



MINISTRY OF AGRICULTURE AND LIVESTOCK DEVELOPMENT  
STATE DEPARTMENT FOR AGRICULTURE  
PLANT PROTECTION & FOOD SAFETY DIRECTORATE

# **REPORT ON 2019- 2021 DESERT LOCUST INVASION AND MANAGEMENT IN KENYA**





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# Report On 2019-2021 Desert Locust Invasion And Management In Kenya



## FOREWORD



The desert locust is a migratory pest belonging to a group of short-horned grasshopper family Acrididae, uniquely characterized by morphological dimorphism. It is one of the most dangerous migratory pest species due to its ability to reproduce rapidly, migrate long distances with the aid of the wind, and devastate crop and rangeland vegetation in large parts of Africa, the Middle East and Asia. The desert locust (DL) is a global threat to food and nutrition security, and the socio-economic network of over 60 African countries. In the Sahel region in North Africa, it caused crop damage and famine, impacting approximately 8 million households in 2004. In 2019, approximately, 1.5 million hectares in East Africa were affected, risking the livelihoods of 3.3 million farmers. In the Horn of Africa, it affected about 685,000 pastoral and agro-pastoral households in the arid and semi-arid regions.

The DL recess in their solitary form in low numbers scattered throughout the deserts of North Africa, the Middle East, and

Southwest Asia. When heavy rains occur in these areas, locusts multiply rapidly, concentrate and gregarize to form hopper bands and swarms. The locust will migrate to invasion areas in search of more vegetation if not controlled. A single average swarm covering a square kilometre can contain up to 80 million adults, with a single adult consuming green vegetation equivalent to its body weight (two grams) daily. Therefore, a small gregarious swarm can consume approximately 80 metric tonnes of vegetative biomass which is estimated to be sufficient food for about 35,000 people.

In 2019-2021, Kenya experienced three waves of DL invasion in varying magnitudes, which the Ministry of Agriculture and Livestock Development (MoA&LD) in collaboration with sector stakeholders managed to contain through coordination and communication mechanisms that guided harmonisation for efficient and effective management operations. This report presents the post-management assessment carried out within the communities in the affected regions and outlines the impacts of desert locust invasion and management from 2019 – 2021. The lessons learnt and recommendations can be incorporated into the contingency plan for the management of DL. Implementation of recommendations will address DL management gaps to achieve improved farmers' livelihoods and increased food and nutrition security through rapid response, and safe and effective management of DL outbreaks.

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## PREFACE

The 2019-2021 desert locust upsurge affected several countries in the Horn of Africa, and it is the worst that hit Kenya in 70 years, greatly affecting the northern part of the country and spreading across about 28 counties in three waves of varying magnitudes.

The first wave invaded Kenya from Somalia and Ethiopia through Mandera and Wajir on 28th December 2019. The invading swarms later spread to other frontline counties of Isiolo, Garissa and Marsabit. The second wave crossed into the country in mid-December 2020 eventually contained by April 2021, while third wave crossed into the country from Ethiopia across Dawa River in November 2021 and swarmed back to Ethiopia after three days. The invasions affected several households by ravaging vegetation in pastureland, farmlands and protected areas. In response to DL invasion, the Ministry of Agriculture and Livestock Development (MoA&LD) through Plant Protection and Food Safety Directorate (PP&FSD) ; Emergency Locust Response Program (ELRP) enhanced its collaboration with global, regional,

and local partners to institute strategic surveillance and control measures to contain the pest. Eight regional bases were established in the affected Counties with infrastructure and human capacity drawn from different sectors to enhance the DL management operations.

An assessment was carried out across the affected counties to capture the impact of the 2019-2021 DL management exercise at the community level, record lessons learnt and derive recommendations to improve management. The lessons and recommendations in this report will enhance the capacity of State Department of Agriculture in the effective and safe management of DL. Some of the areas that would be enhanced include early detection and preparedness, