitization theory helped to broaden and deepen the concept of security beyond national interest as the focal point, and away from the 'Nation-State' as the dominant unit of analysis (Stritzel, 2007). As such, the Copenhagen School considered five aspects of security that were not traditionally considered core dimensions of security. These five aspects include the economy, politics, society, environment and the military (Collins, 2006). In this way, scholars developed a parallel understanding of human security that focused on four aspects: freedom, identity, development and survival.

Within this extended understanding of security and threats, it is possible to conceptualize the securitization of desert locust management and its threat to human security. For instance, desert locust invasion was labelled as a national security risk that posed existential threat to humans. Therefore, these heightened security threats are faced with the need for urgent and extreme countermeasures. According to Eroukhmanoff (2018), issues that seem to have extreme security risks are dealt with urgently when they are labelled dangerous, menacing, threatening or alarming.

In relation to this study, the desert locust invasion of 2019-2021 was securitized by international organizations and politicians at both county and national levels by publicising it as a natural disaster through mass media. Desert locust invasion was framed as a national security issue that required emergency response. Securitization of desert locust management allowed everyone (individuals, communities, government, and partner agencies) to use every available means (cultural, physical, chemical, and biological) to deal with the pest. These haphazard interventions were oblivious to the dangers that some of the practices could pose.

Securitization theory was selected based on its strengths of expounding on the "normative dilemma" (Huysmans, 2002). The normative dilemma illustrates a situation where efforts to protect human security from desert locust risks could have produced unintentional threats to human security (Huysmans, 2002). The theory informed the study of human security dimensions that could have been threatened by desert locusts unintentionally and subsequent risks from securitised pest management practices. Securitization theory, therefore, illuminates the need to analyse the effect of urgent, extreme and large-scale risk management practices that were used to manage desert locusts.

2.8.2 Resilience Theory

The securitization theory provided an opportunity to understand threats from desert locusts and securitized interventions. It, however, did not fully account for desert locust management challenges and modalities of addressing them to make people and ecosystems more resilient through mitigation or adaptation. Resilience theory sought to address this gap. Resilience is the capacity of technological, ecological or social systems to adapt to interruptions, undergo adjustment and retain functionality, structural capability, identity and responsiveness (Breda, 2018).

The principles of resilience theory were initiated by Holling in 1973 to try and reconcile concepts of ecosystem changes with ecological stability (Breda, 2018). Resilience theory acknowledges the inevitability of transformation and seeks to continuously influence sustainable change in ecosystems and societies. According to Carlson *et al.* (2012), a resilient system should lower the chances of failure, and reduce the consequences of such failure in terms of loss of lives, damage and adverse economic effects. Resilience also increases the recovery speed in terms of restoration to average performance (Carlson *et al*., 2012).

As such, resilience is a key element in understanding the sustainability of ecological and social systems. Risk management practitioners, therefore, consider resilience as a tool for understanding how people manage the effects, stresses and shocks that affect their lives and livelihoods in terms of resultant outcomes (Matter *et al.,* 2021; Ayeb-Karson*,* 2015). Resilience theory, therefore, provided a justification for securitization of desert locust management through urgent, extreme and large-scale interventions. This is because securitized interventions reduced desert locust risks, protecting people's lives and livelihoods.

Resilience theory, however, recognizes that disturbances in an ecosystem carry with them opportunities, which could end up being beneficial to people and the environment rather than being counterproductive (Folke, 2016). On one hand, securitization of desert locust risk management using urgent, extreme and large-scale interventions posed some unforeseen human security threats. On the other hand, it created opportunities for resilience-building through capacity building and development of early warning systems that would enhance preparedness against similar risks in future.

Resilience theory also illuminated the need to analyse the challenges that could have exacerbated risks from desert locusts and securitized pest management practices. Such challenges can easily be turned into opportunities. For instance, limited desert locust technical experts meant that the urgent need for training resulted in rapid capacity building of personnel whose acquired knowledge and skills would stay to serve other pest management activities. Resilience theory therefore envisions a situation where identified opportunities could be used to customize risk management best practices that balance resultant cost with benefits to yield a win-win outcome. This way, both social and ecological systems stand to benefit in a sustainable mutual interaction.

2.9 Conceptual Framework

The conceptual framework is a visual representation of the anticipated relationship between the independent variable (desert locust management) and dependent variable (human security), as shown in Figure 2.1. The study had also anticipated the operating environment as an intervening variable.

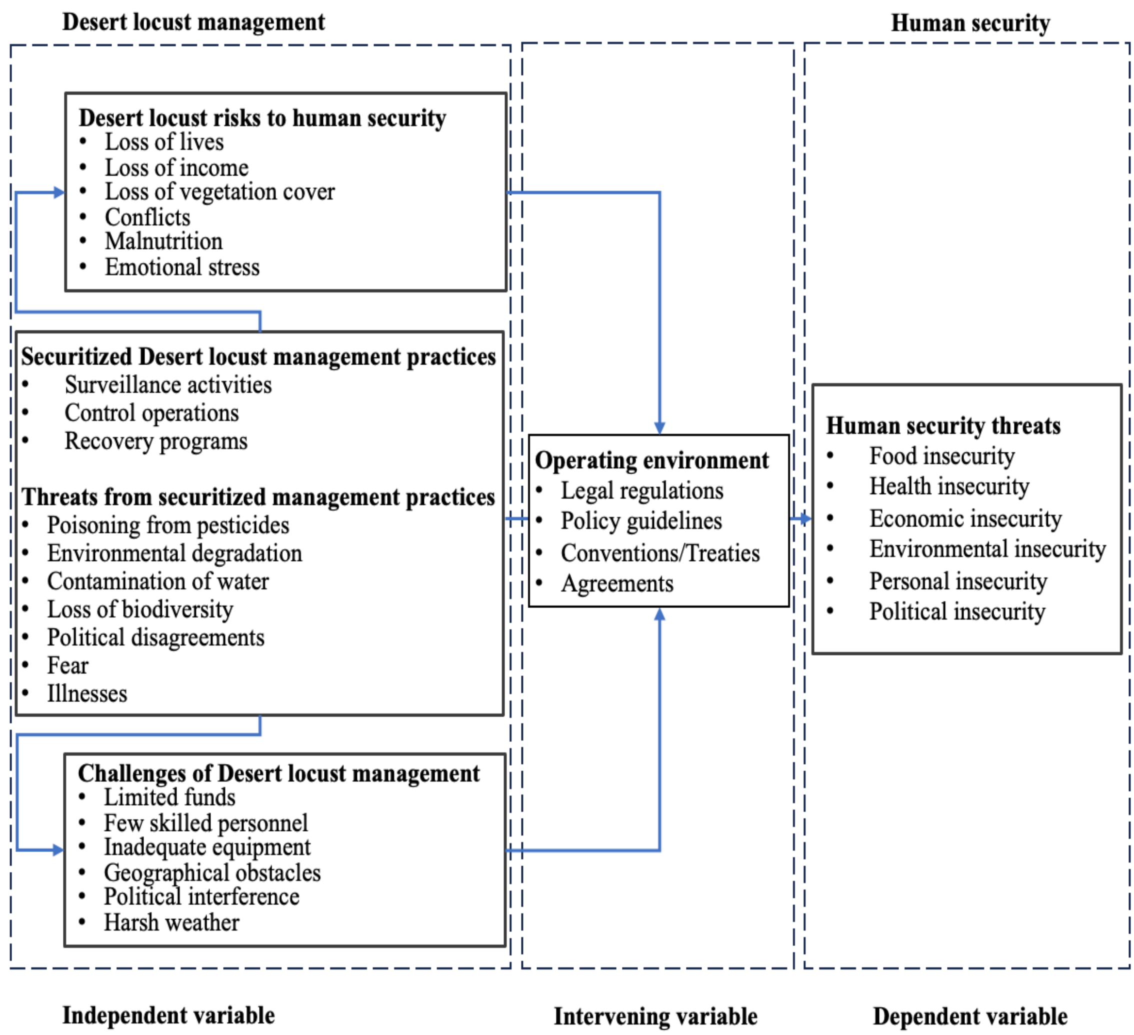

Figure 2.1 Conceptual framework (Source: Field data – 2024)

Indicators of desert locust management included risks from pests, securitized practices, threats from securitization and operational challenges. Indicators of human security threats were food, health, economic, environmental, personal and political insecurities. Predictors of desert locust risks included loss of lives, income and vegetation cover, conflicts, malnutrition and emotional stress. Predictors of securitized desert locust management practices were analysed with reflection on surveillance activities, control operations and recovery programs.

Predictors of threats from securitization included poisoning, environmental degradation, contamination of water, loss of biodiversity, political disagreements, fear and illnesses. Predictors of desert locust management challenges included limited funds, few skilled personnel, inadequate equipment, geographical obstacles, political interference and harsh weather. Indicators of the operating environment included regulatory and institutional structures in terms of legal regulations, policy guidelines, conventions/treaties and service-level agreements.

CHAPTER THREE

RESEARCH METHODOLOGY

3.0 Introduction

This chapter covers the research design, study area, target population, and sample methodologies. It also describes the research tools and methodologies employed for data collection, analysis, and presentation. Finally, the chapter delineates the ethical considerations that were adhered to throughout the study.

3.1 Research Design

Research design is the strategy underpinning data collection and analysis, which ensures the coherent and logical integration of the elements of research (De-Vaus, 2001). The study employed a mixed methods approach using ex-post facto evaluation and cross-sectional survey designs to retrospectively analyse the relationship between desert locust risk management and human security in Kenya. This provided an opportunity to assess the experiences of managing the pest from December 2019 to November 2021. The study deployed mixed methods to leverage the triangulation of quantitative and qualitative data drawn from multiple groups of respondents from diverse geographical locations.

3.2 Study Area

The study was carried out in Kenya, among the nine countries that experienced a significant upsurge in desert locust activity between 2019 and 2022 in the East and Horn of Africa region. Kenya was unique since it had not had such a severe desert locust invasion in several decades. The unit of analysis consisted of the counties that reported instances of desert locusts. The study relied on the Ministry of Agriculture and Livestock Development (MoALD) rapid assessment report, FAO bulletins, the

2020 Kenya Red Cross report, and the Emergency Locust Response Program (ELRP) project documents to target 30 counties affected by desert locusts (Figure 3.1).

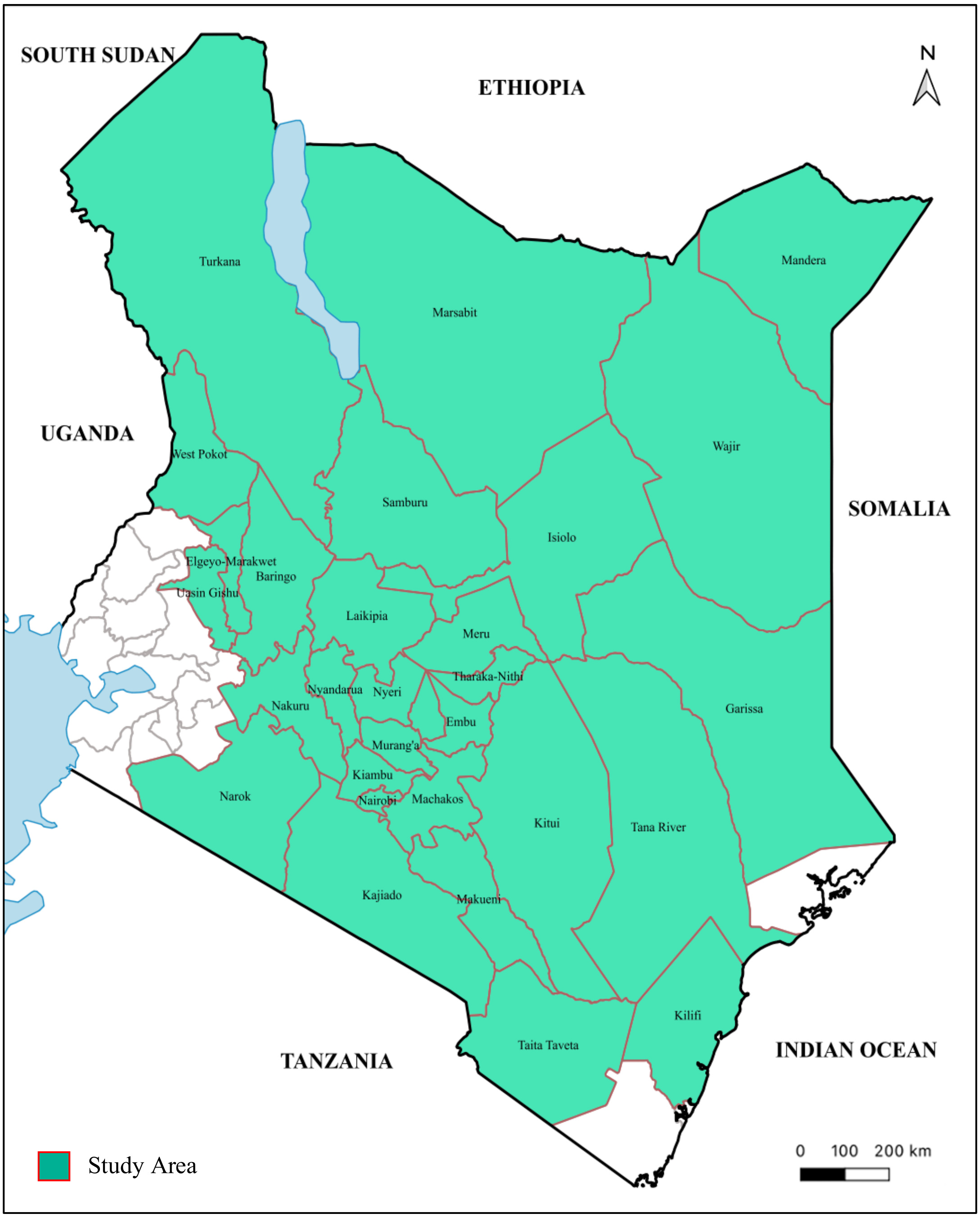

Figure 3.1 Map of the study area (Source: Author – 2024)

3.3 Target Population

The target population included people who were affected and participated in desert locust management. The population included general public/community members, national government employees, county governments and international /non-governmental organisations (I/NGOs). The general public was represented by affected farmers and community scouts who participated in monitoring and reporting of desert locust incidents. The national and county governments were represented by the personnel of MoALD, departments and agencies who participated in desert locust management activities. The I/NGOs were represented by field officers who supported desert locust management surveillance, control and recovery activities.

3.4 Sampling Technique and Sample Size

This study used a multistage sampling technique to identify and select respondents. Out of the East and Horn of Africa countries that experienced the 2019–2022 desert locust upsurge, Kenya was purposively selected as one of the most affected invasion countries (FAO, 2021). Purposive sampling was also used to select desert locust-affected counties based on the spatiotemporal distribution of reported incidents and published assessment reports. In addition, purposive sampling was used to target only people affected by or who participated in desert locust management. Specific respondents were then selected using systematic random sampling from an alphabetically ordered national database of people who participated in desert locust management operations or benefited from recovery programs as key informants. From the predetermined list of potential respondents, every (N/n) person per cluster was selected to participate in the survey.

The study targeted 900 respondents, as shown in Equation 1. According to Roscoe (1975), a sample size of 30-500 is appropriate for most research studies. However, the higher the sample size, the lower the margin of error and vice versa. The high number of target respondents also reduced the chances of type 1 error where false positive inference is made from research findings.

Equation 1

$$\boldsymbol{n} = \frac{Z^2pq}{d^2}$$ (Fisher *et al.*, 1998) in which:

n represents the desired sample size

Z is the standard deviation

p represents the proportion of the target population with features being studied

q=1-p

d is the level of statistical significance at a 5% margin of error

Therefore:

$$\boldsymbol{n} = \frac{(3.0)^2\ (0.5)(1-0.5)}{(0.05)^2} = 900$$

3.5 Research Instruments

This study collected primary data using a structured questionnaire and focus group discussion (FGD). Research objectives informed the framing of various questions. The questionnaire had closed and open-ended questions, as shown in Appendix 2. The questionnaire was intentionally prioritized due to its potential to give respondents anonymity and independence when answering questions. The questionnaire was also digitised using the Kobocollect toolkit to ease administration and reinforce participants' independence when responding. One-day seminars, which were FGDs, were carried out in the 30 target counties to generate deeper insights into the issues being studied.

3.6 Validity and Reliability

Validity is the degree to which the measurement procedures accurately address the demands of the studied concepts (Case, 2007). Construct validity was achieved by aligning specific objectives to the research goal and operationalising variables according to the respective objectives. In addition, content validity was achieved by ensuring key domains, as outlined in the objectives, were accurately and adequately included in the tool. The tool was also reviewed through consultations with supervisors and subject matter experts who assessed and proposed amendments to enhance the readability, clarity and comprehensiveness of questions. Data was collected from various clusters of people (national and county government employees, community and NGOs) to reduce institutionalised biases. Both quantitative and qualitative datasets were triangulated to provide a corroborative discussion of the findings.

Reliability refers to the level at which outcomes acquired through measurements can stay stable over time. To ensure that questions were reliable regarding dependability, stability, and predictability, a reliability assessment was done through a pilot study with respondents excluded from the final sample size. The presence of duplicate records in the final dataset from people who submitted the online questionnaire more than once also helped to carry out test-retest reliability.

Framing of variable predictors/constructs as positive and negative statements ensured interrater reliability. Reliability was also assured by reducing the chances of type 1 and 2 errors that could have led to false positive and false adverse inferences, respectively. This risk was managed by having a large sample size and choosing appropriate data analysis techniques with consideration of resultant dataset as ordinal with abnormal distribution and outliers.

3.7 Pretesting of Research Instruments

To test the research questionnaire, a pilot study was carried out in Narok County, targeting 15 respondents who were excluded from the final sample of respondents. Despite having had limited desert locust infestation, Narok County was purposively identified for piloting because of its heterogeneous geographical morphology encompassing both low and high-potential agricultural landscapes. Data from the pilot study was then subjected to Cronbach's alpha reliability test to make sure that the research questionnaire was clearly understood and correctly responded to by participants. According to Bolarinwa (2015), the normal range of Cronbach's alpha reliability is between 0 and 1. However, the closer Cronbach's alpha is to 1.0, the greater the internal consistency. The Cronbach's alpha reliability for the pilot data was 0.82, while that of the actual data was 0.89.

3.8 Data Collection Techniques and Procedures

A research questionnaire was digitized using the Kobocollect toolkit for online distribution and remote filling by respondents. While distributing the questionnaire, the researcher also attached an official invitation letter to email and social media. The letter encouraged respondents to voluntarily participate and feel free to withdraw their participation at any stage when responding to the questions. The invitation letter also highlighted the rationale for the study and assured participants that their identity would remain undisclosed. The online questionnaire remained active for 30 days, but the researcher monitored and downloaded submissions daily for backup. At the end of the data collection period, all the data was downloaded in Excel and SPSS label formats for analysis.

After the administration of the questionnaire was completed and preliminary analysis of resultant data was done, one-day seminars in the form of FGD were organised at county and national levels to get deeper insights into the issues being studied. During county-based FGDs, an independent but heterogeneous team of 10 participants was invited to a central venue. The FGD membership was drawn from farmers, community scouts, county directors of agriculture, county agricultural officers, I/NGO staff and chiefs from locations that were affected by desert locusts. The approach enabled the researcher to obtain relevant qualitative data from information-rich individuals. This helped to enrich the discussion by corroborating and/or disputing responses from the questionnaire.

The national FGD invited 20 participants. These participants were drawn from farmer representatives, national, regional, and international plant protection agencies, research organizations, ministries, departments, semi-autonomous agencies, institutions of higher learning, and private sector organizations. The national FGD targeted people who directly participated in or supported desert locust management during the 2019–2021 invasion in Kenya.

3.9 Data Analysis and Presentation

Both quantitative and qualitative methods were used to analyse the collected data. Quantitative data was collated, coded and analysed statistically using descriptive and inferential statistics aided by the Statistical Package for Social Sciences (SPSS). The study used descriptive statistics (frequencies and percentages) and inferential statistics (regression test) to analyse the data. Non-parametric statistical test was preferred because the collected data was ordinal, did not assume a normal distribution, and had several outliers whose removal or regularization could have affected inferences from the findings. Relationship among variables was tested using ordinal logistic regression.

Non-parametric test reduced chances of type 1 error where false favourable inference is made from research findings. Qualitative data from FGD was analysed using content analysis and thematic review. Content analysis entailed scrutinising frequencies of key terms associated with several constructs framed as predictors of specific variables (Holsti, 1980). The thematic review comprised the identification of important themes emerging from qualitative data that were related to specific objectives. The summaries of the thematic review were used to complement the discussions in relation to each specific objective.

3.10 Ethical Considerations

The study followed Kenyatta University's stipulated proposal development and thesis writing guidelines. The proposal was processed through Graduate School, which provided authority to carry out the fieldwork. The proposal was also assessed for compliance with participants' recruitment and data protection guidelines by the Kenyatta University Ethics Review Committee (KUERC) and the National Commission for Science, Technology and Innovation (NACOSTI).

An official letter was issued to all respondents, inviting them to voluntarily participate in the study. The letter also assured participants that their identity would remain undisclosed and that they had the freedom to withdraw from the study at any stage. Informed consent to, voluntary participation by, and confidentiality of respondents was strictly observed. The researcher also respected copyrights by ensuring that all sources of borrowed materials and ideas were properly cited and referenced appropriately.

CHAPTER FOUR

DATA ANALYSIS, PRESENTATION AND DISCUSSION

4.0 Introduction

This chapter provides a thematic analysis of field data, presents findings, and discusses the same. It examines response rates and socio-demographic data based on the study objectives, including risk assessment, securitized management techniques, threat appraisal, challenge identification, and best practices. The study also examines participant characteristics, such as county, gender, age, education level, and organizational affiliations.

4.1 Response Rate

The sample size for the study was 900 respondents. The respondents were invited to remotely fill out an online Kobocollect questionnaire. Some 93 questionnaires were excluded from the analysis for lacking more than 75% of responses, while 28 questionnaires (from respondents who had made more than one submission) were excluded as duplicates. After the data-cleaning exercise, 779 (86.6%) questionnaires were considered for analysis. A high rate of responses reflects satisfactory data quality, and at least 70% of responses are acceptable (Stoop *et al*., 2010). The response rate was considered high and sufficient to provide insights to address the specific objectives.

The number of valid questionnaires that were considered for analysis from each of the participating counties is represented in Table 4.1. The number of respondents varied among the counties. Marsabit and Kitui counties had the highest number of valid respondents at 40, followed by Wajir with 38, while Uasin Gishu county had the lowest response rate. The high number of respondents from Marsabit and Wajir counties could be attributed to the fact that these were the most affected counties during the desert locust invasion in Kenya. The contrast is true for Uasin Gishu County, where the few responses could be attributed to the fact that the county was among the least affected.

4.1.1 Socio-Demographic Characteristics of Respondents

Social demographic data collected during the study included sex, age, education level and organizational affiliations (Table 4.1).

Table 4.1 Frequency and percentage of respondents per county

County	Frequency	%	County	Frequency	%
Marsabit	40	5.13	Embu	27	3.47
Kitui	40	5.13	Elgeyo Marakwet	27	3.47
Wajir	38	4.88	Nyandarua	26	3.35
Isiolo	36	4.62	Kirinyaga	25	3.21
Turkana	34	4.36	Nakuru	24	3.08
Mandera	34	4.36	Meru	23	2.95
Garissa	33	4.25	West Pokot	22	2.82
Baringo	32	4.11	Nyeri	22	2.82
Laikipia	31	3.98	Murang'a	20	2.57
Tana River	30	3.85	Kilifi	17	2.18
Nairobi	30	3.85	Taita Taveta	14	1.8
Machakos	30	3.85	Kiambu	12	1.54
Makueni	29	3.72	Narok	10	1.28
Tharaka Nithi	29	3.72	Kajiado	9	1.16
Samburu	28	3.59	Uasin Gishu	7	0.9
			Total	**779**	**100**

(Source: Field data – 2024)

There were more males (80.6%) respondents in the study compared to females (19.4%). The high number of male respondents is due to the nature of desert locust management operations that are carried out in geographically remote locations and hence require some level of resilience that could be associated with masculinity. The majority of respondents were youths at 50.4%, middle-aged respondents represented 48%, while only 6 (1.6%) old people participated in the study. The high number of respondents who were youths is due to the active participation of young Kenyans either as community scouts or NYS spray-serve providers and the fact that the questionnaire was administered through a digital platform.

Out of the total number of participants, 31.6% of respondents had a degree certificate while 0.5% were PhD holders. Primary, secondary, certificate, diploma and master's education holders represented 2.2%, 11.3%, 22.8%, 21.1% and 10.5% of respondents, respectively. The high number of respondents with undergraduate degree qualifications could be attributed to the participation of national and county government employees whose recruitment qualification is a university degree. The low number of respondents with PhD qualifications is due to the limited number of scholars who served in Kenya's little-known field of desert locust management before the 2019 invasion.

Out of the total number of participants, 40.3% of respondents were from county government, while 7.8% were affiliated with I/NGOs (Table 4.2). The high number of responses from county governments could be attributed to the fact that agriculture is a devolved function and hence there was active participation of county employees in desert locust management operations. Community members and national government personnel represented 30.2% and 21.7% of respondents, respectively. The high number of responses from national government could be attributed to the fact that management of migratory pests is still a national function despite devolution of agriculture, and enrolment of NYS members in desert locust spray-service program. This high number of responses from community members could be attributed to their participation in monitoring and reporting of desert locust presence in their localities. The low number of responses from I/NGOs could be attributed to their periphery participation in desert locust management as they were contributing through the national and county government structures.

Table 4.2 Response rates by gender, age, education, and affiliation

Variable	Attribute	Frequency	Percentage
Sex	Male	628	80.6
	Female	151	19.4
Age	18–35	393	50.4
	36–60	374	48.0
	Above 60	12	1.6
Education	Primary	17	2.2
	Secondary	88	11.3
	Certificate	178	22.8
	Diploma	164	21.1
	Degree	246	31.6
	Masters	82	10.5
	PhD	4	0.5
Affiliation	Community Member	235	30.2
	County Government	314	40.3
	National Government	169	21.7
	I/NGO	61	7.8

(Source**:** Field data – 2024)

4.2 Desert Locust Risks to Human Security

The main objective of this research was to analyse the securitization of desert locust risk management and human security in Kenya. There was a need to first assess desert locust risks that could have necessitated securitization of the pest management practices. This is because security is an epiphenomenon intersubjectively created construct that could lead to a zero-sum outcome (Jain *et al*., 2011). To assist in the assessment, desert locust risks were aligned to the various human security dimensions.

Constructs of desert locust risk analysis were grouped in line with human security dimensions which included food security, economic security, health security, environmental security and personal security. Food security risks from desert locusts was assessed using reduced food supply after crop damage and reduced livestock production due to the destruction of pasture by desert locusts. Economic security risk from desert locust was assessed using decreased household income from crop and livestock enterprises. Health security risk from desert locust was assessed using emotional stress, human deaths and malnutrition in children.

Personal security risk from desert locusts was assessed using resource-based and human-wildlife conflict as well as internal displacement of people and reduced school attendance. Environmental security risk from desert locusts was assessed using land degradation due to soil erosion after loss of vegetation cover, following indiscriminate foraging by desert locusts. Results for the constructs that were used to assess desert locust risks are illustrated in Figure 4.1.

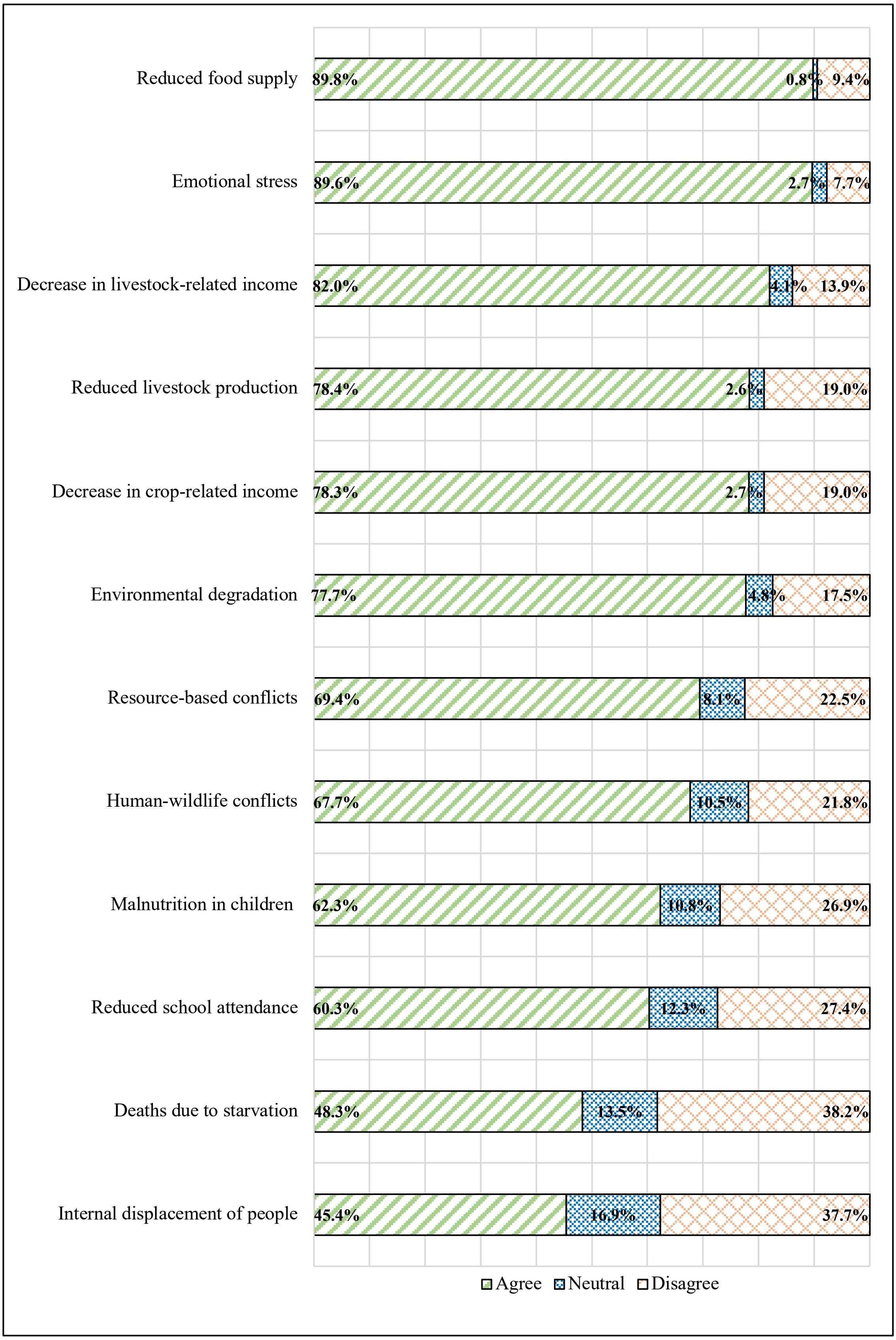

Figure 4.1 Percentage response to assessing desert locust threats to human security

(Source: Field data – 2024)

Out of the 779 respondents that participated in the study, 700 (89.8%) had the opinion that desert locusts reduced food supply, 698 (89.6%) agreed the pest caused emotional stress, and 639 (82.0%) affirmed they led to a decrease in income from livestock-related farm enterprises. In addition, 611 (78.4%) of respondents agreed that desert locusts reduced livestock production, 610 (78.3%) felt that the pest led to a drop in income from crop-related farm enterprises, while 605 (77.7%) affirmed they caused environmental degradation. Moreover, 541 (69.4%) of respondents agreed that desert locusts caused resource-based conflicts, while 527 (67.7%) felt that the pest led to human-wildlife conflicts.

There was also an opinion that there was malnutrition in children and reduced school attendance by 486 (62.3%) and 470 (60.3%) respondents, respectively. Out of all respondents, 298 (48.3%) and 353 (45.4%) alleged there were deaths due to starvation and internal displacement of people as a result of desert locust invasion in Kenya. The minority opinion represented people who did feel that desert locust risks were as serious as portrayed by the majority. This could have been due to the inclusion of persons who were not affected much by the desert locust invasion in the sample size.

To get deeper insights, constructs of desert locust risk assessment were grouped in line with human security dimensions, including food security, economic security, health security, environmental security and personal security. Each human security dimension was treated as a dependent variable and was assessed by respondents on a 5-point Likert scale based on various constructs. Food security was assessed using reduced food supply after crop damage and reduced livestock production due to the destruction of pasture by desert locusts.

Economic security was assessed using decreased household income from crop- and livestock-related farm enterprises. Health security was assessed using emotional stress, human deaths and malnutrition in children. Personal security was assessed using resource-based and human-wildlife conflict as well as displacement of people and reduced school attendance. Finally, environmental security was assessed using land degradation due to soil erosion after loss of vegetation cover due to indiscriminate foraging by desert locusts.

4.2.1 Desert Locust Risks to Food Security

Food security is a condition where every person, individually or within a community, has economic and physical access to sufficient food of acceptable nutritional value and preference at all times and has the means to either produce or procure the same (UNDP-HDR 1994). According to FAO (2017), the link between food security and human security pivots on the notion that humans can fully realize their human rights in situations of adequate food for all people anywhere. Food security risks from desert locusts were assessed using reduced food supply after crop damage and reduced livestock production due to the destruction of pasture by desert locusts.

Out of the 779 respondents who participated in the study, 700 (89.8%) believed that desert locusts reduced food supply. This was not surprising as desert locusts are known to destroy crops indiscriminately. The findings resonated with the FAO *et al.* (2020) report that showed desert locust invasion had resulted in cereal loss estimated at 356,286 metric tonnes and affected 806,400 farming households in the year 2020. The report documented that the pest had destroyed cropland and pasture estimated at 197,163 hectares and 1,350,000 hectares, respectively (FAO *et al.*, 2020).

These are huge acreages of land whose farm produce could support many people with food. The quantification of the level of destruction was, however, beyond the scope of this study. The high number of respondents who agreed that the desert locusts reduced food supply affirmed the alarmist food insecurity that could have pushed the government to securitize pest management operations. Accordingly, FAO (2020b) reported that countries in the east and horn of Africa experienced food security crises. As such, the desert locust invasion directly affected individuals, households, communities and countries. The threat posed by desert locusts to human security could have compelled securitization of management measures implemented at local, national and regional levels.

Desert locusts feed on green vegetation, providing food for humans and animals. The fact that desert locusts consume nearly all types of vegetation reduces the food supply for humans. According to Getabalew (2020), vegetation is subject to attack when an outbreak of desert locusts occurs, and damage is considerable in all types of crops. Reflecting on the population's diet worldwide, specifically in Kenya, vegetables constitute most of the meals. Vegetables are used for stew that is eaten alongside grains, which are also prone to destruction by desert locusts.

Therefore, the threat of desert locusts to food security was real, as one of the respondents described this finding, lamenting: “I woke up one morning only to find my maize looking like Napier grass; all the leaves had been stripped off. That meant I would have to buy food in the following season.” The damage described by the participant could have happened at different stages of crop development. The stripping of leaves meant that the maize (*Zea mays)* could not produce any grains since they help in photosynthesis and transpiration. All plants need nutrients from these two processes for vegetative growth and generative production.

Jackson (1997) observed that removing leaves affected the growth of the shoot, which consists of stems, branches, leaves, flowers, fruits, and seeds, all of which are important in crop production. As such, dwarfed growth of plant shoots due to the destruction of leaves by desert locusts makes plants unproductive. Other than the edible value of green leafy vegetables for human nutrition, the destruction of leaves has far-reaching effects on the food security of a nation. Reflecting on botany, leaves are the primary sites of photosynthesis, a process through which food for plants is manufactured (Jackson, 1997).

Loss of leaves, therefore, meant that the photosynthetic capacity for crops was drastically affected. Therefore, the plants could have taken time to regenerate, and hence, there would be reduced yields, directly threatening food security. The photosynthetic role of leaves also supports the reproductive capacity of cereals and tubers. The destruction of leaves means that even the production of root crops such as sweet potatoes, yams, cassava, arrowroots, and carrots could be affected. In some instances, entire plants, especially crop seedlings, were consumed, necessitating the need to replant.

A participant complained, saying, "All my young pawpaws were eaten by locusts. They ate all the leaves and upper parts of the stems. I continued watering them daily, hoping they would regrow, but that did not happen." This quote confirms the destructive nature of desert locusts. It also points to indirect livelihood risk due to stalled agricultural enterprises meant to generate household income. In addition, the challenge of reviving the investment through replanting the pawpaw (*Carica papaya*) is observed. Replanting had two predicaments: the cost of production could have increased, and the risk of crop failure could have been heightened due to lost time for the plant to optimise during the rainy season, especially in ASALs.

The fact that replanting new crops could not be feasible, as they could also have been susceptible to attack by desert locusts, exposed a population to extended periods of food insecurity. Crop failure could also have exacerbated food insecurity at the household level, especially for subsistence farmers who depended on their produce for family consumption. Destruction of leaves also meant a reduced supply of farm produce and increased prices of these food items in the market. As such, the effects of desert locusts on food security could be felt over a long time. Perhaps from this reasoning, securitization came into play as extraordinary measures were employed to safeguard both lives and livelihoods regarding household food supply and incomes.

The results of desert locust risks to food security, as suggested by 89.8% of respondents, were attributable to the rapid breeding of desert locusts, long-distance migration and indiscriminate foraging of the pest on any green vegetation, which predisposed crops and pasture to destruction by the pest. As a reminder, an adult desert locust can feed on vegetative biomass equivalent to its weight (2 grams) during the gregarization phase, in which rapid breeding occurs to develop swarms of sometimes more than 40 million insects (WMO & FAO, 2016). This means that the pest has the potential to consume about 80 metric tons of green vegetation and hence could end up wiping out all crops in a farm within a short time and, as a result, expose people to food crisis.

The findings are supported by FAO *et al.* (2020), who noted that the 2019–2021 desert locust invasion resulted in crop destruction and poor yields. FAO (2017) also supports the study findings, which estimated that close to 800 million people faced chronic hunger due to desert locusts. In addition, Emana (2002) reported that two-thirds of farmers in Sudan considered desert locust as the most dangerous crop pest that caused 20-30% reduction in potential yield during upsurges. The threat of desert locusts to food security was therefore not unique to Kenya, but it was transnational and spread to the eastern and horn of African countries.

Destruction of crops led to reduced yields, which in turn affected the supply of food produce to markets. During an FGD, a participant stated: "Nzigi destroyed everything. We hardly had enough for ourselves let alone a surplus that we could take to the market for sale." The "Nzigi" is a local name for locusts in the coastal parts of Kenya. The quote confirmed that household earnings were also affected other than food insecurity due to locust infestation. With a reduced food supply, demand for agricultural commodities increased, and hence, prices for farm products went up, limiting some households' purchasing power. For example, the World Bank (2020a) reported that desert locust invasion increased food prices since the demand exceeded supply.

The results of this study are supported by Sultana *et al.* (2021), who reported that more than 3 million people were facing food insecurity while about 34,000 households needed emergency food due to crop losses occasioned by desert locusts between 2019 and 2020 in Pakistan. Taking cognizance that food security is an inherent human right that is enshrined in the constitution of Kenya 2010, the government had a duty-bearing responsibility to safeguard it by securitizing management practices. The government was, therefore, bound to employ urgent and extreme measures to ensure that the problems associated with the desert locust did not escalate to many counties. As such, the gregarious nature, long-distance migration potential and rapid breeding of desert locusts may have informed the securitization of surveillance, control and recovery measures.

Out of the 779 respondents who participated in the study, 611 (78.4%) agreed that desert locusts reduced livestock production. Most of the frontline invasion counties rely on nomadic pastoralism as the primary source of livelihood. As such, the destruction of grasslands reduced pasture for livestock, especially cattle, goats, sheep and camels, leading to low milk and meat production. One of the county-based FGD participants expounded on the destructive nature of desert locusts, saying: "These insects were eating anything to the extent I was worried they could finally eat us."

The above highlighted statement resonates well with the existential threat that desert locusts can cause to human security. Their devastating feeding and long-distance migratory habits mean they can clear massive areas of vegetation cover, which can lead to livestock deaths. Without food from livestock produce such as milk and meat, affected families were left vulnerable to starvation. As such, desert locusts predispose human beings to famine and the imminent threat of death from hunger in multiple locations.

The findings resonate with the views of FAO *et al.* (2020), who noted that the 2019–2022 desert locust upsurge led to livestock deaths due to starvation following massive pasture damage. Without livestock, pastoral communities would suffer not only from food crises but also economically due to loss of income. The surviving emaciated livestock would attract low prices in the market during enforced off-take programs or desperate voluntary sales. The results are supported by Yuga and Wani (2022), who reported that 60% of respondents said desert locust infestation impacted pasture, thus affecting livestock body conditions in Sudan. Humans are generally heterotrophic and need carbohydrates, fats and proteins in their diets. All these dietary needs come from plants and livestock as meat and milk are key protein sources. Although milk, meat, and honey come from animals, plants have to provide food for them as primary producers of the food web.

Natural vegetation in rangelands contributes to some communities' wild foods (Milton & Barnard, 2003). Destruction of natural vegetation by desert locusts could have reduced alternative sources of freely available nutritional nourishment. Landing rangeland damage by desert locusts threatens people's lives since these ecological systems provide local communities with the requisite natural resources for livestock production as pasture and grazing areas. Notably, increases in food prices not only affected the certainty of poor households' food security in terms of affordability of meals, accessibility of foodstuff, and nutritional acceptability but also denied people dietary preferences, especially those with special needs such as people with allergies and medical conditions such as diabetes.

With specific reflection on humanistic theories where physiological needs are key to survival, the food deficit that was occasioned by desert locusts could have been too massive to justify the securitization of the pest's management practices. Remarkably, in early 2020, over 20 million people were already experiencing food insecurity in the East and Horn of Africa countries, especially Kenya, Uganda, Tanzania, Ethiopia, Somalia and South Sudan, due to desert locusts (FAO, 2020b). The overall outlook for 2020 indicated that over 450 million people residing in desert locust-infested areas globally would face food security threats (Geladari *et al.,* 2020).

The FSNWG, which monitored the regional impact of desert locusts, estimated that the 2019-2021 invasion in East Africa led to a 42–69% loss in crop production in the affected areas (FSNWG, 2021). The interdependence of countries on the food supply within the region that was under high threat of desert locusts could have informed national policymakers to initiate securitized management practices through rapid and extreme measures in order to reduce the potential risk of the pest to human security.

Desert locust risk to food security had effects at individual and household levels as well as at national and global levels in terms of economic development. For example, the UN considers hunger to be unfavourable to development, human rights, peace, and security. Under the UN Agenda 2030, which stipulates the 17 Sustainable Development Goals (SDGs), issues of hunger are factored in SDG No. 2 (UNDP, 2015). Effects of desert locusts negate agricultural productivity, which directly pursues SDG No.2, which focuses on ending hunger, achieving food security and improving nutrition while indirectly supporting SDGs 1, 3, 8, 9, 12, 13, 15 and 17 (UNDP, 2015).

Impact of desert locust to crop and livestock production also reverses any gains towards realization of Aspiration No.1 of the African Union (AU) Agenda 2063. Destruction of crops also denies people one of the human rights as enshrined in the Constitution of Kenya 2010 in Article 43 states that every person has the right to be free from hunger and to have adequate food of acceptable quality (GOK, 2010). As such, the impending risk of desert locusts to food security could have forced the government as a duty-bearer to securitize desert locust management.

4.2.2 Desert Locust Risks to Economic Security

Economic security denotes having an assured basic income either from productive or remunerative work or, in the worst-case scenario, from government stipends (UNDP-HDR, 1994). Loss of productive livelihoods due to the destruction of crops and pasture for livestock by desert locusts could have had economic security implications. It was, therefore, important to assess the effect of desert locusts on economic security as one of the aspects of human security. Economic security risk from desert locusts was assessed using decreased household income from crop and livestock enterprises.

Out of the 779 respondents that participated in the study, 639 (82.0%) affirmed desert locusts led to a decrease in livestock-related income. Most frontline invasion counties rely on nomadic pastoralism for income generation, and therefore, any damage to pasture directly affects their livestock and, in turn, reduces their income. In addition, poorly fed livestock are vulnerable to pests and diseases and hence require regular treatment. This treatment cost was an unforeseen cost that could have depleted household savings.

Extreme cases of deaths of livestock due to starvation after the destruction of pasture would demand restocking. Restocking is a costly recovery measure to be implemented by an already economically struggling household. The findings concur with those of FAO et al. (2020), who noted that there were unprecedented agricultural production losses. Rangeland contributes to communities' livelihoods in terms of the provision of fuel wood (Milton & Barnard, 2003), and hence, their destruction by desert locusts led to a reduction in alternative sources of income.

Out of the total number of participants, 610 (78.3%) respondents felt that desert locusts led to a drop in crop-related income. Although the majority of the desert-locust-affected counties were ASALs, where livestock farming was the main economic activity, some of the affected regions practice crop farming. Indiscriminate devastation of green vegetation by desert locusts led to reduced crop yields, thus reducing income from crop enterprises. In addition, farmer initiatives to manage the pest on their own increased production cost, reducing expected returns on investment from the farm enterprises. For instance, one of the respondents noted: “Before government interventions, I had to purchase pesticides using my little savings to try and kill the locusts.”

It is worth noting that the purchase of pesticides to manage locusts was an unexpected expense and, hence, could have affected the farmer’s household budget. In some instances, young crops were completely destroyed, necessitating replanting at an unplanned additional cost. There could also have been cases of livestock death due to starvation or vulnerability to pests and diseases as a result of malnutrition. As such, crop failure and poor livestock body conditions or even deaths meant families relied on purchased food for survival.

Without any hope of financial replenishment from their agricultural enterprises, this dependence on purchased food affected farmers’ economic security, leading to a crisis at the household level. The findings echo the views of Chatterjee (2020), who reported that there were economic losses due to reduced yields and increased cost of agricultural production associated with the expenses of managing desert locusts in India. The results also rebound Sultana *et al.* (2021) study that reported there were 3.4 to 10.21 billion US dollars’ worth of losses resulting from desert locust infestation in Pakistan.

The threat of desert locusts to economic security had the potential to affect people at local, national, regional and even global levels. A participant during the study described this with sorrow, saying: “Desert locusts made us beggars. We had to rely on our family members in town, government and NGOs for money to help us buy even small things like salt and matchboxes.” This quote suggests that other than hunger, desert locusts led to the deterioration of poverty. Hunger and poverty have been linked to insecurity, especially an increase in criminal activities, through the strain theories.

Globally, agriculture, particularly livestock and crop production, is a primary livelihood for billions of people (FAO, 2017). The effect of desert locusts on economic security could, therefore, have led to an increased crime rate. According to FAO (2013), more than 86% of the rural population depended on agriculture as a principal source of livelihood and provided employment to at least 1.3 billion landless workers and smallholder families across the world. Destruction of crops and pasture by desert locusts is, therefore, a global threat to economic security. In addition, the UN considers hunger and poverty to be unfavourable to development, human rights, and peace and security.

To place the effects of hunger and poverty due to desert locusts as a critical issue that warranted securitization of management operations, the UN Agenda 2030 stipulates the 17 SDGs, positions 'no poverty' as SDG No. 1 and 'zero hunger' as SDG No.2 (UNDP, 2015). Crop and livestock production directly pursues SDG No.1, which focuses on ending poverty in all its forms everywhere (UNDP, 2015). Effects of desert locusts on crops and pasture compromise the realization of these global aspirations. Crop and livestock production are also aligned to Aspiration No.1 of the AU Agenda 2063 for contribution to households' and national prosperity, and hence desert locusts negate the gains that have been progressively made towards achieving this ambition.

The global and continental goals, as outlined above, are aimed at ensuring peace and prosperity in member countries. All countries, including Kenya, have ratified the goals and act as a blueprint towards sustainable development. To this end, every government has a responsibility to counter any threats that may affect the achievement of these goals. Given the threats associated with desert locusts, the government of Kenya was bound to respond in an extraordinary way through urgent and extremely securitized interventions.

Reflecting on the local scenario, most of the Kenyans who practice agriculture come from poor households, and the agricultural sector remains Kenya's largest source of income for both economically privileged and vulnerable poor rural households. To demonstrate the critical role the sector plays in Kenya's economic stability, Kenyan households exclusively relying on agriculture amounted to 31.4% of rural poverty reduction (World Bank, 2018). In addition, agricultural productivity is crucial for poverty reduction (Birch, 2018). This means that the destruction of crops and pasture by desert locusts and the resultant reduction in income from farm produce could have worsened poverty levels in Kenya.

The Constitution of Kenya 2010 under the Fourth Schedule in Part 1 (32) acknowledges that agriculture is vital to the country's economic growth (GOK, 2010). In addition, Kenya's Big Four Agenda recognized agriculture as a driver of development (Kenya Association of Manufacturers, 2020). As such, desert locust risk to economic security through reduced income from crop and livestock production affects human aspirations at the national level. Kenya's economy is mainly agriculture-dependent, and hence, the sector contributes immensely to the country's GDP, contributing 51% of which 25% is direct and 26% is indirect (Birch, 2018).

Effect on crops and pasture that could have resulted from desert locusts inversely influenced Kenya's economic well-being. According to the World Bank (2018), Kenya's agricultural sector accounts for 65% of the country's exports and 60% of employment. In addition, Ngungu *et al.,* (2018) put the proportion of Kenyans who depend on agriculture for food and employment at 80% of the entire country's population. Reduced income from crop and livestock enterprises due to desert locusts, as reported by 78.3% and 82.0%, respectively, meant that Kenya's foreign exchange revenue and agricultural jobs were negatively affected.

The agriculture sector is dominated by subsistent and smallholder farmers who account for at least 78% and 70% of agricultural and commercial production in Kenya, respectively (World Bank, 2015). Unfortunately, these smallholder farms were the most affected due to their limited capacity to manage desert locusts on their own. A farmer explained this incapacity, stating, "The insects were covering the entire village. They were eating anything on our farms. Without external support from the government and NGOs, we could not have managed to kill them."

The quote suggests that small-scale farmers were desperate due to the high number of desert locusts and their indiscriminate destruction of plants. The statement also confirms recognition of the role of government and stakeholders in managing desert locusts. The smallholder farmers account for 70–75% of total agricultural production (Kenya Bankers Association, 2018). Kenya's agricultural production sector includes food crops, industrial or commercial crops, livestock, horticulture, forestry and fisheries.

Maize, as the staple food in Kenya, and milk, as an essential agricultural commodity, account for 70 and 80% of the total market supply of agricultural produce, respectively (Kenya Bankers Association, 2018). Anything that affects the agricultural sector such as desert locusts, therefore negates Kenya's economic development and the livelihoods of the populace. It is worth noting that maize as a staple food and milk as an essential commodity are some of the farm products that were affected by the desert locust invasion in Kenya. Reduced milk production was, however, a result of the destruction of pasture by desert locusts.

The World Bank (2018) found that a boom in agricultural productivity between 2005 and 2015 largely accounted for poverty reduction in that period. The negative impact on agricultural productivity as a result of desert locust invasion, therefore, had a facilitating effect on poverty levels. A farmer described desperation due to desert locust invasion, lamenting:

> "I considered stopping farming after all my crops were destroyed by desert locusts. But again, farming is the only thing that I've done all my life. What else would I do to feed and educate my children?"

The statement brings out the frustrations of the farmers who were affected by desert locusts. This is because people lost their agriculture-based investments after reduced crop and livestock production. Others might have stopped investing in agriculture.

Destruction of croplands by desert locust invasion had a negative effect not only on food security but also on livelihoods, employment and economic growth (World Bank, 2020a). Most households that relied on the sale of crop and livestock produce to educate their children had reduced ability to do so. The findings of this study mirror observations made by De-Vreyer *et al.* (2015) that desert locusts had the potential to cut household budgets and destroy private assets, thereby driving down household expenditures on education, food and health.

While the effects of desert locust invasion can appear trivial at the macroeconomic level, it had huge consequences at the household level, especially for households that relied entirely on crops or livestock. The consequences of this increased strain on finances were felt in another aspect of security, including health security. The World Bank (2020a) reported that some households ended up selling off their productive assets to purchase food or to finance other expenses, including school fees and hospital bills, thereby becoming poorer. Destruction of crops and livestock has direct economic repercussions for communities and households as it means that investments in agricultural production are lost and more investments need to be made during and post-invasion (De-Vreyer *et al.,* 2015).

The economic strains are in the form of incapacity to purchase replacement seeds, re-cultivation and re-stocking of livestock. These sudden and unforeseen costs may further exacerbate individual households' and communities' poverty status. Kenya has been among the African countries that have recorded steady growth in the agricultural sector (World Bank, 2018). The effects of desert locusts on crops and pasture were, however, likely to reverse these gains. Reflecting on securitisation theory, issues that seem to have extreme security risk are dealt with urgently when they have been labelled 'dangerous,' 'menacing,' 'threatening' or 'alarming' (Eroukhmanoff, 2018). From the above discussion, the threat of desert locusts mirrors the aforementioned labels and hence, securitization of its management was inevitable.

4.2.3 Desert Locust Risks to Health Security

Health security refers to freedom from diseases and unhealthy lifestyles (UNDP-HDR, 1994) such as Kwashiorkor and Marasmus as well as malnutrition and stunted growth, respectively. Health security risk from desert locusts was assessed using emotional stress, human deaths and malnutrition in children. Out of the 779 respondents, 698 (89.6%) agreed that the pest caused emotional stress. This may seem clear but from the percentage response, but it is an indirect effect from desert locust itself.

Plants, as major sources of human nourishment, support immunity against diseases by providing both macronutrients, such as proteins and carbohydrates and micronutrients, such as vitamins. For instance, according to Abdel-Aal *et al.* (2013) leafy vegetables are excellent sources of fibre, folate and carotenoids that help in vision enhancement. Similarly, Barahona *et al.* (2021) observed that leafy vegetables provide dietary fibres, minerals, α-linoleic acid and vitamins that have excellent nutritional benefits as antioxidants.

Destruction of leafy vegetation by desert locusts could, therefore, have denied people this much-needed nutrition supply and hence expose them to opportunistic diseases that compromise their health security. Other than physical effects from desert locusts on human beings as a result of limited food supply, there were also emotional ramifications as one of the FGD participants explained that "I had anxiety day-in-day-out not knowing when this plague would end. I was convinced it was a punishment from God." As noted in the quote, the invasion by desert locusts affected not only the physical health of the victims but also their mental health.

The uncertainty caused by the desert locust invasion, as captured in the quote, could have led to unhealthy conditions that could have compromised the security of the citizens. Uncertainty exists when details of situations are ambiguous, complex or unpredictable, leading to feelings of insecurity. Mental health issues are critical for the well-being of society. As such, anxiety, as expressed in the above quote, is a feeling that is associated with fear, which could develop into mental health conditions and end up affecting the day-to-day activities of an individual.

Although anxiety may seem like a normal anticipatory feeling of real or perceived future threats (Grupe & Nitschke, 2013), it can lead to irrational worries and difficulties in maintaining daily routines due to uneasiness, difficulty in concentration, sleep disorders, fatigue and anger (Saghir *et al.,* 2018). In addition, stress could lead to hypervigilance, violence and avoidant behaviours due to the expectancy of looming dangers. The irrational worries that negatively affect the activities of the day could mean that many livelihoods would be affected. For example, anxiety in women has been found to act as a barrier for women in meeting their children's needs and failure to do household chores such as cleaning and cooking.

Stress therefore not only puts women's health at risk but also those who depend on them. The inability to attend to daily activities, coupled with a lack of concentration, may increase mental health problems, leading to withdrawal from friends and family. This could even escalate to reduced economic productivity as stressed individuals may feel unable to go to work or might be less productive at their places of work. Absconding from paid-up work could further affect the economic well-being of the people through lost man-hours and even loss of employment through dismissal.

The findings are supported by FSNWG (2021), which revealed that desert locust-affected households experienced increased anxiety and emotional stress. Accordingly, a natural disaster such as a desert locust invasion creates stressful moments that can give rise to a series of related health challenges. These human health challenges could have provoked the securitization of desert locust management programs to safeguard human security. It should also be noted that stress lowers individuals' immunity. The human body's immune system protects people from diseases and other harmful toxins (Seiler *et al.,* 2020).

A low immune system exposes individuals to health challenges that compromise their health security. Indirectly, desert locusts posed a great danger of exposing individuals to opportunistic diseases that could compromise their health security. These are issues that could have provoked the securitization of desert locust management programs to safeguard human security.

In addition, there was a feeling that malnutrition occurred in children, as indicated by 486 (62.3%) respondents. Confirmation of reduced food supply due to low crop yields, less livestock production following the destruction of pasture, and loss of purchasing power due to decreased household income qualifies the possibility of malnutrition among children. As previously explained, there was also reduced income from crop and livestock enterprises and increased foodstuff prices that could have decreased households' ability to meet recommended dietary requirements. One community participant explained this scenario, saying:

> "Food was hardly enough for everyone. People hardly had more than one meal in a day. Sometimes, people were also sleeping hungry. It was really frustrating for us parents. You sit there with children, and they expect food from you, but you are helpless as locusts have eaten everything."

From the quote, it was clear that most people were affected by desert locusts, which led to serious frustrations.

The frustration as depicted in the quote could be indicative of feelings of powerlessness to provide basic needs for the family. As can be seen from the quote, desert locust had devastating effects on availability of food which is critical for a healthy population. Accordingly, reduced food uptake by children could have resulted in malnourishment, stunted growth and wasting. For example, FAO *et al.* (2020) observed that stunting undermines the physical and cognitive development of children, increases risk of infant mortality from common infections and predisposes them to overweight and non-communicable diseases later in life. This implies that extended periods of malnutrition could cause lifelong health challenges for populations.

A government with a keen interest in the well-being of its citizen would, therefore, not hesitate to take extraordinary measures to safeguard their health security. This may be more so when children, who are seen as the future generation, are at risk. In cognizance that the government has the duty to protect the lives of its citizens, it could partly explain the justification for securitization of desert locust management. The findings reverberated FAO and WFP (2020) report that found the proportion of households reporting poor food consumption had increased between August 2019 and February 2020, a period during which desert locust invasion commenced in Kenya. The study findings also agree with FAO (2017) results that estimated about 2 billion people were at risk of experiencing nutritional deficiencies.

There was concurrence by 353 (45.4%) respondents that there could have been illnesses or even deaths due to starvation during the 2019-2021 desert locust invasion. Low crop and livestock production due to effects of desert locusts reduced accessibility and affordability of food commodities. As a result, there were incidents of poor nutrition that could have lowered human body immunity and hence made people especially children vulnerable to illnesses such as Kwashiorkor as well as other opportunistic diseases.

Although there was no officially recorded case of death, the believe by some respondents that people could have died due to impact of the pest is of great concern. This is because as already highlighted in previous sections, issues of poor diet and stress do lower immunity of individuals. This makes people vulnerable to opportunistic diseases and thus exposing them to many ailments that could result in fatalities. The results resonate with Geladari *et al.* (2020) study, which observed that severe cases of food insecurity due to desert locusts may affect human health through malnutrition, starvation, illness or even death. In addition, the study corroborated the findings by the World Bank (2020a) that poor nutrition occasioned by desert locust invasion had direct risks to human health.

In line with the findings of this study, food and economic insecurity are core issues hindering health security. FAO (2017) estimated that close to 800 million people faced chronic hunger, while about 2 billion others experienced nutritional deficiencies. The desert locust upsurge of 2019-2022 could, therefore, have worsened micro-nutrient deficiencies and undernutrition in Kenya. According to the World Bank (2020a), poor nutrition that was occasioned by desert locust invasion had direct risks to health security for individuals. The impending risk of desert locusts to health security could have made the government safeguard rights holders, who are the citizens, using securitized swift and extreme countermeasures against desert locusts.

4.2.4 Desert Locust Risks to Personal Security

Personal security is freedom from physical violence or emotional assault, whether from the State or external States, vicious individuals and sub-sectors, domestic abuse or predatory adults (UNDP-HDR, 1994). Personal security risk from desert locusts was assessed using resource-based and human-wildlife conflict as well as internal displacement of people and reduced school attendance. There were 541 (69.4%) respondents who agreed that desert locusts caused resource-based conflicts. Most of the people who were affected by desert locusts are nomadic pastoralists. Nomadic pastoralists move with their livestock to places where there is pasture and water. As such, their livestock depends on grass and shrubs for feed.

Diminishing vegetation for cattle, sheep, goats and camels due to devastation by desert locusts, therefore, led to the forced movement of pastoralists in search of alternative grazing areas. One FGD participant explained this, saying, "We had to move from our villages into a neighbouring county. Our neighbours were accusing us of invading their territory. Everyone treated us with suspicion." This quote confirmed that desert locust affected communities had to move in search of pasture from the neighbouring region. This statement also points to potential development of a conflict. Destruction of pasture exposed individuals to resource strain that could have triggered contradictions, differences and even polarise into violence between affected communities with direct implication on personal security.

The findings are supported by (Lecoq, 2005), who reported that desert locust invasion led to the emigration of local communities from affected areas, leading them to become internally displaced persons (IDP) and hence making them vulnerable to personal insecurity. Reaffirming the results, a respondent commented:

> "We sold the emaciated goat and sheep at very low prices before they could die. The few surviving livestock was also stolen by bandits. We were left with nothing after the locusts were gone."

Death of livestock after pasture was destroyed by desert locusts could have increased incidents of cattle rustling as people sought to restock, as a way of reviving their lost livelihoods. With the few surviving livestock being sold at very low prices, and limited savings to purchase replacement animals due to reduced livestock-generated income as a result of desert locust invasion, cases of cattle rustling could have increased.

Desert locust invasion was in the ASALs where the main source of livelihood is livestock rearing. Death of livestock meant there was a need for replenishing the lost animals, sometimes by all means, including cattle rustling. Cattle rustling in Kenya has, however, been found to be a major source of insecurity in the ASALs. These findings resonate with ICPALD (IGAD Centre for Pastoral Areas and Livestock Development) which observed that cattle rustling is one of the causes of insecurity and resource-based conflicts among pastoral communities in Kenya (ICPALD, 2017). Reduction of livestock due to desert locust invasion and the need to replace the same through cattle rustling could therefore have heightened insecurity.

In addition, gender-based violence could have emerged within households due to stress, depression or even post-trauma. These psychosocial conditions could have resulted from loss of livelihoods after crops were destroyed by desert locusts and livestock were affected after pasture was devastated. A local Chief explained:

> "I had very many cases to deal with during that period of desert locusts. There were many women outside my office every morning especially on Monday reporting of being beaten by their husbands."

As earlier mentioned under the section on effects of desert locust to health security, stress could have triggered frustrations and could have in turn caused aggressive behaviours.

Frustration can be thought of as the thwarting of basic psychological satisfactions and mental autonomy (Breuer & Elson, 2017) which is a key aspect in personal security as it can lead to violence. This explains the reason why inability of parents to provide food for the family could have caused aggressive behaviours such as physical assault and gender-based violence. The study auger well with Yuga and Wani (2022) who observed that desert locust impacted social cohesion and peaceful co-existence of people in South Sudan.

There were 527 (67.7%) respondents who had opinion that desert locusts led to human-wildlife conflicts. Like livestock, most wild animals especially herbivores depend on grass, shrubs and trees for feed. Indiscriminate destruction of vegetation by desert locust therefore reduced availability of feed for wild animals. Reduced wild feed could have led to movement of wild animals from their natural habitats into human settlements in search of alternative grazing areas. This was corroborated by qualitative data in which a participant explained:

> "It is not only human beings that were affected. Even the wild animals suffered. The locusts ate leaves and barks of trees. Sometimes their weight led to the branches of trees they were sleeping on to break and fall. The food for wildlife was also consumed. For survival, the wild animals roamed all over competing for food with livestock. Some people were killing these wild animals for bush meat."

As described in the statement, other than human beings and livestock, wild animals were also affected.

Indiscriminate destruction of vegetation by desert locusts could therefore have led to their movement from protected areas such as conservancies, national parks and game reserves in search of feed. The uncontrolled movement of wild animals could have triggered human-wildlife conflicts after straying into farms and ranches. Although there is limited literature on this desert locust risk, the evidence adduced by more than half of the respondents that cases of human-wildlife conflict could have happened validates the results.

The study indicated that 470 (60.3%) respondents affirmed there was reduced school attendance as a result of desert locust invasion in Kenya. One of the respondents recalled that "I had to stop my children from going to school for some days to help me in chasing away desert locusts from the farm by shouting and beating containers." Temporary discontinuation of children from going to school could have had drawbacks to the gains in their academic progress and even led to dropout cases. In addition, children's presence within communities when their peers were in school could have made them vulnerable to other risks, such as child labour.

The findings are affirmed by De-Vreyer *et al.* (2015) who noted the 1987 to 1989 plague reduced enrolment of boys in school as they were actively involved in desert locust control activities in Mali. The findings are also in line with the World Bank (2020a) observation that desert locust invasion can result in gender-based injustices among girls and boys in the infested areas. According to the World Bank report, a link has been established between desert locust upsurges and plagues to school enrolment among girls and boys in the affected areas.

Gender-based injustice that is associated with discriminative school enrolment can be understood by appreciating that the source of revenue is disrupted by desert locust invasions for households that depend on selling of crop and livestock produce to educate their children. In addition, children are forced to drop out of school to engage in economic activities to support their families after the loss of crop and livestock-dependent livelihoods. As earlier mentioned, it should not be forgotten that children are often engaged in farms to chase locusts away from crop fields.

De-Vreyer *et al.* (2015) noted that while under normal circumstances, enrolment of girls in schools is less than that of boys, in times of economic troubles such as those presented by desert locust upsurges and plagues, it is girls' education that is affected most. While average household food allocation is disproportionate among children, during scarcity due to the devastation of crops by desert locusts, girls are again disadvantaged as boys are given priority (De-Vreyer *et al.,* 2015). These gender-based injustices have direct implications for the personal security of girls.

From the overall number of respondents, 298 (48.3%) agreed there were incidents of internal displacement of people due to desert locust invasion. This was asserted during FGD session by one participant who said, "We moved closer to the chief's camp where food was being brought by the government and other organizations to avoid missing on any help coming to the people who were affected by locusts." Limited access to food commodities appeared to have caused forced movement of people closer to centres of humanitarian support by government and partner institutions. Although this appeared to have been a positive change, it nonetheless challenged communities' sense of ownership after relocation from their homes to temporary camps.

Ownership as the legal right of possession (Monks & Minow, 2001) accords individuals or communities, the capacity to exercise control over and use of physical and/or economic stake in resource utilization. Sense of ownership guarantees individuals the freedom which is an aspect of personal security. The United Nations (2016) asserts that individuals, especially vulnerable people, are entitled to freedom from fear and freedom from want, with an equal opportunity to enjoy all their rights and fully develop their human potential. As such, forced movement due to desert locust invasion violated this critical aspect of personal security.

The government, as the duty bearer, owed the affected people, as the right holders, some protection and this could have been one of the reasons for the securitization of desert locust management. In addition, strained resources have been found to trigger resource-based conflicts, leading to forced movement of people from their habitats to safer areas. The findings are, therefore, corroborated by the views of Lecoq (2005), who observed that desert locust invasions led to the emigration of people from affected areas. This nonvoluntary movement transformed affected families into internally displaced persons (IDPs) and created vulnerability for these individuals.

To remedy risks associated with the challenges of providing social amenities at temporary settlement camps, the government of Kenya could have securitized desert locust management operations to slow down increases in the number of IDPs. In general terms, the social contract theory suggests that the primary goal of sovereigns transferring their power to govern themselves is to assure them security (Bajaj, 2022). As such, the government had to do all appertaining to this donated power of governance to protect people by securitizing desert locust management.

4.2.5 Desert Locust Risks to Environmental Security

Environmental security is freedom from short- and/or long-term ravages of nature, man-made threats in nature and deterioration of the natural environment (UNDP-HDR, 1994). Environmental security risk from desert locusts was assessed using land degradation due to soil erosion after loss of vegetation cover, following indiscriminate foraging by desert locusts. Out of the 779 respondents who participated in the study, 605 (77.7%) affirmed that desert locusts caused environmental degradation.

Indiscriminate destruction of vegetative biomass by desert locusts leaves the ground bare and hence predisposes soil to erosion by wind and rainfall. Soil erosion would, in turn, reduce the productivity of land for agricultural enterprises. Reduced productivity would, in turn, affect food production and lower farm-based income. Loss of vegetation cover would also reduce the percolation of rainwater, facilitate surface runoff and hence increase the chances of flash floods.

The findings are supported by Lecoq (2019), who documented that indiscriminate destruction of vegetation by desert locusts can lead to desertification and usher in other environmental degradation challenges, such as soil erosion and flooding. The burden of responsibility to protect the natural environment as a life-supporting resource could have, therefore, necessitated the securitization of desert locust management. One desert locust expert during the national FGD cautioned, “Desert locust can eat anything green. If a swarm like the one reported in Marsabit that measured 40 by 65 square kilometres landed in a small county like Kirinyaga, it could wipe out all plants.”

As stated in the quote, swarms had the potential to move from one county to another. In addition, the quote confirmed the big size of some of the swarms that invaded Kenya. There is also an acknowledgement of the danger that comes with the indiscriminate foraging nature of the pest. As such, heavy feeding and long-distance migratory habits of desert locusts could have caused the geographical transfer of carbon and nitrogen and interfered with the hydrological cycle. This could occur when desert locusts eat massive vegetation leaving the soil bare for ease of erosion and evaporation, then moving to deposit the faecal matter in a different location.

Vegetation in rangeland acts as an ecosystem stabilizer in terms of biodiversity conservation and storage of large amounts of carbon (Milton & Barnard, 2003). Plants also facilitate the key life-supporting natural processes by serving as carbon sinks, fixing nitrogen and contributing to rainfall generation through the hydrological cycle. Loss of vegetative cover after consumption by desert locusts would, therefore, increase the chances of greenhouse gas accumulation in the atmosphere, reduce land productivity due to low nitrogen and carbon in the soil and reduce the chances of convectional rainfall that results from evapotranspiration. These findings align with Yuga and Wani (2022), who reported that desert locusts can destabilize ecosystems.

Desert locusts, as a destructive feeder, can also destabilize ecosystems through forced displacement of other organisms. One farmer tried to explain this by saying:

> "Bees were moving from their hives during the desert locust invasion because there were few flowering plants from where they could get food. We had to dissolve sugar in water and place it near the hives to prevent them from disappearing for good."

As mentioned earlier, the loss of vegetative biomass due to devastation by desert locusts led to the forced movement of mammals from protected areas. In addition, this could also happen to foraging insects that cannot be forcibly confined in certain ecosystems. For instance, Worku *et al.* (2022) found that desert locust swarms and hopper bands destroyed plants thereby resulting in pollen and nectar loss in Ethiopia.

As a result, honeybees in the infested areas produced less brood suffered poor health, produced less honey and eventually absconded from their resident apiaries. Based on this example, the interdependence of organisms in nature was threatened leading to forced movement of all types of affected organisms for survival. In addition, desert locusts' destruction of vegetation can lead to desertification and usher in other environmental problems, such as soil erosion and flooding, apart from directly destroying the local flora of the affected areas. In summary, desert locusts were a real threat to natural ecosystems.

Desert locust invasion also sets in motion processes that lead to more significant destruction of the environment. For instance, it enhances environmental stress as animals and man struggle to use the limited remaining crops and pasture (Lecoq, 2003). According to Lecoq (2019), this is problematic in areas where the existing ecological balance is precarious. This vulnerability is usually the case in most desert locust-affected countries, especially those in the Horn of Africa and the Sahel regions. According to FAO *et al.* (2020), Desert locusts damaged 50% of rangelands in the upsurge-affected areas. This clearly demonstrates how desert locust invasion can fast-track desertification, soil erosion, drought, and flooding. Recognition of this risk could have compelled the securitization of desert locust management activities through rapid and extremist responses to protect environmental security.

4.2.6 Desert Locust Risks to Various Human Security Dimensions

Results for desert locust risks to human security were summarised in terms of percentage effects to food security, health security, economic security, personal security and environmental security (Figure 4.2).

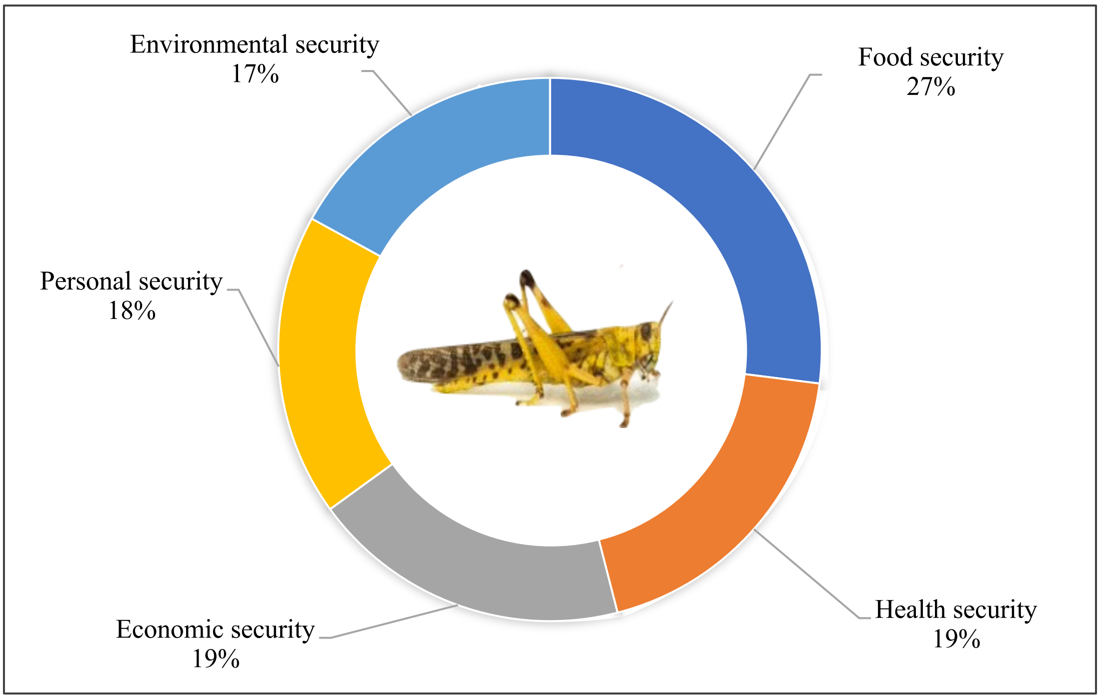

Figure 4.2 Percentage risk from desert locusts to human security dimensions

(Source: Field data – 2024)

The findings revealed that food insecurity contributed 27% to human security risk from desert locusts. The significant risk of desert locusts to food security was due to direct damage to crops and pasture by the pests. Further analysis showed that economic insecurity contributed 19% to the overall human security risk from desert locusts. The risk of desert locusts to economic security is attributable to reduced income from crop and livestock enterprises. The results also showed that health insecurity contributed 19% to the overall human security risk from desert locusts. The findings are qualified directly by health challenges due to emotional stress and indirectly by reduced food supply, which has the potential of causing malnutrition and weakened immunity, leading to illnesses or even death.

Additional assessment showed that personal insecurity contributed 18% to the overall human security risk from desert locusts. The results are rational in that individual or community-initiated desperate efforts to save lives and livelihoods may have exposed people to other unforeseen security threats. The results revealed that environmental security contributed 17% to the overall human security risk from desert locusts. The findings, therefore, conform to De-Vreyer et al. (2015) observations that desert locusts have the potential to cause severe cases of food insecurity, cut household budgets and destroy private assets, thereby driving down household expenditures on education and health.

It cannot be ignored that most attention is given to food and economic insecurity during desert locust risk analysis. This is due to the direct effect desert locusts would have on people as a result of losing lives due to starvation and lost livelihoods when farm earnings reduce. However, it is worth noting that food and economic insecurity due to desert locusts contributed 46% of the overall human security risk. As such, 54% of the overall desert locust risk indirectly affected other human security dimensions, which could be overlooked despite having a higher threat to human security.

This study, therefore, opens up the discussion for scholars and practitioners to broaden their thought processes and develop a comprehensive desert locust management contingency planning strategy. Such an open-minded process would lead to developing a robust desert locust risk management program that addresses threats to all human security dimensions. Based on the findings, there is unambiguous evidence that desert locusts had devastating effects that have compelled the Kenyan government to securitize management operations through urgent and extreme surveillance, control and recovery activities.

Descriptive statistics pointed to obvious risks of desert locusts to human security. However, frequencies and percentages had limitations in validating the segregated effect of desert locusts on various human security dimensions. In addition, the qualitative data used to complement the descriptive statistics was subjective. As such, there was a need to conduct inferential statistical tests to understand the interaction between various dimensions of human security that were affected by desert locust risks.

4.2.7 Effects of Desert Locust Risks to Human Security

Ordinal logistic regression was used to determine the interaction between various dimensions of human security that were affected by desert locust risks (Table 4.3).

Table 4.3 Model fitting and goodness of fit information for desert locust risks

Model Fitting Information					Goodness-of-Fit			
Model	-2 Log Likelihood	Chi-Square	df	Sig.		Chi-Square	df	Sig.
Intercept only	2369.866				Pearson	2134.132	3523	1.000
Final	1162.167	1207.70	5	<0.001	Deviance	1162.167	3523	1.000

(Source: Field data – 2024)

The model fitting information showed statistical significance (χ^2 (5) =1207.70, p<0.001), indicating that there was a significant improvement in fit as compared to the null model. As such, the model illustrated a good fit for the research data. The goodness of fit information shows statistical insignificance (χ^2 (3523) =2134.13, p>1.000); thus, the model fitted the research data because there were no significant differences in the observed data and fitted/assumed model. The regression test results are displayed in Table 4.4.

Table 4.4 Effects of desert locust risks on various human security dimensions

Human security dimensions	Wald	df	Sig.	95% Confidence Interval		
				Exp_B	Lower	Upper
Food security	177.873	1	<0.001	4.389	3.504	5.490
Health security	174.220	1	<0.001	3.177	2.675	3.773
Economic security	166.475	1	<0.001	3.068	2.575	3.655
Personal security	164.983	1	<0.001	2.951	2.502	3.480
Environmental security	158.359	1	<0.001	2.790	2.399	3.241

(Source: Field data – 2024)

Based on the ordinal logistic regression test, all the odds for desert locust risks to human security showed statistically significant effects in all dimensions (Table 4.4). Wald χ^2 (1) = 177.873; p<0.001 for food security risk, Wald χ^2 (1) = 174.220; p<0.001 for health security risk, and Wald χ^2 (1) = 166.475; p<0.001 for economic security risk. Wald χ^2 (1) = 164.983; p<0.001 for personal security risk, and Wald χ^2 (1) = 158.359; p<0.001 for environmental security risk. This meant that for every unit increase in the overall risk from desert locusts, there could have been a corresponding increase in the threat to all the human security dimensions.

Desert locust risk had the highest effect on food security and the lowest threat to environmental security. As such, food insecurity due to desert locusts had the most effect on the overall human security risk, while environmental insecurity had the least effect. An extra day of persistence of desert locust invasion or an increase in the pest population following in-country breeding or re-invasion, therefore, could have led to increased risk to food, health, economic, personal and environmental security. It is recognition of this danger that desert locusts could have been securitized in order to deploy the fastest and most effective management strategies to control the pest.

4.2.8 Summary of Desert Locust Risks to Human Security

In conclusion, the results indicated that there were diverse risks from desert locusts cutting across various human security dimensions. There was, therefore, urgency in responding to manage desert locusts swiftly using extreme countermeasures. Securitization of desert locust management was therefore plausible to avert existential threat to lives, livelihood, and the environment. However, continuous monitoring and evaluation were necessary to change tact in cases where interventions could have triggered unforeseen security threats.

4.3 Securitization of Desert Locust Management Practices to Protect Human Security

It is worth noting that this research aimed to analyse the securitization of desert locust risk management and human security in Kenya. There was, therefore, a need to analyse desert locust management practices that could have been securitized in order to protect human security from the existential threat of desert locusts. This is because securitisation requires the framing of a security threat as an existential danger that requires extreme and timely interventions (Balzacq, 2011).

To assist in the analysis, securitized desert locust management practices were contextualised regarding surveillance, traditional control methods using indigenous skills, physical control, chemical control and recovery programs. The constructs of analysing securitized desert locust surveillance were ground monitoring and reporting by national government officers, county government employees, and community scouts, as well as aerial observation, tracing and tracking using aircraft or drones.

The constructs of analysing securitized desert locust control included spraying the insects with pesticides, scaring them with noise, digging trenches to trap hoppers, praying for divine intervention, spraying with home-made substances, mechanical killing of the insects, harvesting the pest for food and feed, burning them with fire, and using supernatural powers such as witchcraft. The constructs of analysing desert locust recovery measures included the supply of crop input packets, reforestation, relief food supply, reseeding, money-for-work programs, restocking, supply of livestock input packets and cash transfers. Results for the constructs that were used to analyse securitized desert locust management practices are illustrated in Figure 4.3.

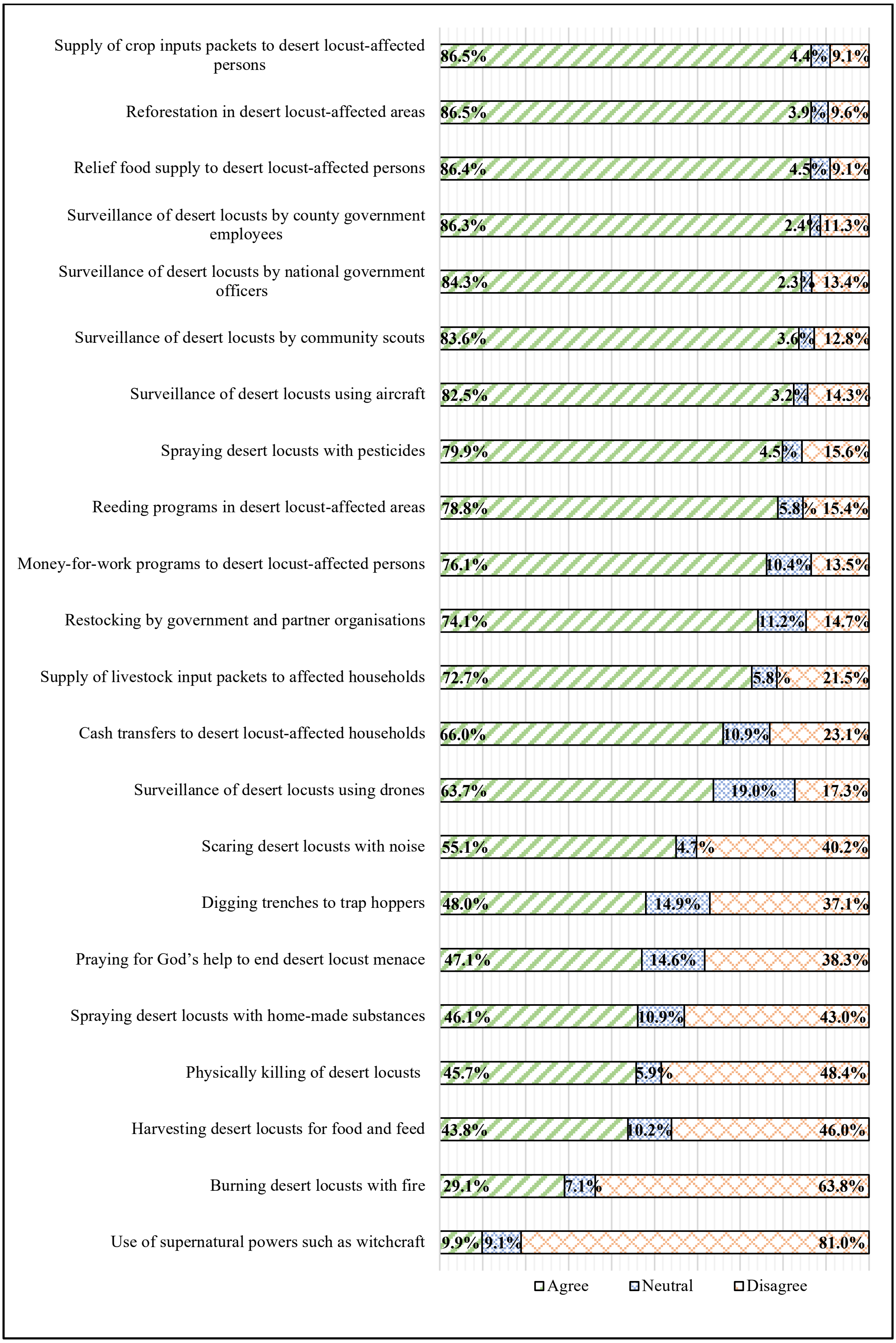

Figure 4.3 Percentage response to securitized desert locust management practices

(Source: Field data – 2024)

Out of the 779 successful participants who responded to the study, 672 (86.3%), 657 (84.3%), and 651 (83.6%) felt that surveillance by county government employees, national government officers, and community scouts, respectively, contributed to protecting human security against desert locust risks. In addition, 643 (82.5%) and 496 (63.7%) respondents agreed that surveillance using aircraft and drones protected human security against desert locust risks.

There were 622 (79.9%), 429 (55.1%) and 374 (48.0%) respondents who had the opinion that spraying the pest with pesticides, scaring the insects with noise, and digging trenches to trap hoppers, respectively, protected human security against desert locust risks. In addition, 367 (47.1%), 359 (46.1%), and 356 (45.7%) respondents agreed that praying for God's intervention, spraying desert locusts with home-made substances, and mechanical killing of the insects contributed to the protection of human security against desert locust risks. There were 341 (43.8%), 227 (29.1%), and 77 (9.9%) respondents who believed that harvesting the insects for food and feed, burning the pests with fire, and using witchcraft, respectively, protected human security against desert locust risks.

A total of 674 (86.5%), 674 (86.5%), and 673 (86.4%) respondents agreed that supply of crop input packets, reforestation, and supply of relief food protected human security against desert locust risks. In addition, 614 (78.8%), 593 (76.1%) and 577 (74.1%) of respondents felt that reseeding programs, money-for-work programs, and restocking programs, respectively, contributed to the protection of human security against desert locust risks. Moreover, 566 (72.7%) and 514 (66.0%) of respondents had the opinion that the supply of livestock input packets and cash transfers, respectively, helped to protect human security against desert locust risks.

4.3.1 Securitization of Desert Locust Surveillance to Protect Human Security

Securitization of desert locust surveillance practices was analysed using ground monitoring and reporting by national government officers, county government employees, and community scouts, as well as aerial observation, tracing and tracking using aircraft and drones. Out of the 779 participants who successfully responded to the study, 672 (86.3%) respondents felt that county government employees' surveillance protected human security against desert locust risks.

This assertion is because agriculture is a devolved function, and hence, county employees actively participated in desert locust surveillance activities. To emphasize this discovery, one of the county agricultural officers said, "Everyone was running after locusts from one village to another and sending location coordinates to control teams for them to come fast and help in killing the pest." This statement shows extreme practices that would not be sanctioned for normal pest management. From the statement, evidence of police-like patrols to trace, track, and report desert locusts was an extreme venture.

One of the responsibilities of agricultural extension officers is managing plant pests and disease. However, the respondent reported the involvement of "everyone" in supporting the surveillance of desert locusts and an urgent need to report the pest, which indicates the extreme and exigent nature of surveillance. The mention of control teams also suggested the interventions were multifaced, which indicates there were layers of different teams.

Such an organizational approach in pest management is also extreme, and hence, it points to the securitization of desert locust management. County agricultural officers played a critical role during desert locust surveillance by verifying crowd-sourced reports and guiding control teams during spray operations. They also sensitized the public and created awareness of the need to report desert locusts for rapid control. Such a level of community mobilization signifies an escalation of desert locusts beyond normal plant pest circumstances where only the concerned parties would be informed.

From the quote, it was clear that the migratory and destructive nature of desert locusts could have led to the securitization of their surveillance. Securitized surveillance led to everyone monitoring the pests, precise reporting of their roosting locations, and fast response by control teams to kill them. This is because there was only a limited time window for control either in the evening or early in the morning before take-off and sustained flight throughout the day. They, however, get down from the plants in the morning and bask in the sun for a while before flying. This is an opportune time to control desert locusts, as spraying a flying swarm is difficult.

Gregarious desert locusts fly during the day and roost on plants at night as they continue to feed on the leaves of any green plant (WMO & FAO, 2016). This explains why their surveillance was securitized with extreme and highly organized police patrols to ensure every available opportunity to reduce their population was utilised. The findings of the study corroborated the report of Tabar *et al.* (2021) that the global strategy for desert locust management is supported by ground surveillance.

There were 651 (83.6%) respondents who alluded that surveillance by community scouts contributed to the protection of human security against desert locust risks. Training of community scouts by the government, development partners and NGOs on reporting using GPS-enabled mobile applications created a burden of responsibility on citizens to report desert locust presence. Community scouts played an important role in reporting desert locust presence in their localities.

One youth from a remote village passionately expressed himself about surveillance of desert locusts, saying: "We acted like spies. We spoke to random people on our way to ask where locusts were seen. We then carefully took pictures of the locusts and sent them to authorities using our phones as if we were reporting thieves." As the quote shows, desert locust surveillance was organised like an anti-crime intelligence collection operation. Reporting had a chain of command as depicted by the statement "…to authorities…." Such a high level of community mobilization and organization would not be necessary when dealing with a normal pest management procedure.

The success of desert locust management is dependent on successful surveillance, especially the ability to trace and track migrating swarms from one location to the next until spraying is done (Showler *et al.,* 2021). Community scouts, therefore, played a critical role in ground monitoring and reporting precise coordinates for precision spraying of the pest. From the literature, foot transects by trained professionals are often used during surveys to estimate the total infested area, thus assisting in delimiting areas that require control (Cressman, 2008).

Given the diverse risks from desert locusts, as outlined in the first objective, the process was upscaled to include the general public. This ensured fast and continuous reporting for prompt response that is required to reduce the threats. As such, making desert locusts a political issue allowed resources to be availed for training scouts and provided them with special equipment such as GPS-enabled mobile applications.

There was an increased number of swarms that were invading Kenya from December 2019 to November 2021 (GOK, 2022). The increased number of swarms, coupled with the fear of many previously elaborated human security risks from the pest, made both national and county governments, in collaboration with other local, regional and international institutions to scale up surveillance activities. This resonates with the observation by USAID (2020) that emphasised the need to scale up desert locust management operations in, among other regions, central and northern parts of Kenya. This globally recognized planning of desert locust surveillance confirms the securitized nature of monitoring and reporting the pest in its gregarious phase during upsurges and plagues.

Out of the total number of respondents, 657 (84.3%) agreed that national government officers' surveillance helped manage desert locust risks and thus protect human security. Although agriculture is a devolved function, the management of migratory pests is still coordinated by the national government through the responsible ministry, departments and agencies. However, the decision by both levels of government to suspend the separation of roles and work interdependently shows how crises can leverage the securitization process.

One plant protection expert noted, “Migratory pest invasions are a national security threat. Desert locust as a transboundary disaster should even be considered an international security issue that requires high-level collaboration by different countries just like terrorism.” The statement indicates the crucial political position that migratory pests such as desert locusts take in national security management. For example, desert locust invasion coincided with the COVID-19 pandemic.

Desert locust management was, however, treated as an essential service that necessitated waiver from some of the COVID-19 containment measures, such as restricted movement. One officer explained this situation: "Despite COVID-19 lockdown, we criss-crossed the country chasing locusts from one county to another. We had special passes that we would show the police at checkpoints, and they would allow us through." The quote demonstrates the securitization of desert locust management.

For example, everyone who played a critical role during desert locust management was given the authority to move beyond lockdown boundaries, just like security personnel and medical practitioners. By securitizing desert locust management and framing the pest as an existential threat that required urgent intervention, national government plant protection officers were accorded special movement privileges. This was to allow them to trace, track and control desert locusts, especially in remote, protected and insecure areas that were inaccessible to county technical teams and community scouts.

Other than national plant protection officers, national government administrative officers (NGAOs) in the counties played an important role in collecting and disseminating information related to desert locust information. The NGAOs included members of the administrative arm of government, such as assistant chiefs and chiefs, as well as assistant, deputy, county and regional commissioners. The participation of NGAOs, who form part of security committees at national and sub-national levels of governance, portrayed the securitization of desert locust management.

Under normal circumstances, these officers focus on crime and intelligence collection. However, the elevation of desert locusts as a national security issue created a burden of responsibility for NGAOs as they were required to report on the progress of its management in their areas of jurisdiction. The NGAOs also assisted with public sensitization and awareness creation among community members to promote reporting by citizens. The results of this study are in line with survey and control standard operating procedures (SOPs) that recognize security agents as an important source of information (FAO, 2021b).

There were 643 (82.5%) and 496 (63.7%) respondents who agreed that surveillance using aircraft and drones, respectively, protected human security against desert locusts. Tabar *et al.* (2021) acknowledged that the global strategy for desert locust management is supported by ground surveillance. As such, the use of aircraft and drones went beyond the norm to suggest the heightened need for speed, precision and safety in reporting desert locust positions for rapid control. The results support Alemu and Neigh (2022) in recognising the critical role of aerial surveillance in accessing rugged terrains in Ethiopia during desert locust management operations.

Recognizing this opportunity, a participant commented, “There were low-flying aircraft every morning and evening. We thought they were chasing bandits only to learn they were looking for locusts.” Cressman (2008) observed that settled swarms and large hopper bands are visible when looking down at an angle from a low-flying aircraft. In addition, navigating a helicopter as low as safely possible and not higher than 5 metres above the ground can disturb any locusts that may be present making them fly upwards (FAO, 2021b). As such, in order to identify desert locust for precision targeting with pesticides, surveillance aircrafts had to fly low above suspected roosting sites.

Securitization of desert locusts by elevating their human security risk to an existential level allowed the use of aircraft in surveillance. Fixed-wing spotters and rotary-wing helicopters were used during search surveys to trace and track desert locusts. Rotary-wing aircraft were also used to demarcate spray zones for precision spraying to prevent non-target areas from contamination with pesticides. This created a relative advantage as aerial surveys are more accurate for fast and effective spraying of the pest than foot transects. Based on the biology and behaviour of desert locusts, the pest roosts on plants in the evening after flying during the day (WMO & FAO, 2016). They remain on plants eating throughout the night and get down to the ground in the morning after sunrise to bask for energy that supports their flight.

The extreme organization and coordination of tracing roosting sites reduced the time that was required for control. This was critical for successful desert locust operations because losing their migratory route would mean transferring human security risk to other counties, countries or even regions. Recognizing this danger of risk transfer, securitization of desert locust surveillance using low-flying aircraft could have been to avoid irresponsible omissions that would expose more people to devastating threats of the pest.

There were 496 (63.7%) respondents who alluded that surveillance using drones contributed to the protection of human security against desert locust risks. Although UAVs were not extensively used for desert locust surveillance in Kenya, drones were piloted to survey remote and hilly areas. One farmer commented, "We thought it was a bird. We wondered which bird made a continuous whistling noise and why other birds were following it without attacking it. We later got to know that they are called drones." Although drones are quickly gaining popularity for use in many human activities, they are seldom used for pest surveillance.

The extreme efforts by authorities to seek alternative means of tracking desert locusts in hard-to-access areas point to securitization. Drones were a safer surveillance option in hilly places where the manoeuvrability of fixed-wing aircraft at low altitudes, as recommended by Cressman (2008), could have been dangerous. The results are in resonance with Matthews (2021) that drones can complement manual surveillance in harsh geographical terrains. In addition, drones were more practical than aircraft in insecure areas where the attack of helicopters by bandits with projectiles could occur. Other than assessing surveillance options that were used to protect human security against desert locust risks, the study also assessed securitized control methods.

4.3.2 Securitization of Desert Locust Control to Protect Human Security

Securitization of desert locust control practices was analysed in terms of chemical control, physical control and tradition/indigenous methods. Securitization of chemical control was assessed by spraying desert locusts with synthetic pesticides or biological insecticides. Securitization of physical control was assessed through mechanical killing of the insects, digging trenches to trap hoppers, harvesting the pest for human food and animal feed, scaring swarms with noise as well as burning desert locusts with fire. Securitization of traditional control was assessed using prayers to God and the use of other supernatural powers such as witchcraft.

4.3.2.1 Securitization of chemical control of desert locusts

Securitization of chemical control was assessed by spraying desert locusts with synthetic pesticides or biological insecticides. Out of the 779 participants who successfully responded to the study, 622 (79.9%) respondents stated that spraying desert locusts with synthetic pesticides protected human security by reducing damage to crops, pasture and vegetation. During the national FGD, one participant asserted this saying:

> "Desert locusts were damaging everything on their way like terrorists. The pest required a silver bullet to eradicate it. Pesticides provided that lethal option. There was spraying of desert locusts through ground and aerial options using EC and ULV pesticides especially Fenitrothion and Deltamethrin. Deltamethrin was preferred in Kenya as a safer option

among synthetic pesticides as it contains pyrethroids which are not detrimental to humans and wildlife."

Equating desert locusts with terrorism indicated the level of destructiveness and fear the pest caused in Kenya.

The mention of a need for the silver bullet connotes a magical solution to a complex problem. Indeed, the invasion of desert locusts was a complicated problem for the Kenyan population. From one of the FGD sessions, one participant said that "None of us seated here had ever witnessed this kind of phenomenon. This kind of thing, we are told, happened about seventy years ago." The quote suggested that desert locust menace was an unfamiliar pest problem to many Kenyans. The implication was that the problem though global and rampant in most breeding areas, it had been forgotten and perhaps unforeseen in Kenya.

The rapidly evolving threat of desert locusts to human security, as discussed in the first section, seemed to have created fears that awakened the desire to use multiple strategies. These desert locust management strategies were implemented in a securitized (doing-everything-possible approach) to reduce the pest population and deter its impact on human security. The spraying of pesticides through ground and aerial platforms demonstrated that extraordinary measures were employed. The multiple strategies that were implemented demonstrated the urgency required to minimize its impact on different dimensions of human security. In addition, the use of synthetic pesticides despite the adverse effects on the environment and population indicated the need for an immediate and assured response to contain the desert locust invasion.

The use of uncommon pesticide formulations such as ULV also suggested there was securitization. The use of ULV depicts that special considerations must be made in decision-making during desert locust management. For example, in ASALs, where access to water is sometimes limited, ULV was usually preferred as they are oil-based and ready-to-use pesticides that do not require mixing with water. In addition, quantities as low as low as 0.5 litres of ULV pesticides can control up to 1 hectare of desert locusts (Mamo & Bedane, 2021). This reduces operational costs in controlling desert locusts especially in water-scarce desert areas.

Use of ULV pesticide formulation in desert locust control however requires specialized skills as calibration of spray equipment, handling of the chemicals and consideration of prevailing weather conditions are essential factors for effective and efficient application. The use of ULV pesticides in desert locust control demonstrated some level of special operations. Special operation considerations support the earlier statement, “treating desert locust invasion like terrorism…” which also requires a special force skillset to counter. However, the use of pesticides could have had negative ecological implications and may have posed health security risks (Mamo & Bedane, 2021). Therefore, chemical control of desert locusts could have had negative ecological impacts on non-targeted organisms, humans and the environment. The mention of Deltamethrin, in the quote, as a safer pesticide shows recognition of the need to protect human security amidst the need for urgent and extreme interventions.

To demonstrate the national security nature of desert locust management, one of the county government officials asked, “Why couldn’t the national government give us money to spray locusts ourselves instead of running all over the country like we didn’t exist? The national government made it look like a security operation.” These sentiments are valid based on the devolution of agricultural functions to counties. However, desert locusts, as a transboundary migratory pest with the potential to move up to 200 kilometres daily (Symmons & Cressman, 2001), meant they could not be contained within county administrative boundaries.

The long-distance mobility of the pest also meant there was limited time to build the capacity of desert locust management personnel across all 47 counties for uniform and coordinated operations. Through the ministry responsible for agriculture and livestock development, the national government had to coordinate desert locust management activities in all the affected locations across the country. Organization of desert locust management like a security operation, as described by the participant, also suggested that authorities went outside the norm. This elevated scale of operations was conspicuously discernible even by the locals.

Limited financial, technical and human resource capacity to manage desert locusts also required high-level decision support mechanisms for the mobilisation of requisite monetary facilitation, pesticides, equipment and skilled manpower. These unique needs could have been the basis for the securitization of desert locust control operations to take advantage of readily available government resources that, under normal circumstances, would not be availed for pest management activities. A national FGD participant reported, "Aerial control of desert locusts was done by military aircraft. Ground spraying was mainly done by the army using vehicle-mounted sprayers, and trained NYS members using hand-held and backpack sprayers." This quote portrays an outright extreme approach to desert locust management. Military aircraft, soldiers, and NYS members are not routine plant protection resources.

The use of national security critical resources in desert locust control operations helped to ease the mobilising of personnel, increase work rate and hence ensure the operations were not only effective but also efficient in protecting human security. For instance, other than hiring private aircraft, it was easy to take advantage of military aircraft that would otherwise be idle in airbases during peacetime when there is no war. In addition, it was easy to access many youths during the NYS community service stage, train them and quickly deploy them as part of their corporate social responsibility.

Initiation of and following through the lengthy government recruitment processes, which takes months, meant that desert locusts could have had more time to cause severe destruction to crops, pasture and other plants, thus increasing the risk to human security. Other than the effectiveness and efficiency that come with using already available government resources, the military and NYS teams were equipped with special self-defence, survival and endurance skills, and hence, they were able to access geographically remote and rough terrains as well as insecure areas. To reaffirm the securitization of desert locust control, one participant commented, "They were spraying locusts with machine guns." It is worth noting that vehicle-mounted sprayers (VMS), from a distance, may look like machine guns to some communities in insecure parts of the country where security equipment is common. The securitization of control operations allowed the importation of VMS.

A VMS is an improved spray equipment that is mounted on pickup to enhance the work rate. Although the statement sounds ignorant to a subject matter expert, it is a clear indication of the securitization of desert locust control because regular pest infestations would be managed using handheld sprayers, knapsacks and motorised sprayers. Remember, a 1 square kilometre swarm of desert locusts can have up to 40 million insects with the potential to eat 80 metric tonnes of green vegetation (WMO & FAO, 2016).

These insects with such a high destructive capacity could not have been controlled using regular sprayers. To show the extreme and urgent nature of desert locust management, a participant enthusiastically expounded on military involvement in desert locust operations that, “I thought Jeshi are only concerned with terrorists, only to find them flying all over and driving Land rovers with sprayers instead of machine guns.” “Jeshi” is a Swahili word for soldiers. The mention of soldiers in a plant protection conversation illustrated the securitization of desert locust management operations. Acknowledgement by the participant that military vehicles ought to be mounted with machine guns, not sprayers, reinforces the securitization discourse.

Desert locust invasion was framed as a natural disaster that posed an existential threat to humanity. As such, due to the securitization of desert locust management, the military assumed their secondary mandate of supporting civilian activities during disasters. Soldiers were, therefore, performing one of their rightful peace-time humanitarian duty. The resilience and discipline of military personnel also allowed for their rapid mobilisation and deployment to remote, geographically difficult, and insecure areas. The findings concur with Yates (2019), who reported that the British army participated in anti-locust operations in desert locust recession areas of the Arabian Peninsula between 1942 and 1945 during World War II.

In cognizance of the transnational nature of desert locust upsurges, an FGD participant reminded others that “This is an imported problem, and Kenya should not behave like it can deal with it alone. Had our neighbours done their bit, we would not be where we are today.” This statement seemed to reiterate that the securitization of desert locusts was not a perception but an inevitable discourse. The participant felt there was a need for a regional approach to desert locust management. The pest’s long-distance migratory attribute (GOI, 2019) poses a transnational threat to regions and sometimes continents. Individual countries could, therefore, not manage the pest alone. Remember, one respondent had earlier compared desert locusts to terrorism. Securitization of desert locust management required escalation of the issue to geopolitical status.

The geopolitical approach allowed joint efforts by national, regional and international organizations to be an indication of the securitization of desert locust management. There were, therefore, multilateral collaborative efforts through DLCO-EA, IGAD and FAO Central Region Commission for controlling the desert locusts (CRC). The findings concur with Tabar *et al.* (2021) that the overarching strategy for desert locust outbreak control involves spraying the pests with pesticides. In addition, Kenya is a frontline invasion country where preventive management of desert locusts was almost impossible because the pests had already arrived in gregarious swarms. Pesticides may, therefore, have been one of the most practical first lines of defence against the destructiveness of pests to safeguard human security.

There were 359 (46.1%) respondents who felt that spraying desert locusts with homemade substances protected human security. A participant explained this further, saying, “We mixed pilipili with wood ash in water and sprayed locusts.” The “Pilipili” is a Swahili word for hot pepper. This mixture is part of the community-based indigenous technical knowledge and skills (ITKS). Moharana *et al.* (2020) discovered that farmers used biological concoctions, especially garlic spray, to repel desert locusts in India. However, the urgency of the local community to act and do so fast, despite having no prior experience and requisite knowledge of desert locust management, suggested that individuals as a unit of analysis could securitize threats. This is because the mixture may not have passed through prerequisite efficacy tests, but the risk of losing crops and pasture to desert locusts justified its use.

4.3.2.2 Securitization of physical control of desert locusts

Securitization of physical control was assessed through mechanical killing of the pest, digging trenches to trap hoppers, harvesting desert locusts for human food and animal feed, scaring the swarms with noise, and burning the insects with fire. Among the 779 participants who successfully responded to the study, 429 (55.1%) agreed that scaring the insect pest with noise protected human security by reducing damage to crops, pasture and vegetation by desert locust risks. The results are in tandem with those of Yuga and Wani (2022), who found that affected communities in Sudan used noisemaking as a desert locusts management strategy.

During county FGD, a participant reported:

> "When we arrived to do a search survey in one of the counties, everyone in the entire village was shouting as if they were chasing a thief. Even police reservists were shooting bullets in the air to try and scare away desert locusts."

The fact that people were making loud noises points to securitization at the community-level unit of analysis because a normal pest would not require such an abnormal response. In addition, the act of police reservists shooting bullets in the air confirms the securitization of desert locust management. The use of bullets, in whatever form, is considered lethal force, which would not be needed when dealing with pests.

The human security risks from desert locusts, as comprehensively discussed in the previous section, however, called for urgent and extreme interventions. This could have warranted gunshots to scare away the swarms and thus stop them from destroying crops and pasture. The findings conform to Chitre (2020), who documented the use of police sirens to scare away desert locusts in India. However, from a logical point of view, making noise only disturbed desert locusts and may have led to their short-distant movement. As such, noisemaking only reduced the level of damage in one location but transferred the security challenges to the neighbouring locations.

The actions that were taken by locals demonstrated a shared understanding that desert locusts needed to be considered and collectively responded to as a threat to livelihoods (Baysal, 2020). Their actions awakened the political elites and government to respond to the human security challenges they were facing. Although their actions could have made little contribution as far as the management of the pest is concerned, their cry for help could have contributed to the securitization process.

This resonates well with securitization theory, which recognizes speech acts as a key medium of escalating threats beyond normalcy to attract enhanced and urgent attention (Kjaer, 2020). Accordingly, securitization theory leans more on speeches by politicians, opinion leaders, and business capital owners (Baysal, 2020). However, speech-language, such as distress calls for help by people in desert locust-affected areas, could have shaped a discourse capable of creating a unique space where political action was acceptable (Kjær, 2020).

It should be noted that politicians are elected by citizens and, therefore, have to remain sensitive to the needs of their electorate. As such, the securitization of desert locusts by the general public could have forced politicians to persuade the government to respond urgently to manage the pest. In line with this view, a high-ranking agriculture officer stated:

> "I could receive calls from politicians in affected constituencies questioning why we had not gone in their area to spray desert locusts. Some Governors were even calling the President who would turn the pressure to the ministry. We received phone calls from top ministry

> leadership questioning why it was taking too long to deal with the locust in some areas and demanding immediate action. It was disturbing and overwhelming."

As stated in the quote, the desperation of communities in desert locust-affected areas might have created space for securitized operations. People acted in despair, which could have transferred the agenda of 'panic politics' (Buzan et al., 1998) to compel political leaders to demand extraordinary measures against desert locusts. Therefore, although political action may not have done much in reducing the desert locust population, it could have contributed to the securitization process, allowing immediate action using all available means.

There were 374 (48.0%), 356 (45.7%) and 227 (29.1%) respondents who supported digging of trenches to trap hoppers, mechanical killing of desert locusts and burning the pest with fire, respectively, as control measures that contributed to protecting human security. A respondent explained the use of physical control, saying, "We would step on them, beat them with sticks and burn them early in the morning before they wake up and start flying." The mention of people beating and burning desert locusts suggests desperation.

The precision of these desperate actions demonstrated the determination of people to control the pest. Moharana *et al.* (2020) assessed the status of desert locust control strategies and found that farmers were beating and burning pests in India. Physical efforts to manage desert locusts may seem labour-intensive and time-consuming. However, physical control measures could have helped manage low-scale desert locust infestations. Physical control could also have been practical in sensitive locations where aerial spraying could have been risky.

Physical control of desert locusts may also be a useful preventive control method in recession areas during outbreaks. However, it may be ineffective in invasion areas such as Kenya, where gregarious swarms arrive in large numbers. These desperate actions were very important, however, to raise the alarm for immediate action to protect human security from desert locust risks. Looking at desert locusts as a security threat at household and community levels showed the dire need for external support from the government.

There were 341 (43.8%) respondents who felt that harvesting the pests for food and feed protected human security against desert locust risks. A respondent recalled, "We would wait until late at night, go to where locusts were sleeping, shake the trees for them to fall, then collect them and put them in sacks. We were paid Kshs 50 per kilogram." Another respondent during the national FGD session explained, "There is a village that harvested one tonne of desert locusts, and we paid a whopping Kshs 50,000. We couldn't believe it!"

Harvesting desert locusts at night appears out of the norm as an extreme way of managing pests. The tactical move of villagers to wait until late at night to catch the locusts also seemed premeditated and well-executed. This kind of manoeuvre would not be necessary in routine pest management practices. Such actions reveal recognition of the existential risk from the pest that required extraordinary response. The mention of one tonne of desert locusts having been harvested in a night also served as evidence of the magnitude of the risk. While harvesting and processing desert locusts may not be sustainable in invasion countries due to a few upsurges that are spread far apart in time, this could have been a complementary method of managing the pest to safeguard human security. The tonnage of the harvested insects was also justified using all possible means to control the pest.

Harvesting and converting desert locusts into food, feed, and fertilizer is evidence of extraordinary measures that could have emerged from the need to control pests. The findings are corroborated by Kietzka *et al.* (2020), who reported that locusts can produce human food and livestock feed. In addition, the results asserted by Stanford *et al*. (2021) that desert locusts can also be used as organic fertilizer. Indeed, harvesting of desert locusts could form part of the integrated recovery mechanism as part of work-for-pay programs where communities are paid to collect the insects. The same desert locusts could then be processed and given back to the communities for free as input packets in the form of bio-fertilizer or animal feed.

4.3.2.1 Securitization of traditional methods of controlling desert locusts

Traditional control was assessed using prayers to God and the use of other supernatural powers such as witchcraft. There were 367 (47.1%) and 77 (9.9%) respondents who believed that praying for divine intervention and using witchcraft, respectively, contributed to protecting human security against desert locust risks. During county FGD, a participant recalled saying, "I prayed, sometimes fasting with the hope that God would not punish us for long." Another old participant reported, "During the last invasion before Kenya got independence, there used to be an old man who could blow ash with his mouth and the locust would follow the direction of the ash without settling in our area." Usually, only threats that are beyond human control are considered for divine and supernatural interventions.

The belief that prayers and witchcraft could have resolved the desert locust problem indicated that the pest was securitized at an individual's personal level. The above highlighted quote suggests that modern societies still believe in indigenous technical knowledge, where traditionally, some community members were bestowed with special powers to cast spells on anything that could affect people negatively. However, there is little empirical evidence that prayers or other supernatural powers could have helped to manage desert locusts, but community beliefs cannot be ignored.

4.3.3 Securitization of Desert Locust Recovery Measures to Protect Human Security

Desert locust recovery programs were categorised into adaptive and resilience recovery programs. Adaptive recovery programs were meant to help communities with short-term endurance from immediate shocks of lost livelihoods. Adaptive recovery measures included the provision of relief food, cash transfers and money-for-work programs. There were 673 (86.4%) respondents who supported relief food supply as a recovery program that acted as a safety net against food insecurity occasioned by desert locusts. To describe the dire situation that people found themselves in, one participant commented, “Locusts made us start living like refugees. We received food from the government and well-wishers. Without them, we would all be dead by now.”

The above quoted statements suggest that the government and other stakeholders were involved in distributing relief food during desert locust management in Kenya. Acknowledgement by the respondents that they assumed the status of people in need of humanitarian support points to securitization. Most humanitarian situations attract securitized interventions due to the responsibility to protect people. Normally, security threats would not require humanitarian interventions such as the distribution of relief food. Framing desert locust invasion as a natural calamity that needed an emergency response helped trigger rapid and extreme responses.

The findings are in line with Lassa (2017), who reported that following the invasion of desert locusts in 2016-2017, the government distributed rice to people in East Sumba, Indonesia. Most humanitarian organizations are, however, changing their implementation strategy from relief food supply to cash benefits to broaden support to households. This option of giving people foodstuffs was still useful in remote areas where access to markets was difficult because cash transfers could have caused beneficiaries the additional burden of travelling to urban centres to purchase food.

There were 593 (76.1%) and 514 (66.0%) respondents who felt that money-for-work programs and cash transfers, respectively, contributed to protecting people from economic security risks that had been caused by desert locusts. A respondent narrated, "I received Kshs 4000 for three months from an NGO. The money was not enough, but it helped me feed my family for some days." This statement, coupled with an earlier mention of desert locusts turning people to begging, confirmed the extent to which the pest affected human security. In addition, cash transfers are associated with humanitarian aid during crises (Manley *et al.,* 2012).

The fact that the desert locust invasion in Kenya coincided with the COVID-19 pandemic (Kenya Red Cross, 2020) meant that restricted movement to reduce the disease from spreading also barred people from going far to seek help. This confinement could have easily turned the situation into a crisis, bearing in mind that most people had lost their livelihood from livestock and crop production. Direct interventions such as cash transfers are not sustainable in the long term (Manley *et al.,* 2012). However, cash transfers could have been useful financial safety nets to sustain households' purchasing power after the loss of livelihoods from agricultural enterprises due to the destruction of crops and pasture. The findings are in line with

Geladari *et al*. (2020) documentation that livelihood protection and recovery interventions are critical during and after desert locust invasions.

Other than adaptive recovery programs that were carried out alongside desert locust control operations, there were also resilience recovery programs that followed during the post-invasion period. Resilience recovery programs were meant to help the communities in the long-term revival of the affected agricultural enterprises. Resilience recovery programs included reseeding, restocking and reforestation. There were 614 (78.8%) and 577 (74.1%) respondents who agreed that reseeding and restocking programs, respectively, assisted households in recovering from human security risks that had been occasioned by desert locusts.

A respondent explained this by saying:

> "I received maize, green gram and bean seeds from an NGO. Government officials also gave me one goat that gives me some milk. The goat has also given me two twin kids. Now I have five goats. I don't know where I would be without this help."

This quote emphasises the important role that resilient recovery programs play in absorbing the economic shocks of disaster emergencies. However, it would not be routine to do recovery as part of a normal pest infestation. Resilient-building interventions would be associated with disaster situations such as floods and drought (Wilson *et al.,* 2021). With the loss of livelihoods after the massive and indiscriminate destruction of crops and pasture by desert locusts, most communities were left vulnerable. There was, therefore, a need to initiate income-generating activities to help the communities earn a living.

Securitization of desert locust invasion gave the pest an elevated status of a natural disaster. This elevated status of desert locusts justified the impetus for extreme recovery interventions such as reseeding and restocking. Reseeding and restocking programs may not have adequately compensated the farmers for the losses incurred due to desert locust invasion. However, they cushioned affected households against the shocks of having to start agricultural investment all over again without capital injection. This also eliminated dependence on unsustainable short-term support such as relief food and cash transfers. Resilient-building interventions also helped to empower affected communities by making them self-sustaining through food production and income generation from surplus produce.

There were 674 (86.5%) and 566 (72.7%) respondents who alluded that the supply of crop and livestock input packets, respectively, protected human security from desert locusts. One respondent recalled, “I received fertilizer, pesticides and poultry feed. Without feed for the chicken, I could have eaten them rather than watching them die of hunger.” This statement shows the desperate situation that desert locust-affected families found themselves in. This desperate voice of citizens could have contributed to the Speech Act (Kjaer, 2020) that led to the securitization of recovery interventions. Without securitization, it would not have been urgent to supply farm inputs as part of normal pest management strategies.

Such extreme recovery interventions would be associated with natural calamities such as extended drought situations (Wilson *et al.,* 2021). It also points to a need for integration of both protective and empowerment recovery measures to safeguard early wins that could have been lost if the people were left on their own. Households’ economic well-being was greatly affected, and the purchasing power was reduced. It would have been a zero-sum intervention to provide seeds and livestock without some accompanying support mechanism in terms of farm inputs. It is from this understanding that, as a follow-up to reseeding and restocking initiatives, government and NGOs provided input packets to sustain the revival of agricultural enterprises in desert locust-affected areas.

There were 674 (86.5%) respondents who felt that reforestation helped in protecting the environment against the damage of vegetative biomass by desert locusts. A respondent elaborated on this by reporting, *"*We received fruit tree seedlings, especially avocados, from government and NGOs. They promised us that from every successful transplant, we would get additional seedlings." Avocado (*Persea americana*) is a common fruit in Kenya. This statement confirmed that institutions that were involved in post-desert locust invasion recovery interventions, were aware of the environmental security risk that could have been caused by the pest through indiscriminate devastation of vegetation.

It would however not be a normal activity to do reforestation due to ordinary pest infestation. Reforestation would be expected to be occasioned by disaster situations such as wildfires. However, while environmental security could have been the most affected by desert locusts, most recovery programs focused on livelihood restoration. There is, therefore, a need to intentionally plan for environmental rehabilitation in the desert locust-affected areas after upsurges and plagues. In addition, despite emotional stress having been identified during the assessment of desert locust risks to people, there was limited documented evidence of psychosocial rehabilitation.

4.3.4 Securitized Desert Locust Management Practices

Results for the securitized desert locust management practices that protected human security were summarised in terms of percentage contribution from surveillance, physical control, chemical control, traditional methods and recovery programs (Figure 4.4).

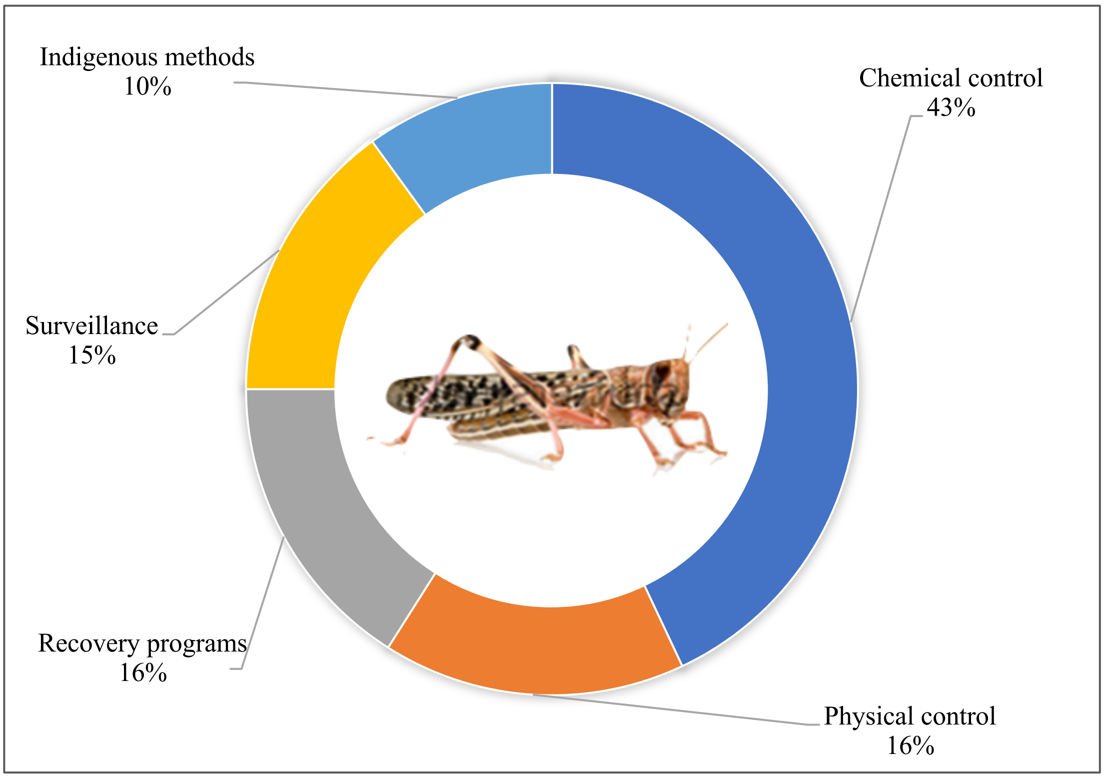

Figure 4.4 Percentage contribution of securitized desert locust management practices (Source: Field data – 2024)

Among the various securitized desert locust management practices, chemical control contributed 43% to protecting human security. The high contribution of chemical control is due to the use of pesticides as the first line of defence against desert locusts, especially in invasion countries. This is due to the fact that in invasion countries, preventive strategies may not be practical because outbreaks occur far from infestation areas. Physical control contributed 16% to the overall protection of human security against desert locusts. This can be linked to securitized countermeasures by community members to try and reduce the number of desert locusts through any available option.

Recovery programs contributed 16% of the overall human security safeguards against desert locusts. This can be attributed to the emergency security threat that desert locusts posed to lives and livelihoods, calling for urgent interventions. Surveillance contributed 15% of overall desert locust risk reduction. Surveillance, as the most critical phase of preventive and responsive desert locust management, was overly securitized at local, national, and international levels. Indigenous methods of managing desert locusts contributed 10% to the overall risk reduction.

Although the use of indigenous technical knowledge and skills points to securitization, its limited contribution to risk reduction could be due to the fact that there is little empirical evidence of their success in managing desert locusts. The findings are in concurrence with Joffe (1997), who estimated that effective and efficient desert locust management measures could generate net benefits in about 20% of cases, but for less effective and efficient approaches, the figure falls to 10%. Therefore, there was every reason to securitize desert locust management practices to exponentially optimize benefits from each of the deployed interventions.

Based on the results, there was evidence that securitized desert locust management practices protected human security against risks from pests. Descriptive statistics alone were, however, not conclusive because frequencies and percentages neither revealed differentiated contributions from each of the securitized desert locust management practices. In addition, qualitative data from the FGD session could not entirely be used to validate the findings as opinions could sometimes be subjective. As such, there was a need to conduct regression analysis to understand the causative effect of various desert locust management practices that were securitized.

4.3.5 Contribution of Securitized Desert Locust Management Practices in Protecting Human Security

Ordinal logistic regression was used to determine the contribution of various desert locust management practices that were securitized to protect human security (Table 4.5).

Table 4.5 Securitized desert locust management model fitting and goodness of fit

Model Fitting Information					Goodness-of-Fit			
Model	-2 Log Likelihood	Chi-Square	df	Sig.		Chi-Square	df	Sig.
Intercept only	2819.807				Pearson	4363.003	4059	1.000
Final	1648.548	1171.260	5	<0.001	Deviance	1648.548	4059	1.000

(Source: Field data – 2024)

After carrying out an ordinal logistic regression, the model fitting information showed statistical significance (χ^2 (5) =1171.26, $p<0.001$), indicating that there was a significant improvement in fit as compared to the null model. The model, therefore, illustrated a good fit for the research data. The goodness of fit information showed statistical insignificance (χ^2 (4059) =4363.00, $p>1.000$). Thus, the model fitted the research data because there were no significant differences in the observed data and fitted/assumed model. The results of regression analysis are shown in Table 4.6.

Table 4.6 Securitized desert locust management approaches to safeguard human security

Desert locust management practices	Wald	df	Sig.	95% Confidence Interval		
				Exp_B	Lower	Upper
Chemical control	389.447	1	<0.001	7.885	6.424	9.679
Physical control	280.748	1	<0.001	2.939	2.591	3.333
Recovery programs	152.948	1	<0.001	2.878	2.396	3.456
Surveillance	128.054	1	<0.001	2.680	2.293	3.136
Indigenous methods	68.325	1	<0.001	1.865	1.608	2.162

(Source: Field data – 2024)

Based on the ordinal logistic regression test, all the odds for the securitized desert locust management practices to protect human security showed statistically significant contributions as follows (Table 4.6): Wald χ^2 (1) = 389.447, p<0.001 for chemical control, Wald χ^2 (1) = 280.748, p<0.001 for physical control and Wald χ^2 (1) = 152.948, p<0.001 for recovery programs. The odds also showed statistically significant contributions, Wald χ^2 (1) = 128.054, p<0.001 for surveillance and Wald χ^2 (1) = 68.325, p<0.001 for indigenous methods.

The results revealed that securitization of chemical control contributed the most while indigenous methods had the least contribution in protecting human security from desert locust risks. As such, an extra effort to securitize either surveillance, control or recovery interventions either by increasing response speed or by enhancing the limit of action led to a corresponding reduction in desert locust risk to human security. It is perhaps recognition of this important role of swift and heightened countermeasures that every phase of desert locust management was securitized by using the fastest and the most effective approach.

4.3.6 Summary of Securitization of Desert Locust Management Practices

In summary, the results indicated that there was securitization of all desert locust management practices using rapid and extreme interventions. The securitized desert locust management practices had varied contributions to protecting human security. Although the securitized interventions were diverse, there was no systematic integration. Implementation of multiple securitized desert locust management practices was, therefore, ad hoc. There is a need to develop a securitized action plan that is customized for invasion countries, bearing in mind desert locusts arrive in a gregarious phase as natural disasters; thus, preventive strategies may be complex or even impossible.

4.4 Threats from Securitized Desert Locust Management Practices

There was the need to evaluate threats of desert locust management practices that could have emanated from securitized interventions. This is because securitized interventions could lead to unforeseen security threats (Jain *et al*., 2011), and hence cause unintended counterproductivity by introducing residue risks to human security (Huysmans, 2002). To assist in the evaluation, threats from securitized desert locust management practices were aligned to the various human security dimensions. The human security dimensions included food security, health security, economic security, environmental security, political security and personal security.

Food security threats from securitized desert locust management practices were assessed from destruction of crops by desert locust management teams and early harvesting of crop produce to remedy losses from the pest. Health insecurity threats from securitized desert locust management practices were assessed using possible cases of pesticide poisoning, contamination of water by chemical residues, emotional stress resulting from surveillance and control operations as well as human illnesses and deaths of livestock due to contact with pesticides. Economic security threats from securitized desert locust management practices were assessed based on the re-allocation of budgets.

Environmental security threats from securitized desert locust management practices were assessed using possible cases of the death of birds due to direct contact with pesticides. In addition, environmental security threats were assessed through the indirect death of birds after eating sprayed insects and the death of bees. Environmental security risk assessment was also based on soil erosion due to increased human activities, air pollution by vehicle and aircraft fumes, as well as smoke from fires that were meant to burn desert locusts. In addition, the assessment was guided by the scorching of plants by pesticides as well as the burning of plants and other organisms by fires that were meant to kill the pest. Political security threats from securitized desert locust management practices were assessed using diplomatic tensions.

Personal security threats were assessed based on possible fear of military and NYS personnel and equipment, drones and low-flying aircraft as well as sexual harassment, exploitation and abuse by field teams. Each human security dimension was treated as a dependent variable and was assessed by respondents on a 5-point Likert scale based on several constructs (see Figure 4.5).

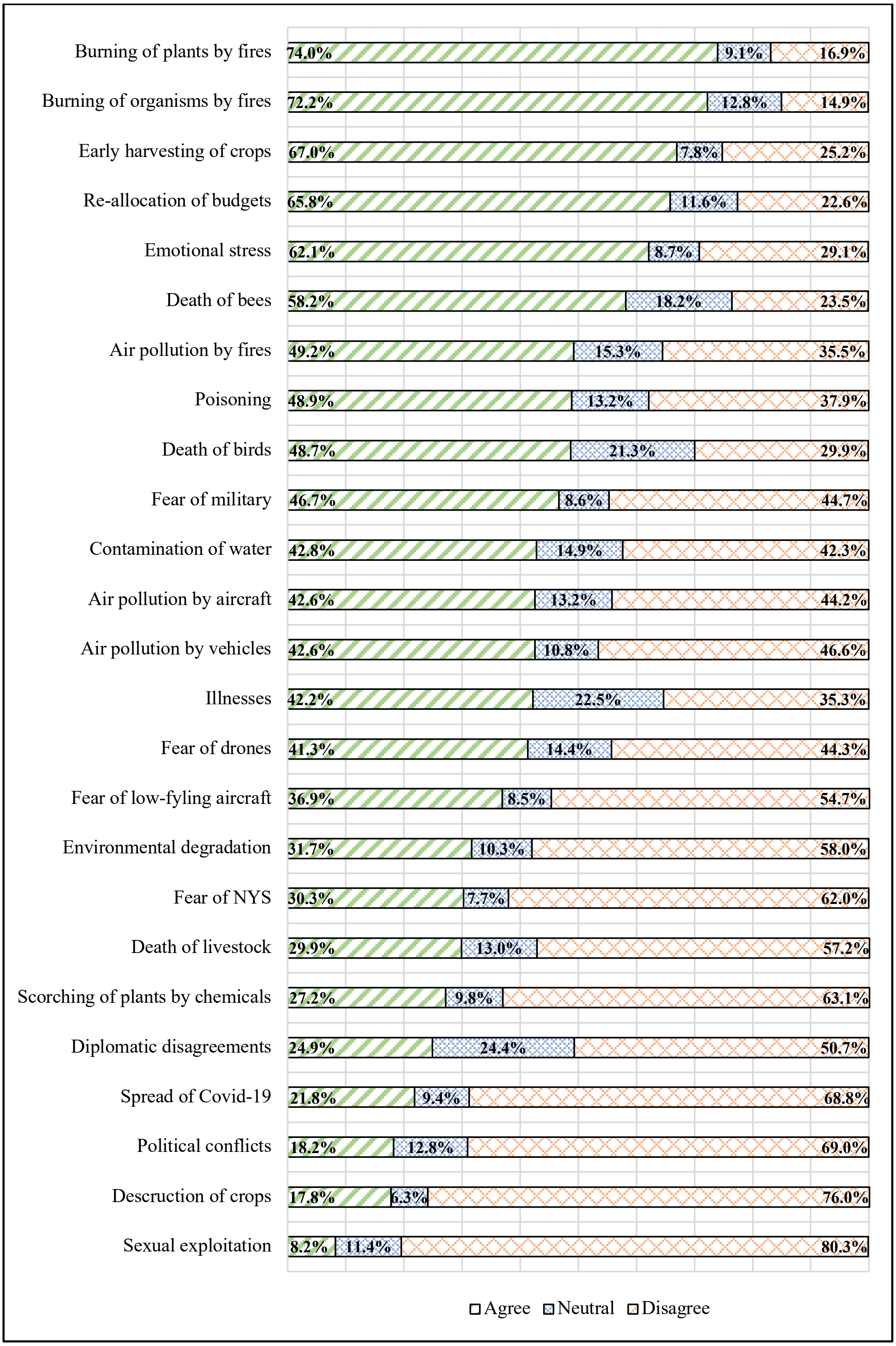

Figure 4.5 Percentage response to threats from securitized locust management practices

(Source: Field data – 2024)

Out of the 779 successful participants who responded to the study, 576 (74.0%) and 562 (72.2%) respondents agreed that fires meant to kill desert locusts ended up burning plants and other organisms, respectively. In addition, 522 (67.0%), 513 (65.8%), 477 (61.2%), and 453 (58.2%) of respondents agreed that early harvesting of crops to protect farm produce from desert locusts, re-allocation of household and government budgets to manage the pest, emotional stress and death of bees, respectively, occurred as a result of securitized efforts to manage desert locusts.

In addition, 383 (49.2%), 381 (48.9%), 379 (48.7%), 364 (46.7%), 333 (42.8%) and 322 (41.3%) respondents agreed that there were cases of air pollution by fires meant to kill desert locusts, poisoning from pesticides, death of birds, fear of military personnel and equipment, contamination of water by pesticides, air pollution by fumes from aircraft and vehicles, illnesses and fear of drones, respectively, as a result of securitization of desert locust management operations. Furthermore, 287 (36.9%), 247 (31.7%), 236 (30.3%), 233 (29.9%), 212 (27.2%), 194 (24.9%), and 170 (21.8%) agreed that there was fear of low-flying aircraft, environmental degradation, fear of NYS personnel, death of livestock, scorching of plants by pesticides, diplomatic tensions and spread of COVID-19 following securitization of desert locust management activities.

From the total sample of respondents, 142 (18.2%), 139 (17.8%) and 64 (8.2%) felt that cases of political conflicts, destruction of crops and sexual harassment occurred due to securitized desert locust management operations, respectively. To get deeper insights, constructs of threats from securitized desert locust management practices were grouped in line with food security, economic security, health security, environmental security, political security and personal security.

4.4.1 Threat of Securitized Desert Locust Management Practices to Food Security

Food security is a condition where every person, individually or within a community, has economic and physical access to sufficient food of acceptable nutritional value and preference at all times and has the means to either produce or procure the same (UNDP-HDR, 1994). Food security threats from securitized desert locust management practices were assessed based on the destruction of crops by desert locust management teams and early harvesting of crop produce to remedy losses from the pest.

There were 522 (67.0%) respondents who agreed that there was early harvesting of crops to protect farm produce from desert locusts, while 139 (17.8%) had the opinion that there were incidents of destruction of crops by ground surveillance and control teams. One of the respondents described having had to harvest their farm produce early saying, "I harvested all my kales and sold them before desert locusts destroyed them. I had seen them eat everything, including trees, leaves, and bark on TV. I was not ready to let them destroy my kales."

The above quoted narrative points to a securitized response to a looming threat from desert locusts through extreme actions to avoid the risk of losing crops. Harvesting the kales may have helped protect them against desert locusts. The remedy is in line with Mamo and Bedane (2021), who observed that early harvesting protected 44:43 kg per hectare and 1176:83 kg per hectare of crop production in the absence and within intervention of baseline chemical pesticide, respectively.

Farmers could have secured considerable gains through early harvesting of produce in the event of imminent threats like desert locust invasion. However, this was not without some negative effects on the food supply chain, such as exposing farmers to unforeseeable risks of losing the harvested produce to post-harvest losses. This is attributable to the fact that some produce, especially fruits and vegetables, are highly perishable due to their short shelf-life, and hence, they could rot if there was no ready market for them. According to, early harvesting disrupted the supply chain as markets for agricultural produce were likely to be flooded with foodstuffs within a short period of time, followed by rapid decline or even scarcity.

This could have denied consumers access to a steady supply of food products, hence threatening food security. According to Adam and Paweł (2018), food supply chain management is critical for food sustainability. Therefore, the fact that early harvesting disrupted the supply chain demonstrated a threat to food security. Similarly, the risk of post-harvest losses could have caused food insecurity by forcing the farmer to get rid of all the kale, some of which she could have used to feed her family. In addition, early harvesting coupled with post-harvest losses could have led to economic insecurity through lost income due to the perishability of vegetables.

It is worth noting that a reduced and unassured supply of farm produce could have had a negative effect on the people who primarily depend on purchased food for everyday dietary needs. This effect could have been due to reduced access to preferred foodstuffs and an increase in prices. Remember accessibility, affordability and acceptability in terms of preference are key elements of food security (Guma *et al*., 2018). In addition, according to the economic law of demand and supply, when the demand is high and the supply is low, the prices of commodities in the market respond by increasing exponentially (Adams & Simpasa, 2015). As such, early harvesting of farm produce led to an unexpected drop in the supply of foodstuffs, necessitating the inaccessibility or unaffordability of farm products.

In cases where desert locusts roosted on crops in farmlands where aerial spraying could have exposed people to pesticide residues, the only option was ground control. Ground control teams were mainly composed of NYS members as earlier reported. These ground teams could have damaged crops during their movement within infested areas. As one respondent observed, “The NYS guys were very good in killing the locusts, but they were stepping on our maize while spraying. We were scared to tell them to be careful not to damage our crops.”

The use of NYS members is a clear indication of securitized operations, as these are paramilitary functions of the government that are used to support crowd control in security management. Their participation in desert locust control operations introduced two unforeseeable threats. First, there was direct damage to crops during spraying that threatened food security by reducing expected yields. Second, there was indirect fear by villagers who saw NYS members as people who were not approachable for consultations. In addition, some community-initiated physical control measures, such as chasing away the locusts with noise, beating them up with sticks and stepping on them when they were basking on young crops, ended up damaging plants.

The findings echo those of a study by Maiga *et al.* (2008) that reported that physical control of desert locusts by communities caused serious damage to crops, thus exacerbating food insecurity in Senegal. Acknowledging the risk of physical control in desert locust management, a participant said, “People lit fires to kill locusts oblivious of the danger it could cause. There was a case where an entire village could have been brought down by fire...the fire had already burnt some crops and plants.” The quote illustrates that some securitized methods of controlling desert locusts, such as the use of fire out of desperation, could have destroyed crops and other vegetation.

This could have affected farm production and hence reduced available pasture for livestock, thereby contributing to food insecurity.

4.4.2 Threat of Securitized Desert Locust Management Practices to Health Security

Health security refers to freedom from diseases and unhealthy lifestyles (UNDP-HDR, 1994) such as Kwashiorkor and Marasmus as well as malnutrition and stunted growth, respectively. Health security threats from securitized desert locust management practices were assessed using possible cases of pesticide poisoning, contamination of water by chemical residues, emotional stress resulting from surveillance and control operations as well as human illnesses or deaths of livestock due to contact with pesticides.

Out of the 779 participants who successfully responded to the study, 477 (61.2%) respondents alluded to suffering emotional stress due to desert locust management activities. During FGD, a participant lamented:

> "It was very frustrating to lose a swarm of desert locusts that we had followed for days. We had followed it all through waiting for it to move from human settlements into a suitable area where it could be sprayed. The swarm was later discovered and sprayed in Tanzania."

This extraordinary act of following desert locusts for days and subsequent frustrations confirms the extent to which surveillance was securitized. The level of commitment among surveillance teams also reaffirms recognition by people about the risk locusts were capable of causing.

The explained level of frustration could have ended up causing stress or even depression. The uncertainty caused by the desperate search for locusts, as captured in the quote, could have compromised the health security of both residents and surveillance teams. Securitization of desert locust management which demanded urgent response, forcing surveillance teams and communities to vehemently trace and track the pest, had health security risks. As such, desperation and frustrations, as expressed in the quote, could develop into anxiety, amnesia, insomnia, exhaustion and annoyance (Saghir *et al.,* 2018).

A total of 381 (48.9%) respondents revealed there were cases of human poisoning from pesticides that were used to control desert locusts. A respondent complained, "I had stomach-ache and vomiting problem after eating Managu from my farm that we had sprayed desert locusts a few days before." The "Managu" is a local name for *Solanum nigrum* which is one of the wild traditional vegetables that is readily available in Kenya. The mention of vomiting and stomach ache in the quote suggests the possibility of human poisoning. Although control of desert locusts was mainly done by trained national government personnel after sufficient public sensitization before spray operations, there were self-initiated spray activities that could have caused poisoning. This could be attributed to limited technical knowledge and skills by individuals, as noted by Showler et al. (2021).

Pesticides that were used by people in the villages out of desperation to kill locusts could have posed a serious threat to health security. In addition, reliance on subsistence farming for household food supply could have exposed families to toxicity. This was likely to happen if they accidentally or intentionally harvested and ate farm produce from recently sprayed areas oblivious of the post-harvest intervals as stipulated on the pesticide labels (Mamo & Bedane, 2021). Even with adequate training and proper use of PPEs, incidents of accidental spillage could have occurred leading to skin injury among spray personnel.

The results are in line with Thompson and Miers (2002), who found that pesticides meant to kill desert locusts led to the poisoning of people. The findings also support Showler (2021), who documented the negative effects of anti-locust insecticides on human health among pesticide applicators and handlers (spray service providers).

Out of the total number of respondents, there were 333 (42.8%) respondents who agreed there was contamination of water by desert locust control pesticides. During FGD, technical personnel recollected that all water bodies were mapped for exclusion from spray zones. There was, however, confirmation that most safe pesticides had slow-action attributes. Sprayed desert locusts could have ended up dying in water bodies therefore depositing residues of active ingredients therein. A plant protection officer described this by saying:

> "We were called by some county administrators to collect a sample of water in a Silanga where many desert locusts had drowned. People were claiming that their livestock died after drinking water from the Silanga. Toxicological results, however, showed no traces of harmful chemicals."

"Silanga" is a local name for earth dam. The claim by community members that livestock died after drinking water from an earth dam where locusts had drowned is worrying enough to suspect contamination of water by pesticide residues.

Death of sprayed desert locusts in water could also lead to the introduction of raw organic matter that could cause diseases such as cholera. Although contamination was ruled out after the toxicological examination, there could have been a delay in the collection of samples, which could have allowed the active ingredients enough time to disintegrate. The results, however, agree with Showler (2021), who reported desert locusts can cause disease epidemics if they die in static water following control operations.

A total of 233 (29.9%) respondents had the opinion that the death of livestock occurred due to poisoning by desert locust control pesticides. An FGD participant noted, "One of my sheep aborted after eating grass from a field where desert locust had been sprayed." In the absence of a veterinary report, abortion by the sheep could have been due to many other reasons. However, the linking of the incident with desert locust control operation cannot be ignored. There was adequate public sensitization and awareness creation for communities to keep their livestock away from sprayed fields. Nomadism could however have exposed some livestock to toxicity if they accidentally veered off into recently sprayed areas, oblivious of the re-entry period, as stated on the pesticide labels. In addition, scarcity of pasture after devastation by desert locusts, coupled with ignorance of community members, could have led to non-adherence to stipulated re-entry periods and post-harvest intervals in the absence of a strict enforcement mechanism.

The findings reverberate with studies by Emana (2002), Lassa (2017), and Mamo and Bedane (2021), which observed that people get contaminated while applying pesticides, working in recently pesticide-treated fields, consuming contaminated water, being in contact with contaminated air or soil, and consuming contaminated farm produce or animal products. Among the successful participants, 170 (21.8%) agreed that desert locust management activities contributed to the spread of COVID-19. A locust management staff member noted with concern:

> "We had gone for surveillance and backstopping control exercise in one of the counties during the COVID-19 lockdown period. When we got back, I started feeling a headache. I decided to go to the hospital and I was diagnosed with Coronavirus. I was admitted to an isolated ward for treatment. I ended up in the intensive care unit and, later, in a high-dependence unit. I almost died. God is great that I'm alive today."

The above quote reports cross-county movement by an officer despite restricted movement to contain COVID-19, unequivocally confirming the securitization of desert locust management.

Although few respondents (21.8%) linked desert locust management with the spread of COVID-19, the quote confirmed there were incidents where desert locust management activities could have led to the spread of the disease. This could be associated with the securitization of desert locust management, where plant protection officers were treated as critical personnel who were allowed transboundary movement across the country despite the COVID-19 lockdown. Most respondents who did not associate desert locust management operations with the spread of COVID-19, however, felt that containment measures, especially handwashing, social distancing and wearing face masks, were strictly adhered to during surveillance, control and recovery activities. This could have reduced the number of instances where contamination with the Coronavirus happened leading to COVID-19 illnesses.

4.4.3 Threat of Securitized Desert Locust Management Practices to Economic Security

Economic security denotes situations where all people have an assured basic income either from productive or remunerative work or, in the worst-case scenario, from government stipends (UNDP-HDR, 1994). Loss of productive livelihoods due to the destruction of crops and pasture by desert locusts, therefore, affected economic security. Economic security threats from securitized desert locust management practices were assessed based on the re-allocation of national and county budgets as well as the re-adjustment of household budgets.

There were 513 (65.8%) respondents who agreed that the reallocation of household and government budgets to manage desert locusts led to economic challenges. For instance, farmers' initiatives to manage the pest on their own increased production costs, thus reducing the expected profit margin. A farmer complained, "Before government interventions, I had to purchase pesticides using my little savings to try and kill locusts." Such unexpected expense could have affected household savings and as such put the family towards poverty-laden trajectory by reducing their self-reliance to purchase new assets, pay school fees for children or even pay hospital bills in case of illnesses.

At the national level, the government acquired a multi-billion World Bank loan to support desert locust management (MoALF&C, 2020). This could have affected the economic well-being of the country, where money meant for development projects was used for crisis management. During the national FGD, a senior officer expounded on this saying:

> "The emergency locust response program in Kenya that started in the year 2020 was initially funded by a World Bank loan. The loan was to support surveillance and control, promote the establishment of an early warning system and help in livelihood recovery by supporting affected households with micro-project grants."

The quote elaborated on how the securitization of desert locust management led to the labelling of the invasion as an emergency that needed an urgent response.

The statement also suggested there were limited financial resources for immediate action. For example, USAID (2021) documented that 38.8 million US dollars were needed for emergency intervention to manage desert locusts. Development partners, therefore, came in to financially support affected countries through loans, in line with Thompson and Miers (2002), who observed that most affected countries rely on international assistance. It is important to note that the money, as described in the quote, was not a humanitarian grant but a loan that eventually would have to be repaid.

The repayment of the loan would have to be from tax collection even though the investments for which the loan was disbursed were not development-oriented, and hence, they may not necessarily have generated revenue for the government. In addition, repayment of emergency loans that the government had no advance planning for could affect other development projects. Such an opportunity cost could have derailed Kenya's development agenda by shifting priority for the national budget. The results are consistent with the initial assessment by FAO (2020b) that at least 138 million US dollars were needed for desert locust management and livelihood protection for about 110,000 affected households.

4.4.4 Threat of Securitized Desert Locust Management Practices to Environmental Security

Environmental security is freedom from short- and/or long-term ravages of nature, man-made threats in nature and deterioration of the natural environment (UNDP-HDR, 1994). Environmental security threats from securitized desert locust management practices were assessed using possible cases of the death of birds due to direct contact with pesticides. In addition, environmental security threats were assessed through the indirect death of birds after eating sprayed insects and the death of bees. The assessment was also based on soil erosion due to increased human activities, air pollution by vehicles and aircraft fumes, as well as smoke from fires that were meant to burn desert locusts. In addition, the assessment was guided by the scorching of plants by pesticides as well as the burning of plants and other organisms by fires that were meant to kill the pest.

There were 576 (74.0%) and 562 (72.2%) respondents who felt that fires meant to kill desert locusts ended up burning plants and other non-target organisms, respectively. Desperate efforts by community members to use all means possible to kill locusts could have led to uncontrollable wildfires, which might have ended up destroying flora and fauna, thus affecting biodiversity and destabilizing ecosystems. A local Chief during county-based FGD narrated an unfortunate incident saying:

> "People lit fires to kill locust oblivious of the danger it could cause. There was a case where an entire village could have been brought down by fire. Nature is very interesting; just when the fire was approaching the settlements after burning everything in the nearby farms, it started raining, and the fire was put out. People had already started running away."

The use of fire as a desert locust control option without contemplation of the potential danger it could pose confirms how securitization happened at the community level.

From the quoted statement, it is clear that although the fire did not destroy the village, it had already burnt crops, vegetation and other non-target organisms. Destruction of crops by fire meant that food security was threatened as there would be no farm produce from the burnt farms. Biodiversity was also affected by the destruction of flora and fauna in the burnt ecosystem. This could destabilize not only the burnt ecosystem but also adjacent ecological zones due to the interdependence of organisms for life support. The results are corroborated by Thompson and Miers (2002), who found fire could destabilize ecosystems by interfering with biodiversity through burning vegetation cover and killing organisms.

Out of the people who participated in the study, 453 (58.2%), 379 (48.7%) and 212 (27.2%) respondents agreed there was death of bees, killing of birds and scorching of plants by locust control pesticides, respectively. These negative effects could have been a result of direct or indirect contact with desert locust control pesticides. A participant explained this lamenting:

> "The young grass that had just come out after recent rain, withered and then dried after being sprayed. Bees absconded from my hives after desert locusts were sprayed using an aeroplane in my area. They have not come back. The money I was getting from selling honey is now not available. I now burn charcoal and sell it to get some money to feed my family."

The use of aerial control to cover as much ground as possible and rapidly reduce the locust population is an indication of securitized operations, as there are other precise options, such as ground control using vehicle-mounted sprayers.

The quote was an indicator that securitization of desert locust management using aircraft threatened their livelihoods when bees disappeared, and the community had to seek alternative means of generating income. However, their coping strategy of burning charcoal to earn a living posed an additional threat to the environment. Cutting down trees for charcoal as household fuel also threatened people's lives through the potential risk of carbon monoxide poisoning. There was also the threat of soil erosion due to the loss of ground cover and the reduction of carbon sinks to manage greenhouse gases. Although there was limited environmental monitoring in Kenya during the 2019–2021 desert locust invasion, as observed by (Mullié *et al.,* 2023), most apiary-prone zones were identified and mapped as protected areas as documented in a pest management plan (GOK, 2022). The absconding of bees could, therefore, have been due to pesticide residues in their foraging fields.

These findings are substantiated by Mullié *et al.* (2023), who found that in Ethiopia, spraying of desert locusts with Chlorpyrifos and Malathion could have coincided with honeybee production season, leading to a decline in honey yields. The quote also indicated that desert locust control pesticide led to withering and drying of grass. Loss of grass could have had a direct impact on livestock body conditions and hence reduce their production, or even lower their value in the market, leading to decreased income for the affected households. As such, the pesticides used could have posed a direct threat to environmental security (Mamo & Bedane, 2021), as they potentially had negative ecological impacts on humans, non-targeted organisms and the environment.

There was also confirmation of birds dying after eating desert locusts that had been sprayed. A plant protection officer jokingly commented:

> "Birds thought manna from heaven had come their way. There were dead locusts all over after spray operations. Birds just picked and swallowed the insects until they could eat no more. Then, we could find them dead when we came back to do a post-spray assessment. I think they were overeating and the spikes on the hind femora were choking them to death."

The statement linked the death of birds with spray operations. The respondent thought that the deaths could have been due to over-eating or choking by the spiked hind legs of desert locusts.

Poisoning by pesticides could however not be ruled out without a toxicological test because there were also unverified claims of Fenitrothion (960 g/L) overdose in Kenya (see Mullié *et al.,* 2023). The report highlighted that higher than recommended pesticide application rates could have led to the mortality of non-target organisms, such as birds and honeybees during the 2019–2021 desert locust invasion. The study results corroborate Worku *et al.* (2022) findings that pesticides led to the mortality of birds, bees and arthropods in Senegal and Ethiopia, respectively.

There were 383 (49.2%), 332 (42.6%) and 332 (42.6%) respondents who felt there was the possibility of air pollution by fires meant to kill desert locusts, fumes from spray and surveillance aircraft, or exhaust waste from survey and control vehicles. One participant complained of having developed breathing problems saying:

> "One afternoon, locusts landed in our shopping centre. People lit fire everywhere to chase them away. We were burning every available waste including plastics. The entire centre was engulfed in smoke. Everyone was coughing. I'm asthmatic and I had to use my inhaler several times because I was choking."

From the quote, securitization of desert locust management using all means possible was inevitable, even at the community level. The results of the use of fire from plastics were, however, threatening, not only to the environment in terms of air pollution but also health security threats, as explained by the respondent.

The quote provides some qualitative evidence of the threat from fires meant to manage desert locusts. However, there was no quantifiable documented evidence of air pollutants emanating from aircraft or vehicle fumes. The use of aircraft or vehicles during desert locust management could, however, have produced carbon monoxide, nitrogen oxide and sulphur dioxide emissions, thus adding greenhouse gases to the atmosphere. In addition, 247 (31.7%) respondents agreed there could have been environmental degradation due to increased human activities. Increased movement during desert locust surveillance and control, as well as the digging of trenches to trap hoppers, could have loosened the soil and, hence, exposed it to erosion. The findings are consistent with Thompson and Miers (2002) that desert locust management affected the environment, especially due to land degradation.

4.4.5 Threat of Securitized Desert Locust Management Practices to Political Security

Political security threats from securitized desert locust management practices were assessed using diplomatic tensions and political conflicts. Out of the 779 participants who successfully responded to the study, 194 (24.9%) and 142 (18.2%) respondents agreed that diplomatic tensions and political conflicts could have emerged from cross-border surveillance and control operations.

During the national FGD, a participant explained this reporting, "We were detained for four hours in a neighbouring country during an aerial surveillance exercise. Phone call correspondence between ministers responsible for agriculture between the two countries saved the day and we were released." Evidence of cross-border surveillance, as detailed by the quote, points to the securitization of desert locust management because the pest does not recognize territorial jurisdictions. Accidental breach of international borders when tracking desert locusts could therefore lead to political security threats as described through the detention encounter by one of the Kenya's aerial surveillance teams.

The findings are supported by Story *et al.* (2008), who reported that ground and aerial spraying was made difficult by property boundaries and administrative borders. Although there is limited literature on the political dynamics of desert locust management, multilateral corroborations among desert locust-affected countries could have helped to resolve diplomatic tensions during surveillance and control operations. However, in cases where diplomatic differences already exist prior to desert locust upsurges, regional and international organizations may find it difficult to intervene. For example, Cosgrove (2020) reported that political polarization of the conflict in Tigray at a time when desert locust upsurge was underway was likely to reduce available opportunities for effective surveillance and control of the pest.

4.4.6 Threat of Securitized Desert Locust Management Practices to Personal Security

Personal security is freedom from physical violence or emotional assault, whether from the state or external states, vicious individuals and sub-sectors, domestic abuse or predatory adults (UNDP-HDR, 1994). Personal security threats from securitized desert locust management practices were assessed based on possible fear of military and NYS personnel and equipment, drones and low-flying aircraft as well as sexual harassment, exploitation and abuse by field teams. There were 364 (46.7%), 322 (41.3%), 287 (36.9%) and 236 (30.3%) respondents who confessed to having been afraid of military personnel and equipment, drones, low-flying aircraft and NYS members, respectively.

An FGD participant narrated how military presence was conspicuous saying, “Jeshi were roaming everywhere, flying all over and driving land rovers with sprayers instead of machine guns. People were worried about their presence. We stayed at home for fear of their presence.” “Jeshi” is a Swahili word for Soldiers. The mention of soldiers in a plant protection conversation demonstrated the level of securitization of desert locust management operations as this is not their routine work. However, Yates (2019) reported that the British Army participated in anti-locust operations in the Arabian Peninsula during World War II. Although these soldiers were performing one of their rightful secondary duties in peacetime, the fact that people were worried about their presence is proof of anxiety. In addition, the fact that people had to stay at home for fear confirmed forced confinement.

In addition, 64 (8.2%) respondents alluded to cases of sexual harassment during desert locust management. An FGD participant made a worrisome joke:

> “How do you allow young men to roam all over our neighbourhood? Then, you allow your beautiful daughters to walk freely, swinging themselves nicely. And you expect the young, energetic men to look the other way and live in peace without seducing the girls?”

The mention of young men illustrates that many community youths and NYS members participated in desert locust surveillance and control operations, as indicated by the biodemographic data of respondents. The positioning of field control camps near desert locust sightings reaffirmed the proximity of field personnel to community settlements.

There were no officially documented cases of sexual harassment, exploitation and abuse in police stations and health facilities. However, such statements as the one in the quote, coming from a community member, could have indicated the possibility of unreported incidents. This is because there is documented evidence of such incidents in other parts of the world, as recorded by Ethiopia's Ministry of Agriculture (2020), which acknowledged the possibility of incidents of sexual exploitation and abuse during desert locust management activities.

4.4.7 Threats of Securitized Locust Management to Human Security Dimensions

Results for threats from securitized desert locust management practices to human security were summarised in percentage risk to economic security, environmental security, food security, health security, political security and personal security (Figure 4.6).

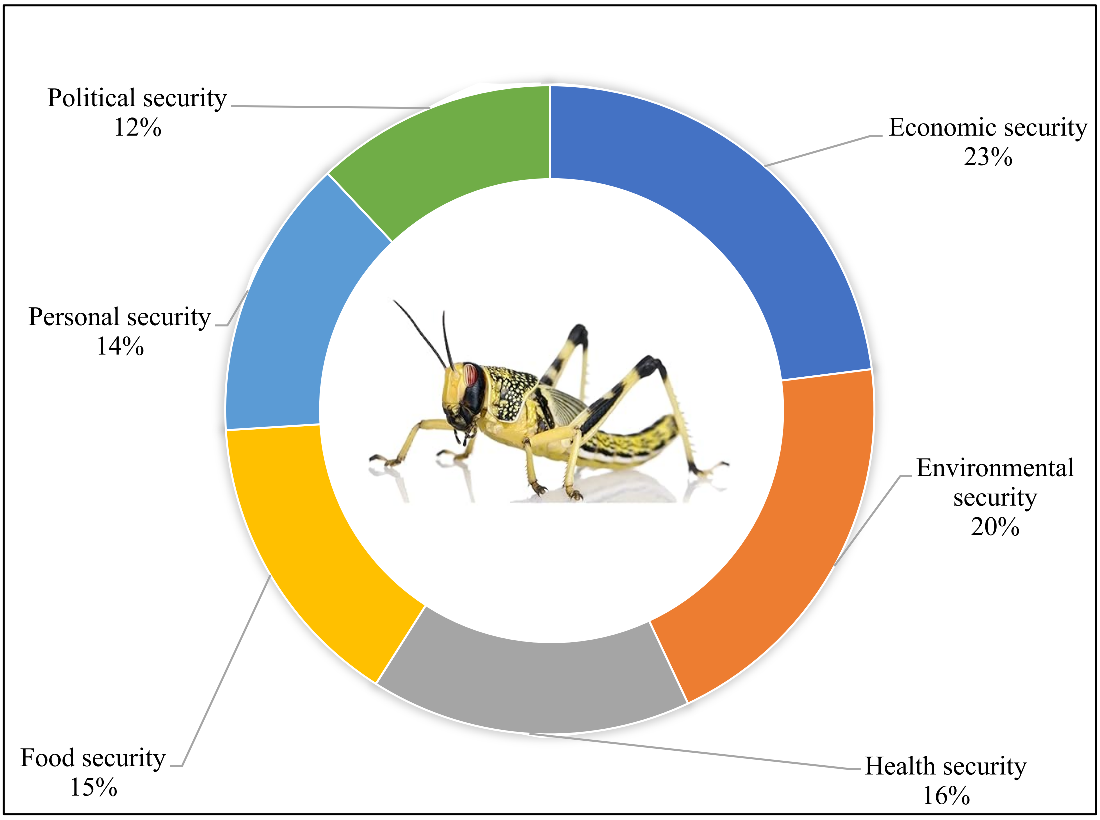

Figure 4.6 Percentage threat from securitized desert locust management practices

(Source: Field data – 2024)

The findings revealed that threats to economic security contributed to 23% of human security risk from securitized desert locust management practices. The threat of securitized desert locust management practices to economic security was due to unexpected expenditures to manage the pest, which could have strained household and government budgets. The results also showed that threats to environmental security contributed 20% to the overall human security risks from securitized desert locust management practices. The threat of securitized desert locust management practices to environmental security was attributable to unforeseen threats during spray programs that could have led to hazardous effects on non-targets such as vegetation, birds, bees, livestock and even human beings.

The results also showed that threats to health security contributed 16% to the overall human security risks from securitized desert locust management practices. The findings are qualified by cases of emotional stress, poisoning, skin injuries, and illnesses associated with desert locust spray activities. In addition, threats to food security contributed 15% to the overall human security risk from securitized desert locust management practices. Threats to food security were directly linked to crop damage by desert locust management personnel and communities during surveillance and control activities, as well as early harvesting of farm produce to protect it from damage by pests.

Threats to personal security contributed 14% to the overall human security risk from securitized desert locust management practices. This could be linked to adequate measures to safeguard community members from direct harm by personnel or associated equipment. Finally, threats to political security contributed 12% to the overall risk to human security. There were few political conflicts or diplomatic scuffles during desert locust management operations due to multilateral collaborations through UN specialized agencies such as FAO and intergovernmental organizations such as DLCO-EA.

The results showed evidence that securitized desert locust management practices posed inadvertent threats to human security. Frequencies and percentages, however, neither demonstrated the differentiated threat of securitized desert locust management practices to various human security dimensions. In addition, qualitative data from FGD sessions could not be relied upon to independently validate the findings because personal views from participants could have been predetermined. As such, there was a need to conduct inferential statistical analysis to understand the causative effect of securitized desert locust management practices on each human security dimension.

4.4.8 Impact of Securitized Locust Management on Human Security

Ordinal logistic regression was used to understand how securitized desert locust management practices affected each human security dimension (Table 4.7).

Table 4.7 Model fitting and goodness of fit information for threats of desert locust management practices

Model Fitting Information					Goodness-of-Fit			
Model	-2 Log Likelihood	Chi-Square	df	Sig.		Chi-Square	df	Sig.
Intercept only	4032.983				Pearson	5262.245	10522	1.000
Final	2093.802	1939.181	6	<0.001	Deviance	2093.802	10522	1.000

(Source: Field data – 2024)

The model fitting information showed statistical significance (χ^2 (6) =1939.18, p<0.001), indicating that there was a significant improvement in fit as compared to the null model. This meant that the model illustrated a good fit for the research data. The Goodness of fit information shows statistical insignificance (χ^2 (10522) =5262.25, p=1.000); thus, the model fitted the research data because there were no significant differences between the observed data and fitted/assumed model. The results of regression analysis are shown in Table 4.8.

Table 4.8 Threats to human security from securitized desert locust management practices

Human security dimensions	Wald	df	Sig.	95% Confidence Interval		
				Exp_B	Lower	Upper
Economic security	344.766	1	<0.001	5.447	4.554	6.508
Environmental security	330.944	1	<0.001	4.655	3.885	5.579
Health security	320.663	1	<0.001	3.766	3.258	4.354
Food security	277.215	1	<0.001	3.600	3.136	4.133
Personal security	273.320	1	<0.001	3.394	2.895	3.983
Political security	225.928	1	<0.001	2.773	2.457	3.130

(Source: Field data – 2024)

Based on the ordinal logistic regression test, all the odds for securitized desert locust management practices to protect human security showed statistically significant contributions as follows (Table 4.5): Wald χ^2 (1) = 344.766, p<0.001 for economic security, and Wald χ^2 (1) = 330.944, p<0.001 for environmental security. Wald χ^2 (1) = 320.663, p<0.001 for health security and Wald χ^2 (1) = 277.215, p<0.001 for food security. Wald χ^2 (1) = 273.320, p<0.001 for personal security and Wald χ^2 (1) = 225.928, p<0.001 for political security.

This meant that for every unit increase in the overall risk from securitized desert locust management practices, there was a corresponding increase in the threat to all the human security dimensions. The results revealed that securitised desert locust management practices had the greatest threat to economic security. The results also indicated that securitised desert locust management practices had the least threat to political security.

4.4.9 Summary of Threats from Securitized Desert Locust Management Practices

In summary, the findings indicate threats from securitized desert locust management practices, which cut across various human security dimensions. This created a normative dilemma (Huysmans, 2002), where efforts to protect human security from desert locust risks produced unintentional threats to human security.

Recognizing this residual but unforeseeable danger, desert locust risk management requires a comprehensive approach to ensure securitization does not introduce or legitimize potentially harmful, neglectful or exclusionary use of urgent, extremist and large-scale interventions. This would help risk managers to think beyond the pest and prepare to cushion human security against possible unforeseeable residue threats.

4.5 Challenges During Desert Locust Management that Hindered Protection of Human Security

There was the need to establish challenges during desert locust management that could have hindered the effective and efficient protection of human security. This is because challenges during the implementation of risk management plans could slow down and reduce the effectiveness of desert locust operations (Li *et al*., 2023). To guide the assessment, each category of desert locust management challenge was treated as a dependent variable and was assessed by respondents on a 5-point Likert scale based on several constructs. Constructs of evaluating desert locust management challenges were categorised as technical, human resource, coordination, geographical, political, financial and social-cultural challenges.

Technical challenges were evaluated based on insufficient tools and equipment, poor mobile phone signal, and limited internet connection. Geographical challenges were evaluated based on extreme weather and difficult landscapes. Coordination challenges were evaluated in terms of poor communication, lack of clear leadership, inadequate information, poor supervision and unclear division of roles. Financial challenges were evaluated based on limited funds and corruption caused by misappropriating mobilised resources.

Human resource challenges were evaluated based on inadequate training and limited knowledge and skills among desert locust management personnel. Political challenges were evaluated regarding insecurity, political interference, and COVID-19 containment measures. Social-cultural challenges were evaluated based on communities' refusal to report desert locust presence and people's withholding of empty pesticide containers. Results for the constructs that were used to establish desert locust management challenges are shown in Figure 4.7.

Figure 4.7 Challenges in desert locust management: percentage response

(Source: Field data – 2024)

Out of the 779 successful participants who successfully responded to the study, 647 (83.0%) and 608 (78.0%) respondents agreed that rugged landscape terrain and poor mobile phone signal affected desert locust management to protect human security. There were 589 (75.6%) and 584 (75.0%) participants who had the opinion that insecurity and insufficient equipment, respectively, hindered the protection of human security from desert locust risks.

In addition, 582 (74.7%) and 571 (73.3%) respondents felt that limited funds and extreme weather affected desert locust management practices from effectively protecting human security. There were also 562 (72.1%) and 549 (70.5%) participants who saw poor communication and lack of clear leadership as challenges that interfered with protecting human security from desert locust risks. From the total sample, 534 (68.6%) and 531 (68.2%) respondents agreed that inadequate information and limited internet connection were limitations that slowed down the response rate and thus hindered the protection of human security from desert locust risks.

There were also 476 (61.1%) and 450 (57.8%) participants who thought that limited expertise in terms of knowledge and skills, as well as inadequate training among plant protection stakeholders, reduced the chances of successfully protecting human security from desert locust risks. From the total number of successful participants, 445 (57.1%) and 442 (56.7%) respondents believed that under-reporting of desert locust presence and poor supervision, respectively, affected the effective management of Desert locusts and thus put human security at risk.

There were also 416 (53.4%) and 411 (52.7%) participants who had an opinion on COVID-19 containment measures, and unclear division of roles among plant protection stakeholders reduced the chances of protecting human security from desert locust risks. Finally, 398 (51.1%), 390 (50.5%), and 261 (33.5%) respondents believed corruption, political interference, and withholding of empty pesticide containers by community members hampered the protection of human security from desert locust risks. To get deeper insights, constructs of evaluating desert locust management challenges were categorised as technical, human resource, coordination, geographical, political, financial and social-cultural challenges.

4.5.1 Technical Challenges During Desert Locust Management

Technical challenges were evaluated based on insufficient tools and equipment, poor mobile phone signal, and limited internet connection. Out of the 779 participants who successfully responded to the study, 608 (78.0%) respondents felt that poor mobile phone signal hindered real-time reporting of desert locust presence. This reduced opportunities for early warning, adequate preparedness and early action to control the pest. A participant expounded on this challenge by asking:

> "We were told to take a picture of the locust and send it to authorities. How could this happen if we usually have to go several kilometres to make emergency phone calls? There is only one hill in our village where mobile phones work."

As described in the above statement, the absence of mobile phone signals in some remote locations denied affected community members an opportunity for timely assistance.

This limitation in communication infrastructure could have exposed their crops and pasture to an extended period of destruction by desert locusts. The challenge was common in many rural villages of the ASAL counties that were affected by desert locusts. Although the challenge could have been surmounted through the deployment of satellite-enabled gadgets (FAO, 2021b), this had an additional cost limitation as it required monthly prepaid subscriptions.

The mention of "we" in the above quote meant that anyone could report desert locust presence through mobile phones especially the eLocust3m application (FAO, 2021b) that promoted crowdsourcing of information. Crowd-sourcing through elocust3m allowed anyone with a smart-phone to download elocust3m on Play store for free, install it, and send desert locust presence reports to a centralized database in real-time. However, as an information management officer complained, crowd-sourcing had additional challenges, saying, "We could receive multiple reports from different people on the same location. People were sending false-positive and false-negative reports of desert locusts. Others were reporting solitary locusts in central Kenya and reporting Tree locusts and grasshoppers as desert locusts."

The quote confirmed the challenges of duplication, misreporting and mixed reporting. False-positive reports where desert locusts were reported in areas where the pest did not exist meant resources could have been wasted to carry out unnecessary confirmation search surveys. False-negative reports meant that desert locusts were not reported in areas where they were destroying crops and pasture, and as such, there could have been extended periods of devastation by the pest. In addition, misreporting and mixed reporting could have led to anxiety among people, which could quickly escalate to stress and depression (Saghir *et al.,* 2018).

There were 584 (75.0%) participants who had the opinion that insufficient equipment was a major hindrance to effective surveillance and control of desert locusts. One of the participants during the national FGD explained:

> "There was only one old surveillance gadget in Kenya when Desert locusts arrived in December 2019. The only eLocust3 tablet was not even in the hands of Kenyan government but Desert locust Control Organization for Eastern Africa (DLCO-EA). Kenya could not rely on that one gadget to report Desert locust that had invaded several counties.

> That is why a more accessible eLocust3m mobile app was developed to address this challenge."

The above quote demonstrates how underprepared Kenya was to manage desert locusts. The challenge of having only one surveillance gadget (eLocust3 tablet) meant that reporting was delayed and hence response to manage the pest was slow.

The destructive nature of desert locusts means that a small swarm could destroy several metric tonnes of crops (WMO & FAO, 2016). Any time that was lost before control operations started could, therefore, have had proportionate negative effects on human security. The challenge of having only one eLocust3 tablet was, however, a blessing in disguise because it triggered resilience-building. It led to the development of eLocust3m, which allowed people to send desert locust reports in real time. The government and partner institutions could then analyse the reports to support precise and rapid control activities.

To reaffirm the challenge of equipment during desert locust control, a participant noted during one of the county-based FGD, "We were surprised to see machine guns being used to spray desert locusts." The sentiments came as a surprise to the research team. However, it was clarified that the "machine gun" the respondent was referring to was a vehicle-mounted sprayer (VMS). This was relatively new equipment to the local communities in north-eastern parts of Kenya. However, their likening it to a machine gun was valid because they are used to seeing security vehicles that are mounted with artillery equipment.

An agricultural officer, during the national FGD, explained the limitation of equipment reporting:

> "There were only a few sprayers. Out of the few sprayers, some, such as knapsacks could not be used in desert areas where water, to formulate EC pesticides, was scarce. Through FAO, we got vehicle-

> mounted sprayers form Morocco to support ground control of Desert locusts. Their faster work rate allowed us to cover up to 100 ha per day in open field with limited obstacles."

The statement shows that equipment such as sprayers were not only few but also unsuitable and impractical for use under some circumstances. The confirmation of support having had to come from as far as the farthest corner of northwest Africa also supports the desperate situation of preparedness that desert locust management encountered in Kenya.

Interregional collaborations therefore played a critical role in enhancing resilience by increasing physical capacity by supplying desert locust control equipment (GOK, 2022). Limited equipment meant that desert locust management work rate was slow, which could have created room for the pest to destroy more crops and pasture in the affected areas. The findings substantiate Showler *et al. (*2022) report that documented limited equipment and depletion of control material following many years of recession that lowered desert locust management capacity in India and Pakistan.

The DLCO-EA has a regional mandate to control migratory pests in 9 member states of the eastern and greater horn of Africa. The unexpected magnitude of the 2019-2022 upsurge was, however, overwhelming. There was limited aerial spray-support mechanism besides the few ground-spraying equipment. A participant elucidated this challenge during one of the FGD sessions narrating:

> "The few old but still serviceable spray aircraft could not manage to carry out control operations in all the affected countries. Individual countries had to come up with innovative ways of complementing regional support structures by intervening on their own. We had to use military aircraft and land rovers; we mounted them with spray equipment, calibrated them and trained the pilots and drivers to spray appropriately. These innovations were extremely helpful in remote, hard-to-access and insecure areas. International community and development partners through FAO and the World Bank also supported Kenya by hiring private aircraft to undertake surveillance

> and control operations in collaboration with government plant protection officers."

From the above statement, it is clear that at the regional level, aerial spray aircraft were few and old to serve the expansive eastern and horn of Africa region effectively.

The use of military personnel and equipment by individual countries also indicates that ministries responsible for agriculture had insufficient aerial spraying equipment. Dependence on resources and equipment that were at the behest of ministries not directly responsible for desert locust management shows external means of building resilience. This meant that there could have been delays in response, providing the pest with added time to destroy plants. Recognizing desert locusts' rapid reproductive rate, long-distance migration and indiscriminate devastation of vegetative biomass (Joshi *et al.,* 2020), delayed control could have exacerbated desert locust risks to people and the environment. The findings align with Story *et al.* (2008), who noted that aerial control of desert locusts was hindered by the limited availability of aircraft capable of spraying pesticides.

During the study, 531 (68.2%) respondents agreed that limited internet connection made real-time reporting of desert locusts difficult. A community scout during county-based FGD complained, "We were expected to send locust reports using the internet. How was this to happen if even making phone calls in my village is not possible?" The above statement demonstrates that reporting was not only difficult through internet-based options but also through phone calls. It shows the desperate situation in which some affected communities found themselves while trying to seek help by reporting desert locust presence. With limited real-time opportunities to report desert locusts, there could have been delayed response, which gave the pest additional time to pose human security threats by destroying crops, pastures, and other plants.

The results from this study are sustained by Showler (2021), who documented the limitation of equipment as a challenge that hindered the effective management of desert locusts. This challenge was, however, resolved as a locust management expert reported during the national FGD:

> "Internet challenge was only prevalent during the initial stages of desert locust management in Kenya. Continuous improvement of the eLocust3m mobile application allowed offline filling of survey forms and retrospective submission of several reports upon access to internet signal. A satellite-enabled eLocust3g was also developed to support surveillance in areas with weak mobile-phone signal."

The quote shows that urgent efforts were made to address the challenges of monitoring and reporting desert locust presence. The speed with which some technical challenges were resolved, as highlighted in the above quote, demonstrates some level of resilience-building to enhance the effectiveness of desert locust management.

4.5.2 Geographical Challenges During Desert Locust Management

Geographical challenges were evaluated based on extreme weather and difficult landscapes. Out of the 779 participants who successfully responded to the study, 647 (83.0%) respondents felt that rugged geographical terrain affected survey and control activities. A pilot who participated in the national FGD advised:

> "It is not easy to spray locusts that are roosting between hills because turning is difficult, and maintaining a standard flight height for uniform pesticide application rate is compromised. Spray aircraft crushed in one of the neighbouring countries during the 2019–2022 upsurge due to some of these challenges."

This statement describes the complexity of carrying out aerial surveillance and control activities on difficult topography. This complexity meant that some desert locust infestation could have gone unreported. In addition, it meant that control operations could have been postponed awaiting desert locusts to move to safer spraying zones. Unreported incidents and delayed control meant that the pest continued to destroy crops and pasture thus exacerbating food insecurity.

The findings are supported by Gay *et al.* (2018), Showler *et al. (*2022), and Story *et al.* (2008), who reported that ground and aerial surveillance and spraying were made difficult by geographical remoteness as well as physical obstacles such as isolated stands of forest trees, power lines, property boundaries and administrative borders. Other than complicating surveillance and spray operations, hilly landscapes may put aircraft crew at risk of crushing (Hardeweg, 2001).

A participant reported fatalities emanating from geographical and weather challenges, saying, "In 2021, when the invasion was still active, there was a report of an aircraft that crashed and killed a very experienced spray pilot on its way from Kenya to control Desert locust in a neighbouring country." The quote illustrates the life-threatening personal security risk that could emanate from geographical and weather challenges when aircraft operations are compromised.

The results of this study could easily be associated with Story *et al.* (2008), who found that in some areas, aircraft were forced to operate above the recommended 10-metre spraying height as a safety precaution to avoid unexpected obstacles. However, adjustment of spraying height could have compromised the pesticide application rate and interfered with the effectiveness of control operations. However, there have been deliberate efforts by desert locust management organizations to introduce unmanned aerial vehicles (UAVs) in surveillance and control operations to build resilience against such challenges (Matthews, 2021; Alemu & Neigh, 2022).

There were 571 (73.3%) respondents who agreed that extreme weather affected desert locust management operations. Cloudy weather could have reduced the visibility of surveillance teams and complicated flight navigation for aerial spraying. A national FGD participant narrated:

> "We had to cancel spray operations several times due to cloudy weather. There was one incident when rain fell unexpectedly after spraying part of a medium-sized swarm. The swarm split into multiple smaller swarmlets and tracking them for follow-up control was very hard."

The above quote demonstrates there was fear of safety risks when conducting desert locust control in cloudy weather. In addition, the statement confirms that rainfall caused an abrupt interruption of control operation and this could have led to dilution of the pesticide.

The stoppage of control as a safety precaution and dilution of pesticides shows the ineffectiveness of desert locust management due to extreme weather. The findings are in line with the results of Story *et al*. (2008), who found that ground and aerial spraying was difficult due to bad weather. Splitting of one swarm into multiple smaller swarmlets, as explained in the quote, also meant that more resources would be required to trace, track and control them, leading to economic insecurity from additional cost. The smaller swarms could also have moved in different directions and taken longer to find. This could have exposed more people in other locations to human security risks.

4.5.3 Coordination Challenges During Desert Locust Management

Coordination challenges were evaluated in terms of poor communication, lack of clear leadership, inadequate information, poor supervision and unclear division of roles. Out of the 779 participants who successfully responded to the study, 562 (72.1%) and 534 (68.6%) agreed that poor communication and inadequate information, respectively, affected the effectiveness and efficiency of desert locust management. Ineffective and inefficient desert locust management meant that the protection of human security was jeopardized. One of the county-based FGD participants complained, "We collected a lot of data during desert locust survey operations but we did not know where this information was going to after online submission; we did not even get feedback concerning our reports."

The concern that was raised in the above statement pointed to poor communication especially lack of feedback mechanism. Poor communication and inadequate information could have led to delayed and ineffective control of the pest. Delayed control certainly had direct effect on human security as the pest had more time to destroy crops and pasture that are a source of livelihood to people in the affected areas. In addition, limited feedback could have resulted in misunderstanding and anxiety among people, which could have triggered personal insecurity by causing anger and despair (Saghir *et al.,* 2018).

Kenya had not experienced such a severe desert locust invasion for a long time despite having reported some incidents in the first decade of the current century. As a result, there was a limited structured way of communication among desert locust management stakeholders. A participant during national FGD reported:

> "The data that was collected during surveillance was submitted to multiple third-party databases outside the country due to limited technical capacity to manage desert locust information in Kenya. The situation, however, changed rapidly with the establishment of an information office in Kenya that was linked to the global desert locust information service that coordinates surveillance, forecasting and early warning in 30 countries across Africa and Asia. Today, Kenya has all the desert locust reports that were collected within the country during the 2019–2021 upsurge."

The narrative describes the lack of information management autonomy in Kenya at the start of the recent upsurge.

This limitation in real-time access to crucial information could have compromised both the validity and reliability of decisions made from foreign processed information, making desert locust management inefficient. Inefficiency in desert locust management meant that more resources than expected could have been used, leading to a direct effect on economic security. The findings are corroborated by the results of Showler et al. (2021), which documented coordination as a challenge during desert locust management. The narrative also describes how extreme efforts were made to build resilience by addressing emerging challenges promptly.

There were 549 (70.5%), 442 (56.7%) and 411 (52.7%) respondents who felt that lack of clear leadership, poor supervision and unclear division of roles, respectively, made desert locust management difficult. An FGD participant jokingly said:

> "Desert locust management turned into a lucrative crisis economy; everyone wanted to take the lead. I think the motivation was control of financial flow as there was heavy funding. However, through the emergency locust response program, a national locust control unit and similar units at county levels were established to coordinate surveillance, control and recovery activities."

This statement, at face value, points to some vested interests other than the protection of human security by reducing desert locust risks. Everyone wanting to lead meant unclear leadership and improper division of roles. In such circumstances, decision-making could have taken longer. In addition, holding people and institutions accountable could have been difficult. This could have led to slow action as no one could have felt outrightly responsible.

Delayed action to control desert locusts meant that the pest continued to destroy crops, pasture and other plants, thus exposing the country to food and environmental insecurity. The quote also suggests there was an unstructured modus operandi that could have left vacuums where interested parties found entry points to pursue their personal or organizational ambitions. In pursuit of personal interests, inefficiency could have emerged through the misappropriation of resources, which has an impact on economic security. The findings of this study resonate with the report of Showler *et al. (2021),* who traced the need for coordination in desert locust management as far back as the 5th International Locust Conference of 1938. However, the quote also indicates there were initiatives to build resilience through the establishment of national and county locust management units.

4.5.4 Financial Challenges During Desert Locust Management

Financial challenges were evaluated based on limited funds and corruption through the misappropriation of mobilised resources. Out of the 779 participants who successfully responded to the study, 582 (74.7%) agreed that limited funds were a serious challenge to desert locust management. Limited financial resources and misappropriation of funds could slow down the response to manage desert locusts. An FGD participant explained the financial difficulties experienced during desert locust management, saying, "The government had to get a loan facility from the World Bank to support desert locust management because such an expenditure had not been projected in the national budget."

The statement shows that the national government had a budgetary constraint to facilitate desert locust management. Both surveillance and control of desert locusts require funds to procure pesticides, purchase equipment, and facilitate field activities. Limited financial resources, therefore, meant that the management of desert locusts was not as rapid and effective as it should have been expected.

Remember that a one-day delay in managing a small swarm of desert locusts could lead to a loss of food adequate to feed 35,000 people (WMO & FAO, 2016). Delays emanating from financial challenges could, therefore, have exacerbated human security risks from desert locusts due to slow response to manage the pest. These findings are closely associated with the results of Thompson and Miers (2002), who documented that most desert locust-affected countries relied on international assistance to fund surveillance, control and recovery programs due to the government's financial constraints.

A State officer expounded on this during the national FGD, saying, "Desert locust invasion started midway the financial year, and therefore, national and county governments hardly had any specific budgetary allocation for management of the pest. There was also limited time for re-allocations through the legislative process of supplementary budget." The statement demonstrates the financial complexity that Kenya found herself in during the 2019-2021 desert locust invasion.

To expound on how severe financial challenges could affect desert locust management, it is essential to note that most recession and invasion regions encompass developing countries. As such, they have limited monetary reserves to deal with natural disasters such as desert locust upsurges and plagues (Kassegn & Endris, 2021). The findings are upheld by Showler (2003), who recognized that insufficient funding for desert locust control operations is a significant challenge. The initiative of the Government of Kenya to secure a loan from the World Bank points to an external resilience-building mechanism that ensured fast response, reduced crop losses and supported livelihood recovery.

There were 398 (51.1%) respondents who felt that corruption was one of the challenges during desert locust management in Kenya. One of the participants noted, "Recovery programs by different organizations were sometimes targeting the same beneficiaries. Some people reaped big and made good fortunes from desert locust recovery programs." Receiving multiple benefits from different entities for the same problem, as described in the above quote, is a classic example of corruption. Corruption leads to inefficiency in resource utilization (Hajilee *et al*., 2021), and this could have had led to economic insecurity. In addition, when some people benefit several times for the same problem at the expense of other potential beneficiaries, it creates inequality and this could pose personal security risks such as social exclusion.

4.5.5 Human Resource Challenges During Desert Locust Management

Human resource challenges were evaluated based on inadequate training as well as limited knowledge and skills among desert locust management personnel. Out of the 779 successful participants who successfully responded to the study, 476 (61.1%) respondents cited limited expertise in terms of knowledge and skills as a challenge during desert locust management. Kenya had not experienced desert locust invasion of a similar magnitude for several decades (FAO, 2020b). As such, the field of desert locust management could not have attracted many scholars or practitioners. A participant during the national FGD jokingly commented:

> "Everyone became an entomologist. As if that was not enough, everybody suddenly turned into a desert locust expert. However, having a critical mass of people with basic locust control skills, especially on the safe use of pesticides and effective spraying, was impossible."

This statement means there were a limited number of desert locust experts in Kenya when the first wave of invasions was reported in 2019.

Limited knowledge and skills meant that the effectiveness of desert locust management was not assured. As such, protection of human security from desert locust risks was not guaranteed. In addition, limited expertise created space for anyone with crop protection, plant pathology and entomology background to try and step in to contribute to desert locust management. While everyone's contribution may have helped to generate valuable ideas on how to kickstart the desert locust management campaign, it complicated the coordination mechanism. Having few people with basic skills in the safe use of pesticides and effective spraying meant that health and environmental security risks were inevitable.

The findings align with Showler et al. (2022), who identified human resource constraints as a major challenge in managing desert locust upsurges and plagues. Showler linked this challenge with the erosion of institutional memory due to staff turnover after retirement and redeployment following many years of remission periods in India and Pakistan. An agricultural officer expounded on the challenge of limited technical staff to support desert locust management field operations, saying:

> "There was no time to waste in trying to experiment locally on how best to control the pest. We had to use the military and NYS members because they were easy to mobilise, and they were also very responsive to instructions."

The use of paramilitary service members, as described above, indicates a need to reinforce the mainstream plant protection officers due to their low numbers.

The presence of security agents, especially soldiers among community members, however, created fear and anxiety, which have health security risks associated with psychosocial instability. The military and NYS members had limited pesticide handling skills, and this could have posed health security risks to them. The findings are supported by Showler (2021), who documented poor field practical skills due to inadequate training as a challenge to the effective management of desert locusts. However, the use of security officers who could be deployed rapidly to support desert locust management was a resilience-building strategy to reduce response time and thus safeguard human security.

There were 450 (57.8%) respondents who had the opinion that inadequate training among plant protection stakeholders was a challenge during desert locust management. With limited expertise in the country, there was a need to import expatriates with requisite knowledge and skills in desert locust management from recession countries to support capacity building. One participant during the national FGD said:

> "Bringing in people with first-hand experience in desert locust management from other countries was seen as a solution to limited local expertise. Initially, we had to bring in a geospatial mapping expert from Mauritania and spray experts from Morocco, Germany and Australia to support desert locust management."

Reports of inviting international experts, as described in the above statement, demonstrate that there were limited desert locust management experts in Kenya.

With limited resources to procure equipment and facilitate field personnel, as aforementioned, sourcing for expatriates could only have worsened the economic insecurity that desert locusts were causing. The findings are in agreement with Showler *et al.* (2021), who noted that the most common challenge during desert locust management has to do with limited access to requisite knowledge. External expert support was, however, a resilience-enhancing approach to reduce delays in the management of desert locusts and reduce negative effects from the pest.

4.5.6 Political Challenges During Desert Locust Management

Political challenges were evaluated in terms of insecurity, political interference and COVID-19 containment measures. There were 589 (75.6%) respondents who agreed that insecurity was a major challenge during desert locust management. An agricultural officer, during county-based FGD, elaborated this, stating:

> "During one of the locust surveillance exercises, a local Chief warned us not to proceed beyond some valley. He claimed that the valley was a cattle rustlers' hideout and anyone who dared to get in the valley could not be found alive."

During the national FGD, another respondent stated:

> "The national desert locust management team had to train special technical teams that were drawn from county directorates of agriculture. These teams were based in counties that have proximity

> to Al-Shabab-prone neighbouring country. In addition, aerial control of desert locust in the insecure areas was done using military aircraft."

The first quote shows that insecurity was a barrier to desert locust operations in some places. Insecurity may have hindered surveillance and control operations, allowing the pest more time to destroy vegetation and thereby worsening human insecurity.

Insecurity could also have allowed the pests to breed and increase the pest population, which would mean more destruction to crops and pastures. Increased pest population would also need additional resources to manage which would lead to increased economic insecurity. The findings are in tandem with a study by Gay *et al.* (2018) who reported that insecurity could deter surveillance and control, facilitate further breeding, cause outbreak development into upsurges and lead to invasions in neighbouring countries. The second quote illustrates the strategies that were used to create resilience against the challenges of insecurity.

There were 416 (53.4%) respondents who felt that COVID-19 containment measures were a challenge to most desert locust management activities, especially awareness creation, public sensitization, training, surveillance and control. One of the filed control base managers contributed to this discussion during national FGD, saying:

> "Early stages of the invasion coincided with the onset of the COVID-19 pandemic in the country that led to the suspension of international flights. This made support by regional and international trainers difficult. The shift from face-to-face to online virtual training created a new channel for capacity development. However, online training had limited opportunities for learning-by-doing which is critical for tactical level interventions such as hands-on practical skills in desert locust survey and control."

The above statement confirms how COVID-19 containment restrictions made an already bad desert locust situation even worse.

Interference with awareness creation, public sensitization and training by COVID-19 containment measures, especially restricted movement and social distancing, meant that surveillance and control activities were slowed down. Delayed surveillance and control operations due to COVID-19 containment measures meant that desert locusts had more time to destroy crops and pasture thus worsening food insecurity. The findings concur with Kassegn and Endris (2021), who found that COVID-19 containment measures, especially lockdown and social distancing, prevented group training and hence exacerbated desert locust risks in Ethiopia. The use of online training channels, however, provided a resilient capacity development option to address the challenge.

Out of the 779 participants who responded to the study, 390 (50.5%) respondents agreed that political interference significantly complicated desert locust management. One officer gave a detailed account of how politics can interfere with desert locust management saying, "We were detained for 4 hours in a neighbouring country during an aerial surveillance exercise." The quote indicates that political circumstances, such as international boundaries, could interfere with the effective management of desert locusts. The heavy-feeding and long-distance migratory behaviour of desert locusts (GOI, 2019; WMO & FAO, 2016), meant that every lost time could have worsened human security risks from the pest. For a pest that can migrate 16-19 kilometres in an hour (Symmons & Cressman, 2001), a four-hour detention of a surveillance team that was tracking a swarm would mean losing sight of the pest.

Losing track of a swarm would give it more time to destroy crops and pasture thus exacerbating its threat to human security. The results are in congruence with the findings of Story *et al*. (2008) who reported that ground and aerial spraying could be severely affected by political boundaries. Urgent action is needed to address these issues. Internal politics of devolved governance in Kenya were also at play and could have affected desert locust management albeit on a smaller scale. For instance, a county government official questioned, "Why couldn't the national government give us the money to spray locusts ourselves instead of running all over the country like we didn't exist?" This question illustrates there was political disquiet where counties felt that it was their responsibility to manage desert locusts.

The rapid migratory habit of desert locusts (see GOI, 2019), and the lack of cross-county mandate by individual devolved governments (see GOK, 2010) however meant that if counties were left to manage the pest, human security risks could have increased. This is drawn from the fact that a swarm that was reported in one county in the morning could be tracked in a different county in the evening and get sprayed in a third county the following day (GOK, 2022). If the national government was not involved, and one or more counties were unable to control desert locusts, there could have been the transfer of human security risks to several other counties.

4.5.7 Social-cultural Challenges During Desert Locust Management

Social-cultural challenges were evaluated as per the refusal of communities to report desert locust presence and the withholding of empty pesticide containers by people. Out of the 779 successful participants who successfully responded to the study, 445 (57.1%) respondents had the opinion that under-reporting of the pest presence curtailed the effectiveness of desert locust management. A respondent explained why they refused to report desert locusts asking, "Why would we report desert locusts to be killed and they brought rains and bumper harvest? It is even written in the Bible that what locusts eat would be brought back multiple folds."

While this belief seems mythical, it could have negatively impacted the effectiveness of desert locust management. Under-reporting of desert locusts meant that the pest continued to destroy crops, pasture and other plants. In addition, failure to report could have allowed desert locusts to breed and increase their population. This could, in turn, amplify Desert locust risks to food and economic security. There were 261 (33.5%) respondents who felt that withholding empty pesticide containers by community members was one of the challenges during desert locust management.

A respondent justified this behaviour by asking, “Why would the government want to collect the drums, and they were bought using our taxes? The drums are very strong and could make very nice jikos, doors and gates.” The “Jiko” is a Swahili word for charcoal-fuelled cooking stove. The quote reveals that community members felt entitled to retain the empty pesticide containers after desert locust control. This statement points to some level of oblivion among community members regarding the health and environmental security risks that pesticide residues could pose if empty containers are reused for food and water storage.

The belief that empty pesticide containers could be used to fabricate other items meant that people could confiscate them instead of surrendering them for cleaning, crashing and safe disposal. This could expose people to pesticide residues that are hazardous to human health and the environment. The findings are supported by Showler (2021), who noted there has been a serious problem in dealing with empty pesticide containers as there is a high demand by the public to reuse them, which poses health and environmental security risks. During the national FGD, one expert from a nearby country described an instance in which pesticides were spilt and iron drums were taken by residents.

4.5.8 Burden from Challenges during Desert Locust Management

The results for challenges during desert locust management were summarised in terms of technical, geographical, coordination, financial, human resource, political, and social-cultural constraints (Figure 4.8).

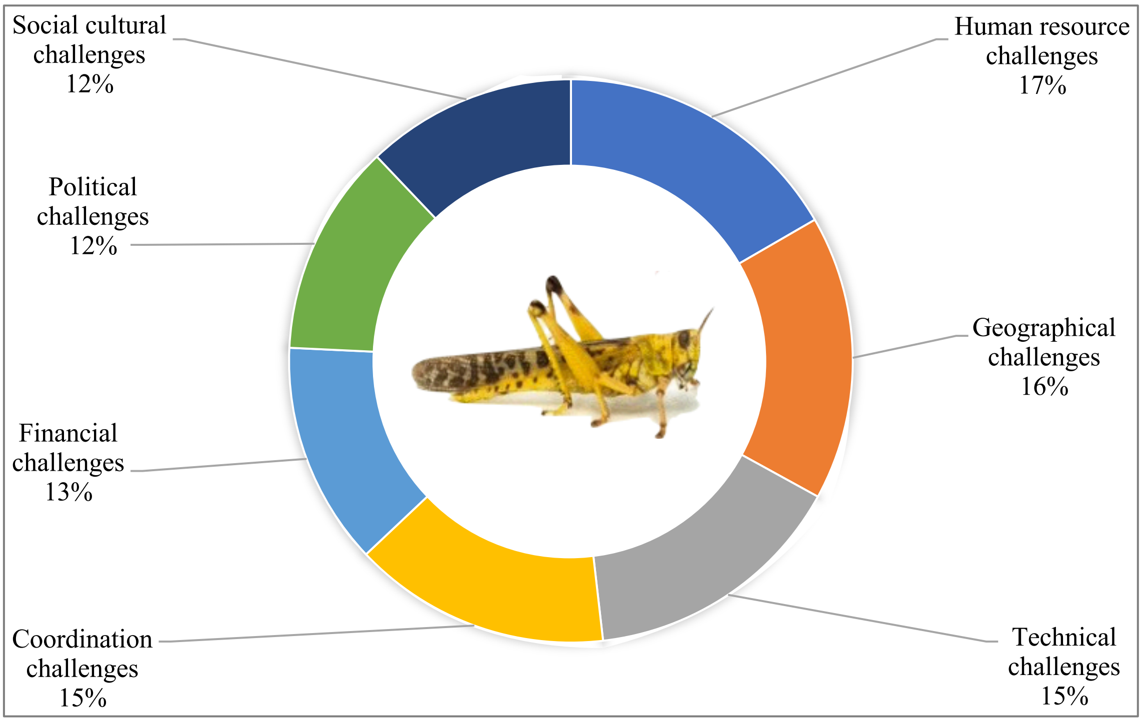

Figure 4.8 Percentage burden from desert locust management challenges

(Source: Field data – 2024)

The findings revealed that human resource constraints contributed 17% to interferences in securitized desert locust management in protecting human security. Kenya, being an invasion country where desert locusts are rare, had little surveillance and control technical capacity in the early stages of the invasion. Geographical challenges contributed 16% to hindrances of securitized desert locust management in protecting human security. The fact that desert locust management has spatiotemporal attributes, in that surveillance, control and recovery programs occur in space and time, makes it evident that any extremes in landscape and weather directly affect the effectiveness of field operations.

Technical challenges contributed 15% to hindrances of securitized desert locust management in protecting human security. Technical challenges were mainly associated with inadequate equipment due to a lack of preparedness after a 70-year lull from the last desert locust upsurge of a similar magnitude (Kenya Red Cross, 2020). Coordination challenges contributed 15% to the difficulties of securitized desert locust management in protecting human security. The engagement of multiple stakeholders with diverse mandates being fulfilled by vast numbers of personnel at strategic, operational and tactical levels meant that integration through a unified coordination structure could have been complex. Financial limitation contributed 13% to deterrents of securitized desert locust management in protecting human security.

Desert locust invasion is a rare phenomenon in Kenya, and the pest's arrival in the middle of a financial year meant that their management could not have been anticipated in the national or county budgets. Political tensions contributed 12% to hindrances of securitized desert locust management in protecting human security. This is due to local and international administrative jurisdictional differences during aerial surveillance and control operations. Finally, social and cultural limitations contributed 12% to the hindrances of securitized desert locust management in protecting human security, mainly due to varied belief systems on how to react to different and new scenarios.

4.5.9 Effects of Desert Locust Management Challenges to the Protection of Human Security

Ordinal logistic regression was used to assess how each category of challenges contributed to the limitation of securitized desert locust management to protect human security (Table 4.9).

Table 4.9 Model fit and goodness of fit for desert locust management challenges

Model Fitting Information					Goodness-of-Fit			
Model	-2 Log Likelihood	Chi-Square	df	Sig.		Chi-Square	df	Sig.
Intercept only	2869.970				Pearson	3940.141	5625	1.000
Final	1540.427	1329.543	7	<0.001	Deviance	1540.427	5625	1.000

(Source: Field data – 2024)

After carrying out an ordinal logistic regression, the model fitting information showed statistical significance (χ^2 (7) =1329.54, p<0.001), indicating that there was a significant improvement in fit as compared to the null model. The model, therefore, illustrated an excellent fit for the research data. The goodness of fit information shows statistical insignificance (χ^2 (5625) =3940.14, p>1.000); thus, the model fits the research data because there were no significant differences in the observed data and fitted/assumed model. The results of regression analysis are shown in Table 4.10.

Table 4.10 Differentiated hindrance of various challenges to desert locust risk management

Desert locust management challenges	Wald	df	Sig.	95% Confidence Interval		
				Exp_B	Lower	Upper
Human resource challenges	179.408	1	<0.001	2.757	2.377	3.196
Geographical challenges	165.276	1	<0.001	2.710	2.307	3.184
Technical challenges	159.583	1	<0.001	2.514	2.179	2.904
Coordination challenges	147.999	1	<0.001	2.447	2.136	2.807
Financial challenges	119.831	1	<0.001	2.119	1.818	2.472
Political challenges	96.491	1	<0.001	2.016	1.777	2.284
Social and cultural challenges	92.337	1	<0.001	2.002	1.742	2.298

(Source: Field data – 2024)

Based on the ordinal logistic regression test, all the odds for desert locust management challenges in protecting human security showed statistically significant as follows (Table 4.10): Wald χ^2 (1) = 179.408, p<0.001 for human resource challenges, Wald χ^2 (1) = 165.276, p<0.001 for geographical challenges and Wald χ^2 (1) = 159.583, p<0.001 for technical challenges. Wald χ^2 (1) = 147.999, p<0.001 for coordination challenges, Wald χ^2 (1) = 119.831, p<0.001 for financial challenges, Wald χ^2 (1) = 96.491, p<0.001for political challenges and Wald χ^2 (1) = 92.337, p<0.001 for social-cultural challenges. This revealed that human resource challenges created the highest burden on Desert locust management operations, and social and cultural issues had the least hindrance. As such, any enhanced effort to address one or more desert locust management challenges could have significantly increased human security protection.

4.5.10 Summary of Desert Locust Management Challenges

In summary, the findings indicated that desert locust risk management operations faced diverse challenges. The challenges negatively affected the expected speed and optimization of effectiveness in protecting human security from desert locust risks. Most of the challenges could be linked to desert locusts being an invasive pest that is not common in Kenya, and hence there was limited time for planning and enhancing preparedness.

As a result, efforts were to address these challenges by building short- and long-term resilience through establishing operational structures, enhanced collaborations, technological innovations, and physical and human capacity developments. These resilience-building approaches assisted in lowering the chances of desert locust management failure and reducing negative consequences from the pests while increasing the speed of livelihood recovery.

4.6 Desert Locust Management Best Practices in Protecting Human Security

In retrospect, the role of this research was to analyse the nexus between the securitization of desert locust risk management and human security in Kenya. As such, there was a need to determine desert locust management best practices that could reduce human security risks from pests and securitized interventions. This is because there is a need to ensure a win-win situation by balancing the benefits of intervening in security threats and the costs of introducing harm accidentally (Jain *et al*., 2011). To help unravel the paradox of securitization, desert locust management best practices were contextualised in terms of non-intervention, early intervention through physical control, early intervention through chemical control and IPM strategy.

Each of the desert locust management best practices was treated as a dependent variable and was assessed by respondents on a 5-point Likert scale based on multiple constructs. Constructs for determining desert locust management best practices were categorised as non-intervention, early physical and chemical control interventions, and IPM. Non-intervention was assessed in terms of doing nothing and letting desert locusts die independently due to predation and unfavourable weather. Physical control was assessed based on traditional community-based methods to kill desert locusts and the physical killing of the pest. Chemical control was assessed based on the use of man-made insect-killing chemicals and natural insect-killing substances.

The IPM strategy was assessed in terms of applying as many desert locust control methods as possible in no particular order, using several but carefully combined methods, and deploying several but carefully combined methods to remedy any risk associated with the pest, as well as securitized interventions. Results for the constructs that were used to determine desert locust management best practices are shown in Figure 4.9.

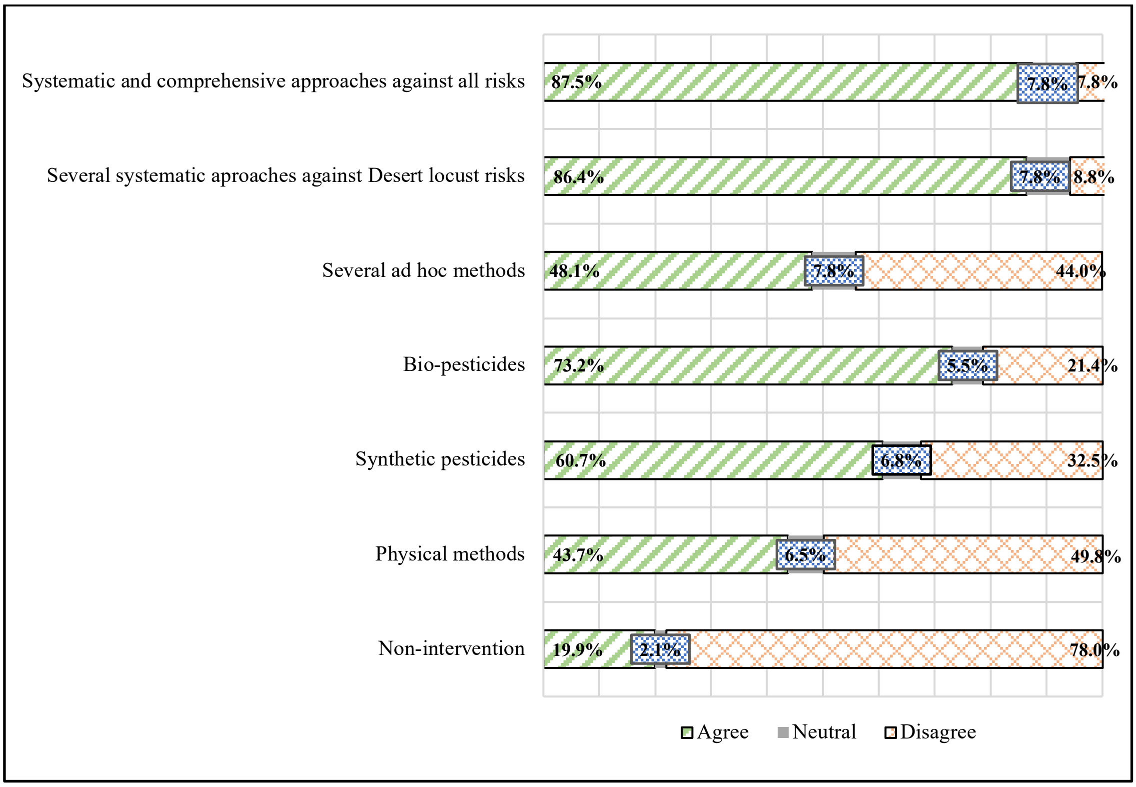

Figure 4.9 Percentage response on best practices in locust management

(Source: Field data – 2024)

Out of the 779 successful participants who successfully responded to the study, 682 (87.5%) considered systematic and comprehensive approaches against all risks as a preferred desert locust management best practice. In addition, 673 (86.4%) and 375 (48.1%) respondents agreed with several systematic approaches and ad hoc control measures against desert locust risks as best practices, respectively. Similarly, 570 (73.2%) and 473 (60.7%) respondents considered using biological and synthetic pesticides as desired desert locust management best practices, respectively. There were also 340 (43.7%) respondents who considered physical control a suitable desert locust management best practice. From the sampled respondents, 155 (19.9%) felt that non-intervention was a possible desert locust management best practice. To better understand, constructs of determining desert locust management best practices were categorised as non-intervention, early interventions through physical and chemical control, and IPM.

4.6.1 Non-Intervention to Desert Locust Outbreaks, Upsurges and Plagues as a Best Practice

Non-intervention was assessed in terms of doing nothing and letting desert locusts die independently due to predation and unfavourable weather. Out of the 779 successful participants who successfully responded to the study, 155 (19.9%) of respondents felt that non-intervention was a possible desert locust management best practice. The minority support of non-intervention as a desert locust management best practice could have been due to realising the human security risks that the pest poses; hence, doing nothing would seem irresponsible. However, during the national FGD, a participant cautioned:

> "Instead of wasting a lot of money purchasing very expensive pesticides and equipment to contaminate the environment with hazardous chemicals, the money could have been used to protect the affected communities against immediate effects from desert locusts through relief food and cash-transfers. This could have also avoided risks of contaminating the environment with pesticide residues."

The statement seemed to acknowledge that desert locust management is an exorbitantly expensive process that negatively affects human security. In addition, the quote recognizes the human security risks associated with using pesticides in desert locust control.

As discussed earlier, other than the hazardous effects of pesticides, most of the other securitized interventions negatively affect human security. From these considerations, the participant could have felt that doing nothing and refocusing efforts and resources on adaptive measures could have been the best option. This approach would address desert locust risks through restorative and rehabilitative measures rather than securitizing surveillance and control of the pest through emergency response.

Non-intervention would, therefore, eliminate the risk of inadvertent threats from securitization. In addition, non-intervention would address some of the challenges during desert locust management by bypassing surveillance and control to address livelihood recovery and environmental rehabilitation. The non-intervention approach is supported by Showler *et al.* (2021) report that documented that one of the desert locust management approaches could be letting outbreaks develop into an upsurge, then build up to plague, and finally allow the pest to run the natural cycle to natural mortality. This is because nature has a means of balancing biodiversity by controlling populations of organisms in ecosystems.

4.6.2 Early Intervention to Desert Locust Outbreaks as a Best Practice

Early intervention can be implemented through physical and/or chemical control measures. Physical control was assessed based on traditional community-based methods to kill desert locusts and the physical killing of the pest. There were 340 (43.7%) respondents who considered physical control as a suitable desert locust management best practice. A farmer in one of the counties explained:

> "We saw the desert locusts pushing their abdomen into the soil. Agriculture officers told us they were laying eggs. So, we decided to plough the entire area with Jembes to expose the eggs and prevent them from hatching, and it worked."

"Jembe" is Swahili word for Tilling hoe. The above quote indicates that community members-initiated control measures independently. Physical control is a readily available option, as it depends on community members' efforts, and it is also cheap. Physical control measures can also be financially and technically feasible against small-scale infestations during the early stages of outbreaks.

Physical control is supported by Magor *et al*. (2008) as a best practice in desert locust management during early intervention because it hastens the return to recession status. Physical control provides an opportunity to reduce human security risks emanating from desert locusts. It also reduces the risk of unintended threats from securitized interventions, especially the use of synthetic pesticides. In addition, physical control would help to address human resource, technical and financial challenges during desert locust management by using cheap and readily available knowledge and skills. Using cheap and readily available knowledge and skills also helps build resilience against human resource, technical and financial challenges.

Chemical control was assessed based on the use of man-made insect-killing chemicals and natural insect-killing substances. There were 570 (73.2%) and 473 (60.7%) respondents who had the opinion that the use of biological and synthetic pesticides, respectively, could be helpful for desert locust management best practices. A locust expert reemphasized the primary role of chemical control, saying, "The only way to win the war against desert locusts is through chemical control. The rest are just good time stories that cannot pass the effectiveness test." The statement implies that pesticide use in desert locust management is inevitable. The mention of other control options as "good time stories" implies that alternatives to pesticide application during desert locust management could be ineffective and thus worsen human security risks from the pest.

The perception that pesticides form a core part of desert locust management acknowledges the human security risks the pest could cause to people and the environment. The control of desert locusts highly depends on the use of pesticides because they are fast-acting and hence could reduce the pest population rapidly (Wakil et al., 2022), protecting human security faster. However, pesticides, especially chemicals, could negatively affect human security through poisoning and loss of biodiversity due to the death of non-target organisms. Biological pesticides are therefore recommended as a safer alternative (Matthews, 2021). Other than protecting human security from risks associated with desert locusts, biological pesticides can reduce unintended risks.

4.6.3 Integrated Pest Management in Desert Locust Control as a Best Practice

The IPM strategy was assessed in terms of the application of as many desert locust control methods as possible in no particular order, the use of several but carefully combined methods, and the deployment of several but carefully combined methods to remedy any risk associated with the pest as well as securitized interventions. There were 682 (87.5%) respondents who considered systematically prioritising the use of multiple approaches against all potential risks (from the pest and securitized interventions) as a preferred desert locust management best practice. There were also 673 (86.4%) and 375 (48.1%) respondents who agreed with several systematic approaches and ad hoc control measures against desert locust risks, respectively, as best practices.

A participant during the national FGD explained the justification of IPM in desert locust management, saying:

> "In-country breeding can be controlled through customised IPM approaches to reduce injection of synthetic pesticide residues into the environment. To begin with, cultural practices such as disrupting the breeding cycle by ploughing breeding sites, burning the pest, trapping hoppers using trenches, harvesting adults, and converting them into food, feed and fertilizer could be practised. The second line of defence against invasion-country-bred desert locusts could be the use of biopeptides such as Metarhizium acridum and predators such as birds and ants. Natural disruptive techniques such as the use of pheromones

> and insect growth regulators could also be used before resorting to chemical pesticides."

The statement recognizes the existence of various pest control options that can be combined to reduce desert locust risks to human security.

The participant explained a systematic manner in which desert locust IPM can be deployed, starting with physical options, biological control and, as a choice of last resort, the use of chemical methods to control the pest. However, the quote acknowledges the detrimental effects of using synthetic pesticides. Therefore, there should be careful selection and judicious use of chemical pesticides based on their safety levels during the development of IPM programs for desert locust management. Under GAP, especially when using IPM approaches, chemical control of pests is done judiciously as an option of last resort (Lecoq, 2010).

The IPM strategy provides an opportunity to reduce not only human security risks emanating from desert locusts but also unintended threats from securitized interventions, especially the use of chemical pesticides. In addition, IPM can help to address human resource, technical and financial challenges during desert locust management by initially using readily available knowledge and skills at a lower cost during physical control. Using readily available knowledge and skills during physical control builds resilience against human resource, technical and financial challenges. The results corroborate the findings of Moharana *et al*. (2020), who reported that the IPM strategy involved the use of physical/cultural practices due to their availability and cost-effectiveness, followed by biological control and then judicious use of chemical pesticides.

4.6.4 Contribution from Desert Locust Management Best Practices

Results for desert locust management best practices were summarised in terms of IPM, early interventions using chemical control, early intervention using physical control, and non-intervention (Figure 4.10).

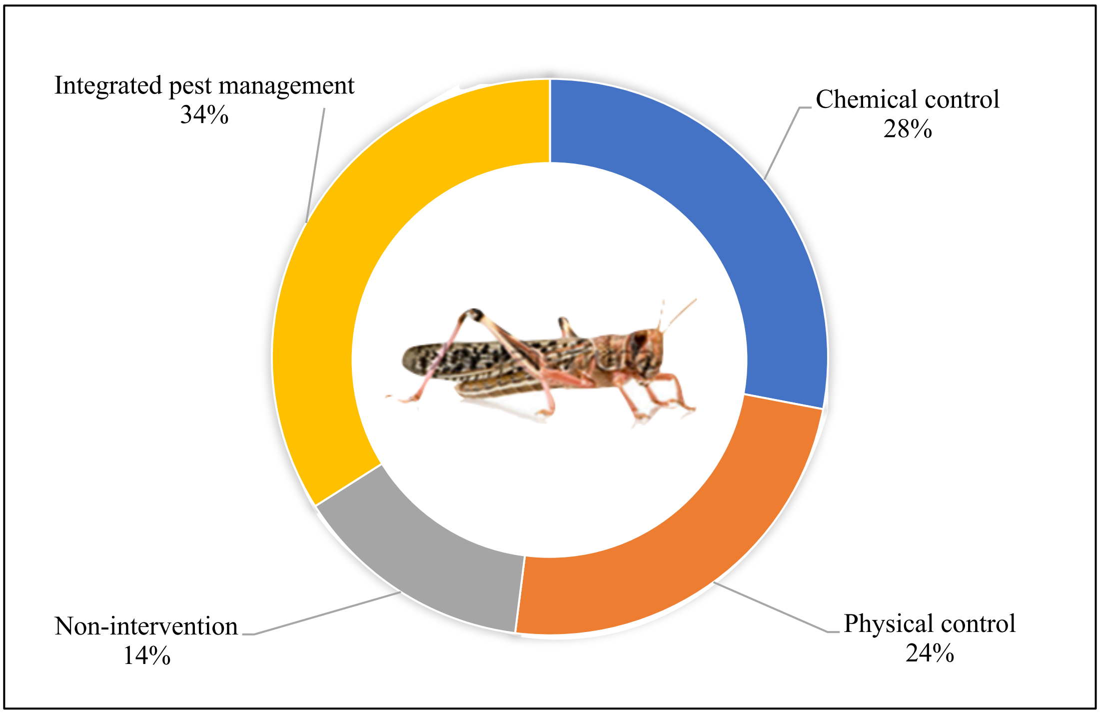

Figure 4.10 Rating for desert locust management best practices

(Source: Field data – 2024)

The findings revealed that IPM received 34% support from respondents as a desert locust management best practice. The tremendous support of IPM is attributable to the fact that respondents recognised the importance of deploying all possible and readily available but practical, efficient and safe control measures to manage desert locusts. Early chemical control intervention received 28% support from respondents as a desert locust management best practice. This can be associated with the fact that pesticides are the most commonly used pest control products in the agriculture sector, especially among commercial farmers. However, they may not be the safest.

Early intervention using physical control received 24% support from respondents as a desert locust management best practice. This is because, by intuition, the first control strategy by subsistence farmers against any pest involves killing them mechanically. Physical control approaches are also readily available and cost-effective, with little inadvertent risks to human security. Non-intervention received 14% support from respondents. Despite being the safest control method where desert locusts take a natural course to self-destruction, non-intervention was perceived as irresponsible. It thus was considered the least of best practices. The disaster situation that comes with upsurges and plagues calls for action; thus, the idea of sitting down, laying back and waiting for desert locusts to wreak havoc and then die on their own was unimaginable among respondents.

4.6.5 Summary of Desert Locust Management Best Practices

In conclusion, the findings revealed several possible desert locust management best practices. However, the IPM strategy received dominant support from respondents due to recognising risks that go beyond desert locusts to encompass unintentional threats from securitized interventions. The IPM approach, therefore, presents an opportunity to build resilience against human resource, technical and financial challenges through the progressive use of readily available knowledge and skills during physical control before advancing to more sophisticated strategies such as biological and chemical control options.

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATIONS

5.0 Introduction

This chapter presents a brief and concise summary of the study's significant findings, conclusion, and recommendations, focusing on the key findings that have the most impact on the topic at hand.

5.1 Summary of Research Findings

The study established that securitizing desert locust management in Kenya has substantial consequences for human security. These findings have significant implications for the need for in-depth examination and the establishment of protective measures to enhance awareness, improve coordination of responses, and implement agricultural measures to preserve livelihoods. However, it is essential to alleviate the adverse consequences, including militarization, human rights difficulties, and resource allocation challenges, while ensuring that residents' rights are not violated. Community trust is essential for cooperation, and excessive securitization can undermine this trust. Additionally, prioritizing securitized responses may divert resources from critical areas like healthcare, education, and social services, leading to inequitable distribution and under-supporting vulnerable regions.

5.1.1 Desert Locust Risks to Human Security

The findings revealed that desert locusts posed risks to various human security dimensions. The results showed that food insecurity due to desert locusts contributed 27% of the overall human security risk, while health and economic insecurity contributed 19% each. In addition, personal and environmental insecurity due to the effects of desert locusts contributed 18% and 17% to the overall human security risk, respectively. As such, desert locusts affected food security the most and environmental security the least.

While food and economic insecurity due to desert locusts contributed 46% of the overall human security risk, 54% of the risk was associated with other human security dimensions. As such, the study notes that these indirect risks could be overlooked despite having a higher threat to human security. The findings resonate with the propositions of resilience theory because desert locust risks caused an ecological and sociocultural imbalance, which could have altered normal functionality, structural capability, identity and responsiveness of ecosystems and people. The findings are also in tandem with propositions of securitization theory because desert locust was framed as an existential threat to humanity to allow the deployment of urgent, extreme and large-scale interventions.

5.1.2 Securitization of Desert Locust Management Practices to Protect Human Security

The results indicated that chemical control contributed 43% to desert locust risk reduction among the various securitised desert locust management practices. Recovery programs and physical control contributed 16% each in reducing desert locust risks. Surveillance and indigenous control methods contributed 15% and 10% to the overall desert locust risk reduction. This shows that the securitization of chemical control contributed the most to safeguarding human security, while indigenous methods contributed the least. As such, despite the securitization of chemical control having independently contributed the most in protecting human security against desert locust risks, alternative control measures had a higher combined contribution. Every effort towards the management of desert locusts was therefore significant.

The findings revealed that although politicians and capital owners are the main drivers of securitization, human collectives such as community members can trigger the process when faced with a common threat, such as a desert locust emergency, by initiating speech acts through united distress calls for help. The results also conform to propositions of resilience theory because securitization lowered the chances of failure of desert locust management activities and reduced negative consequences in terms of loss of lives, damage and adverse economic effects while increasing the speed of livelihood recovery in the affected communities.

5.1.3 Threats from Securitized Desert Locust Management Practices

Results of the study revealed that securitization of desert locust management led to unintended human security threats. Economic and environmental security threats from securitized desert locust management practices contributed 23% and 20% to the overall human security risk. In addition, the results showed that health and food security threats from securitized desert locust management practices contributed 16% and 15%, respectively, to human security risk. Personal and political security threats from securitized desert locust management practices contributed 14% and 12% to the overall human security risk.

The findings showed that securitization of desert locust management practices affected economic security the most. The effect on economic security was due to high capital investment in purchasing pesticides, equipment procurement, and operational expenses. In addition, the effect on economic security was exacerbated by increasing household expenditure due to the scarcity of agriculture-related commodities. Environmental and health security threats were associated with the securitization of chemical control of desert locusts using synthetic pesticides. The findings resonate with propositions of resilience theory because inadvertent negative ramifications from securitized interventions caused an ecological and sociocultural imbalance, which could have altered normal functionality, structural capability, identity and responsiveness of ecosystems and people.

5.1.4 Challenges during Desert Locust Management that Hindered Protection of Human Security

The findings showed that challenges during desert locusts exacerbated human security risks from the pest. Human resource challenges contributed 17% of the hindrance to protecting human security against desert locust risks. Geographical challenges contributed to 16% of the burden against protecting human security. In addition, technical and coordination challenges contributed 15% each to interference in protecting human security against desert locust risks, while financial challenges contributed 13%. Finally, political and socio-cultural challenges contributed to 12% of the hindrance to protecting human security.

The results revealed that human resource challenges created the highest burden on protecting human security against desert locust risks, while social-cultural challenges had the lowest hindrance. Although securitised desert locust management practices threatened economic security the most, financial challenges did not rank highest among the obstacles. However, efforts to address these challenges were aligned with principles of resilience theory as they enhanced Kenya's preparedness in desert locust management. Efforts to address the challenges resulted in enhanced short- and long-term resilience through establishing operational structures, increased collaborations, technological innovations, and physical and human capacity developments.

5.1.5 Desert Locust Management Best Practices in Protecting Human Security

The results showed that several potential desert locust management best practices could help reduce risks from insects and securitized pest management practices. The IPM strategy received 34% support from respondents as a desert locust management best practice. Early interventions using chemical or physical control received 28% and 24% support from respondents, respectively. Non-intervention received 14% support from respondents as a desert locust management best practice. The IPM strategy was, therefore, the most supported desert locust management best practice, while non-intervention had the least backing. Despite non-intervention being the safest control method where desert locusts take a natural course of self-destruction, respondents perceived it as irresponsible.

5.2 Conclusion

The study concludes that securitization of desert locust risk management positively and negatively affects human security. On the one hand, securitization of desert locust risk management protected human security. On the other hand, extreme and urgent interventions after the securitization of desert locust risk management threatened human security. In addition, challenges during desert locust management exacerbated risks from desert locusts and threats from securitized interventions. As such, best practices provide an opportunity to manage risks from desert locusts, balance benefits from securitized interventions by reducing unforeseeable threats, and address challenges that can hinder effective and efficient pest management. The study, therefore, recommends applying a customized IPM strategy as a desert locust management best practice to balance the benefits and risks of securitized interventions while addressing actual and potential operational challenges.

The study also concludes that the findings are in tandem with propositions of securitization and resilience theories. Regarding propositions of securitization theory, desert locust was politicised by framing the pest as an existential threat to humanity, thus allowing securitization of its management by deploying urgent, extreme and large-scale interventions. In addition, the findings resonate with the propositions of resilience theory because securitization lowered the chances of failure of desert locust management. Securitization also reduced negative consequences in terms of damage to crops and pasture. Securitization also increased the speed of livelihood recovery in the affected communities. In addition, efforts to address desert locust management challenges enhanced Kenya's preparedness by building short- and long-term resilience. Resilience was enhanced through establishing operational structures, collaborations, technological innovations, and physical and human capacity developments.

5.3 Recommendations

1) Desert locusts pose an existential threat to humanity, and hence, a comprehensive risk management strategy that seeks to broaden countermeasures beyond food and economic security should be developed.
2) Securitization of chemical control made the highest contribution to protecting human security against desert locust risks, and hence, research on and application of biological pesticides rather than synthetic insecticides should be prioritized.
3) Securitization of well-intended urgent and extreme interventions could trigger unforeseen risks. As such, guidelines for securitization of desert locust management operations should be developed to deploy premeditated and well-planned interventions and reduce inadvertent human security threats.

4) Desert locust management challenges can exacerbate human security risks from the pest and subsequent securitized interventions. Therefore, continuous capacity development through regular training and periodic updates of preparedness plans should be prioritized to build resilience against actual and potential constraints.
5) Scholars, policymakers, and practitioners should develop a customized IPM strategy to balance the benefits of securitizing desert locust management and the risk of introducing unintended human security threats.

5.4 Areas of Further Research

1) In cognizance of desert locusts' destructive feeding and long-distance migration, there is a risk of ecosystem destabilization through nitrogen and carbon transfer. Therefore, research on the environmental risk of desert locusts to ecosystems should be conducted during an active upsurge or plague.
2) Due to the adverse effects of synthetic pesticides on people, livestock and the environment, formative evaluation should be done before any desert locust management campaign as a baseline against which continuous monitoring and summative evaluation can be assessed.
3) Although desert locusts are rare in invasion-affected countries such as Kenya, their presence and securitized management could have caused stress, depression, and sometimes trauma. Psychosocial assessments of people in desert locust-affected countries should be carried out to generate data that can be used to plan counselling and therapeutic rehabilitation as part of recovery programs.
4) Security, weather, and geographical barriers were observed as major challenges to desert locust surveillance and control activities. Field trials for

survey and control using UAVs as a possible means of addressing security, weather, and geographical challenges should be conducted during an active upsurge or plague.

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APPENDICES

Appendix 1: Letter seeking voluntary participation of respondents

Kenyatta University
P. O. Box 43844
Nairobi, Kenya

24th March 2023

Dear Participant,

RE: REQUEST FOR YOUR PARTICIPATION IN A RESEARCH STUDY

My name is Eliud Baraka, a Ph.D. student at Kenyatta University. In order to fulfil requirements of the academic program, I am undertaking a research project on: **Securitization of Desert Locust Risk Management and Human Security in Kenya.** The study seeks to assess desert locust risks, analyse securitized desert locust management practices, evaluate threat of securitized desert locust management practices, establish desert locust management challenges, and determine desert locust management best practices in Kenya.

The findings of this study are anticipated to help in effective and efficient management of desert locusts while safeguarding people and the environment in future. You have been selected randomly from a list of stakeholders who participated in desert locust management during the 2019–2021 invasion. Your participation is voluntary and you may choose to withdraw from the study or discontinue responding to the questions at any stage. Your responses will be treated as confidential and shall be used for academic purposes.

I kindly request you to carefully reflect on each question as you complete the questionnaire and take this opportunity to thank you in advance for taking part in this study.

Yours sincerely,

Eliud G. Baraka

Appendix 2: Research questionnaire

Introduction

My name is Eliud Baraka, a Ph.D. student at Kenyatta University. In order to fulfil requirements of the academic program, I am undertaking a research project on: Securitization of Desert Locust Risk Management and Human Security in Kenya. The study seeks to assess desert locust risks, analyse securitized desert locust management practices, evaluate threat of securitized desert locust management practices, establish desert locust management challenges, and determine desert locust management best practices in Kenya. The questionnaire has 5 questions that may take about 25-30 minutes to respond to. Questions marked with * are mandatory. Your identity will remain anonymous and the information you provide will be treated as confidential for academic use only. Your participation is voluntary and you may choose to withdraw from the study or discontinue responding to the questions at any stage.

Section A: General information

Date____

GPS____

Coordinates____

County____________________________Ward____________________________

Name (Optional): ____

Phone Number (Optional): ____

Sex: Male ☐ Female ☐

Age: 18-35 ☐ 36-60 ☐ Above 60 ☐

Education:

Primary ☐ Secondary ☐ Certificate ☐ Diploma ☐

Degree ☐

Affiliation: Community Member ☐ National Government ☐

County Government ☐ I/NGOs ☐

Name of Community group/Ministry/Department/Organisation/Agency___________

____

Section B: Desert locust risks to people and the environment

1. Do you agree or disagree with following statements about risks that were caused by Desert locusts?

	Strongly disagree	Somewhat disagree	Not sure	Somewhat agree	Strongly agree
There was decreased food supply after crop damage by Desert locusts					
Desert locusts did not reduce livestock production even after destroying pasture					
There was malnutrition in children as Desert locusts led to limited household food supply					
Human-wildlife conflicts emerged due to movement of wild animal into settlements in search of food after devastation of rangelands by Desert locusts					
There was no decrease in household income after Desert locusts destroyed crops					
Desert locusts exposed soil to erosion after they damaged plant cover					
Resource-based conflicts emerged after crops and pasture were damaged forcing people and livestock to move from their settlements					
Desert locusts increased fertility of land where they died					
Children dropped out of school due to lack of fees after loss of household income following devastation of crops and pasture by Desert locusts					
There was no decrease in household income after Desert locusts destroyed pasture for livestock					
Desert locusts increased the number of internally displaced people by creating resource-based and human-wildlife conflicts					
There was malnutrition in children as Desert locusts led to limited household food supply					
Desert locusts increased soil fertility on farms where they stayed					
Desert locust caused emotional stress to people after destroying crops and pasture					

People did not die of starvation after devastation of crops and pasture by Desert locusts					

Section C: Desert locust management practices to protect people and the environment

2. (a) To what extent do you agree or disagree with following statements about methods that were used in dealing with Desert locusts to protect crops, pasture and the environment?

	Strongly disagree	Somewhat disagree	Not sure	Somewhat agree	Strongly agree
Money-for-work programs did not help people to continue generating household income during Desert locust invasion					
Praying for God's help protected crops, pasture and the environment against Desert locusts					
Monitoring and reporting of Desert locusts using aircraft helped to protect crops, pasture and the environment					
Monitoring and reporting of Desert locusts by community scouts did not protect crops, pasture and the environment					
Spraying Desert locusts with purchased man-made insect-killing chemicals minimised their damage to crops, pasture and the environment					
Digging trenches on the path of marching Desert locust hoppers to trap and bury them did not reduce damage to crops, pasture and the environment					
Monitoring and reporting of Desert locusts by using drones did not assist to protect crops, pasture and the environment					
Distribution of domestic animals by government and other organisations helped to replace livestock that had died during Desert locust invasion					
Harvesting Desert locusts for human food and animal feed did not reduce the damage to crops, pasture and the environment					

Supply of crop and livestock inputs assisted farmers to start generating income again after losses from Desert locust					
Money transfers did not sustain households' purchasing power during Desert locust invasion					
Planting pasture seeds did not increase livestock production or enhance household incomes after destruction by Desert locust					
Spraying Desert locusts with natural insect-killing products reduced their damage to crops, pasture and the environment					
Scaring the Desert locusts off with noise did not prevent their devastation to crops, pasture and the environment					
Stealing of domestic animals from other communities helped to replace livestock that had died due to destruction of pasture by Desert locusts					
Physically killing Desert locusts reduced their damage to crops, pasture and the environment					
Burning Desert locusts with fire increased damage to crops, pasture and the environment					
Supply of livestock feed did not prevent deaths of domestic animals during Desert locust invasion					
Witchcraft helped to prevent Desert locusts from destroying crops, pasture and the environment					
Relief food supply protected people from hunger and malnutrition after crop damage by Desert locusts					
Monitoring and reporting of Desert locusts by national government officers did not help to protect crops, pasture and the environment					
Re-planting of trees assisted to restore vegetation cover after destruction of plants by Desert locusts					

Section D: Threats of desert locust management practices to people and the environment

3. (a) To what degree do you agree or disagree with the following statements concerning effects of Desert locust management activities to people and the environment?

	Strongly disagree	Somewhat disagree	Not sure	Somewhat agree	Strongly agree
Chemicals that were used to spray Desert locusts caused injury or poisoning to people during or after spraying					
People who were monitoring and reporting Desert locusts in farms destroyed crops thus reducing expected yields					
Birds did not die after coming into contact with chemicals that were used to spray Desert locusts					
Chemicals that were used to spray Desert locusts made water poisonous to animals					
Monitoring and spraying across country borders led to diplomatic disagreements					
Bees did not die after coming into contact with chemicals that were used to spray Desert locusts					
Desert locust monitoring and spraying vehicles produced harmful gases that spoiled the air					
Chemicals that were used to spray Desert locusts made water poisonous to people					
Increased human activities during Desert locust monitoring and spraying made the soil loose and caused erosion					
Monitoring and spraying across different counties led to political conflicts					
Birds died after eating insects that had come into contact with chemicals used to spray Desert locusts					
Desert locust monitoring and spraying aircraft released harmful gases that spoiled the air					
Chemicals that were used to spray Desert locusts did not kill livestock after spraying					

Presence of military aircraft, vehicles and personnel in villages during Desert locust control operations caused fear among community members					
Desert locust training, monitoring and spraying activities did not increase the spread of Covid-19					
Fires meant to kill Desert locust produced harmful smoke					
Presence of NYS members in villages during Desert locust control operations did not create fear among community members					
Flying drones to monitor and spray Desert locusts created fear among community members					
Plants wilted and dried after being sprayed with chemicals used to kill Desert locusts					
Low flying civilian aircraft used to monitor and spray Desert locusts did not create fear among community members					
People who were monitoring and reporting Desert locusts participated in sexual harassment, exploitation and abuse during field operations					
Lighting of fires to kill Desert locust did not either kill other organisms					
Re-allocation of national and county budgets, and borrowing of money to manage Desert locusts did not affect Kenya's economy					
Harvesting of crop produce early to prevent their destruction by Desert locusts reduced the amount food commodities in the market thus increasing prices					
Fires meant to kill Desert locust did not destroy plants					
Monitoring and spraying of Desert locusts made people emotionally disturbed					

(b) How were the negative effects from Desert locust monitoring and spraying activities controlled?

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Section E: Desert locust management challenges in protecting people and the environment

4. Do you agree or disagree with the following statements concerning challenges that were experienced when monitoring, reporting, spraying and restoring livelihoods during and after Desert locust invasions, and could have exposed people and the environment to unintended risks?

	Strongly disagree	Somewhat disagree	Not sure	Somewhat agree	Strongly agree
Poor communication among people who were monitoring and spraying Desert locusts did not delay control operations					
Insufficient tools and equipment to monitor, report and spray Desert locusts led to destruction of crops, pasture and vegetation					
Poor mobile phone signal prevented quick reporting of Desert locust presence for early spraying of the pest					
Lack of clear leadership among people who were monitoring and spraying Desert locust did not delay operations					
Insecurity in areas affected by Desert locusts prevented access for monitoring and spraying					
Political interference did not affect Desert locust management in any way					
Extreme weather conditions hindered monitoring, reporting and spraying of Desert locusts					
Limited internet connection did not prevent reporting of Desert locust incidents for early spraying of the pest					
Difficult landscape made monitoring, reporting and spraying of Desert locusts difficult					
Inadequate training of people who were involved in Desert locust monitoring, reporting and spraying exposed them to injury or poisoning					

Insufficient money to facilitate Desert locusts monitoring, reporting, spraying and recovery programs did not affect crops, pasture and vegetation					
Limited knowledge and skills to support monitoring, reporting and spraying of Desert locusts made management of the pest unsuccessful					
COVID-19 containment measures did not prevent recovery programs meant to help people recuperate after devastation by Desert locusts					
Inadequate information did not delay recovery programs meant to support people who were affected by Desert locusts					
Corruption by personnel in selecting beneficiaries and allocating resources after Desert locust invasion led to delayed and wasteful recovery					
COVID-19 containment measures did not slow down monitoring, reporting and spraying of Desert locusts					
Poor supervision of monitoring, reporting and spraying teams led to non-compliance with operating procedures exposing personnel, community members and the environment to danger					
Community members sometimes refused to report presence of Desert locusts thus delaying spray operations					
People took away pesticide containers and used them to store water and food thus exposing themselves to poisoning					
Institutions that were involved in Desert locust monitoring, reporting, spraying and recovery activities did not have clear division of roles leading to duplication of interventions					

Section F: Desert locust management best practices meant to protect people and the environment

5. (a) To what level do you agree or disagree with the following statements concerning Desert locust management best practices used to protect people and the environment?

	Strongly disagree	Somewhat disagree	Not sure	Somewhat agree	Strongly agree
Doing nothing and letting Desert locust die on their own is the worst option in protecting people and the environment					
Rapid response to spray Desert locust with man-made insect-killing chemicals is the best option in protecting people and the environment					
Using traditional community-based methods to kill Desert locusts is the worst option in protecting people and the environment					
Applying several but carefully combined methods to reduce the number of Desert locusts is the best option in protecting people and the environment					
Quick response to spray Desert locust with natural insect-killing substances is the best option in protecting people and the environment					
Using as many methods as possible in no particular order to reduce the number of Desert locusts is the worst option in protecting people and the environment					
Applying several but carefully combined methods to remedy any risk associated with Desert locusts is the best management option in protecting people and the environment					

Swift response to control Desert locust by physically killing them to reduce their numbers is the worst option in protecting people and the environment					

(b) What other best practices could have been used to protect people and the environment against risks associated with Desert locusts?

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THANK YOU VERY MUCH FOR TAKING YOUR TIME TO RESPOND TO THE QUESTIONS

Appendix 3: Research approval by Kenyatta University Graduate School

KENYATTA UNIVERSITY
GRADUATE SCHOOL

E-mail: kubps@yahoo.com
dean-graduate@ku.ac.ke
Website: www.ku.ac.ke

P.O. Box 43844, 00100
NAIROBI, KENYA
Tel. 810901 Ext. 57530

Internal Memo

FROM: Dean, Graduate School

DATE: 17th February, 2023

TO: Mr. Eliud G. Baraka
C/o Department of Sec, Diplomacy & Peace Studies
KENYATTA UNIVERSITY

REF: C82/CTY/38618/17

SUBJECT: APPROVAL OF RESEARCH PROPOSAL

This is to inform you that the Graduate School Board at its meeting 15th February, 2023 approved your Ph.D. Research Proposal entitled **"Securitization of Desert Locust Risk Management and Human Security in Kenya".**

You may now proceed with your Data collection, subject to clearance with the Director General, National Commission for Science, Technology & Innovation.

As you embark on your data collection, please note that you will be required to submit to Graduate School completed supervision Tracking and Progress Report Forms. The Forms are available at the University's Website under Graduate School webpage downloads.

By copy of this letter, the Registrar (Academic) is hereby requested to grant you substantive registration for your Ph.D. studies.

Thank you.

DR. HARRIET ISABOKE
FOR: EXECUTIVE DEAN, GRADUATE SCHOOL

c.c. Chairman, Department of Security, Diplomacy & Peace Studies
Registrar (Academic) Att; Mr. Richard Chweya

Supervisors:

1. Dr. Ann M. Sirera
   C/o Department of Sec, Diplomacy & Peace Studies
   KENYATTA UNIVERSITY

2. Dr. George Otieno
   Department of Biology
   University of Nairobi
   C/o Dept. of Sec, Diplomacy & Peace Studies
   KENYATTA UNIVERSITY

HI/cao

KENYATTA UNIVERSITY
GRADUATE SCHOOL

E-mail: kubps@yahoo.com
dean-graduate@ku.ac.ke
Website: www.ku.ac.ke

P.O. Box 43844, 00100
NAIROBI, KENYA
Tel. 8710901 Ext. 57530

Our Ref: C82/CTY/38618/17

Date: 17th February, 2023

The Director General,
National Commission for Science, Technology & Innovation,
P.O. Box 30623-00100,
NAIROBI

Dear Sir/Madam,

RE:RESEARCH AUTHORIZATION FOR MR.ELIUD G. BARAKA REG. NO. C82/CTY/38618/17

I write to introduce Mr. Baraka who is a Postgraduate Student of this University. He is registered for a Ph.D. degree programme in the **Department of Security, Diplomacy & Peace Studies in the School of Law, Arts & Social Sciences.**

Mr. Baraka intends to conduct research for Ph.D. thesis entitled, **"Securitization of Desert Locust Risk Management and Human Security in Kenya".**

Any assistance given will be highly appreciated.

Yours faithfully,

PROF. ELISHIBA KIMANI
EXECUTIVE DEAN, GRADUATE SCHOOL

HI/cao

Appendix 4: Research license from NACOSTI

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Ref No: **357656**

Date of Issue: **02/March/2023**

RESEARCH LICENSE

This is to Certify that Mr.. Eliud Baraka of Kenyatta University, has been licensed to conduct research as per the provision of the Science, Technology and Innovation Act, 2013 (Rev.2014) in Baringo, Bomet, Elgeyo-Marakwet, Embu, Garissa, Isiolo, Kajiado, Kericho, Kilifi,
Kirinyaga, Kitui, Laikipia, Machakos, Makueni, Mandera, Marsabit, Meru, Muranga,
Nakuru, Nandi, Narok, Nyandarua, Nyeri, Samburu, Taita-Taveta, Tanariver,
Tharaka-Nithi, Turkana, Uasin-Gishu, Wajir, Westpokot on the topic: SECURITIZATION OF DESERT LOCUST RISK MANAGEMENT AND HUMAN SECURITY IN KENYA for the period ending : 02/March/2024.

License No: **NACOSTI/P/23/23983**

357656

Applicant Identification Number

Director General
NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Verification QR Code

NOTE: This is a computer generated License. To verify the authenticity of this document, Scan the QR Code using QR scanner application.

See overleaf for conditions

National Commision for Science, Technology and Innovation -

THE SCIENCE, TECHNOLOGY AND INNOVATION ACT, 2013 (Rev. 2014)
Legal Notice No. 108: The Science, Technology and Innovation (Research Licensing) Regulations, 2014

The National Commission for Science, Technology and Innovation, hereafter referred to as the Commission, was the established under the Science, Technology and Innovation Act 2013 (Revised 2014) herein after referred to as the Act. The objective of the Commission shall be to regulate and assure quality in the science, technology and innovation sector and advise the Government in matters related thereto.

CONDITIONS OF THE RESEARCH LICENSE

1. The License is granted subject to provisions of the Constitution of Kenya, the Science, Technology and Innovation Act, and other relevant laws, policies and regulations. Accordingly, the licensee shall adhere to such procedures, standards, code of ethics and guidelines as may be prescribed by regulations made under the Act, or prescribed by provisions of International treaties of which Kenya is a signatory to
2. The research and its related activities as well as outcomes shall be beneficial to the country and shall not in any way;
   i. Endanger national security
   ii. Adversely affect the lives of Kenyans
   iii. Be in contravention of Kenya's international obligations including Biological Weapons Convention (BWC), Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO), Chemical, Biological, Radiological and Nuclear (CBRN).
   iv. Result in exploitation of intellectual property rights of communities in Kenya
   v. Adversely affect the environment
   vi. Adversely affect the rights of communities
   vii. Endanger public safety and national cohesion
   viii. Plagiarize someone else's work
3. The License is valid for the proposed research, location and specified period.
4. The license any rights thereunder are non-transferable
5. The Commission reserves the right to cancel the research at any time during the research period if in the opinion of the Commission the research is not implemented in conformity with the provisions of the Act or any other written law.
6. The Licensee shall inform the relevant County Director of Education, County Commissioner and County Governor before commencement of the research.
7. Excavation, filming, movement, and collection of specimens are subject to further necessary clearance from relevant Government Agencies.
8. The License does not give authority to transfer research materials.
9. The Commission may monitor and evaluate the licensed research project for the purpose of assessing and evaluating compliance with the conditions of the License.
10. The Licensee shall submit one hard copy, and upload a soft copy of their final report (thesis) onto a platform designated by the Commission within one year of completion of the research.
11. The Commission reserves the right to modify the conditions of the License including cancellation without prior notice.
12. Research, findings and information regarding research systems shall be stored or disseminated, utilized or applied in such a manner as may be prescribed by the Commission from time to time.
13. The Licensee shall disclose to the Commission, the relevant Institutional Scientific and Ethical Review Committee, and the relevant national agencies any inventions and discoveries that are of National strategic importance.
14. The Commission shall have powers to acquire from any person the right in, or to, any scientific innovation, invention or patent of strategic importance to the country.
15. Relevant Institutional Scientific and Ethical Review Committee shall monitor and evaluate the research periodically, and make a report of its findings to the Commission for necessary action.

National Commission for Science, Technology and Innovation(NACOSTI),
Off Waiyaki Way, Upper Kabete,
P. O. Box 30623 - 00100 Nairobi, KENYA
Telephone: 020 4007000, 0713788787, 0735404245
E-mail: dg@nacosti.go.ke
Website: www.nacosti.go.ke

Appendix 5: Letter of research approval from KUERC

KENYATTA UNIVERSITY
CENTRE FOR RESEARCH ETHICS AND SAFETY

Fax: 8711242/8711575 **P. O. Box 43844,**
Email: chairman.kuerc@ku.ac.ke
Nairobi, 00100

Tel: 8710901/12

Website: www.ku.ac.ke

Our Ref: **KU/ERC/APPROVAL/VOL.1** Date: 23rd /03/2023

Eliud Baraka
P.O Box 43844, 00100
Nairobi.

Dear Mr. Baraka,

APPLICATION NUMBER: PKU/2674/I1798 - SECURITIZATION OF DESERT LOCUST RISK MANAGEMENT AND HUMAN SECURITY IN KENYA

This is to inform you that ***KENYATTA UNIVERSITY ETHICS REVIEW COMMITTEE*** has reviewed and approved your above research proposal. Your application approval number is **PKU/2674/I1798.** The approval period is **23rd /03/2023** ***to 23rd /03/2024***

This approval is subject to compliance with the following requirements;

i. Only approved documents including (informed consents, study instruments, MTA) will be used
ii. All changes including (amendments, deviations, and violations) are submitted for review and approval by ***KENYATTA UNIVERSITY ETHICS REVIEW COMMITTEE***
iii. Death and life threatening problems and serious adverse events or unexpected adverse events whether related or unrelated to the study must be reported to ***KENYATTA UNIVERSITY ETHICS REVIEW COMMITTEE*** within 72 hours of notification
iv. Any changes, anticipated or otherwise that may increase the risks or affected safety or welfare of study participants and others or affect the integrity of the research must be reported to ***KENYATTA UNIVERSITY ETHICS REVIEW COMMITTEE*** within 72 hours
v. Clearance for export of biological specimens must be obtained from relevant institutions.
vi. Submission of a request for renewal of approval at least 60 days prior to expiry of the approval period. Attach a comprehensive progress report to support the renewal.

vii. Submission of an executive summary report within 90 days upon completion of the study to ***KENYATTA UNIVERSITY ETHICS REVIEW COMMITTEE***

Prior to commencing your study, you will be expected to obtain a research license from National Commission for Science, Technology and Innovation (NACOSTI) https://research-portal.nacosti.go.ke and also obtain other clearances needed.

To serve you better, researchers are kindly requested to access and complete a customer feedback form and sent it back online as you continue with research and upon completion of data collection found on the following website link; ;(https://docs.google.com/forms/d/1ytWefDwvyz5h1oz_VIn0xbxg3uGdlDzMXFWNDsMrRPQ/edit?usp=sharing

Yours sincerely

KENYATTA UNIVERSITY
OFFICE OF THE CHAIRMAN
23 MAR 2023
ETHICS REVIEW COMMITTEE
P. O. BOX 43844 - 00100 NAIROBI

Prof. Judith Kimiywe

Director: Centre for Research Ethics and Safety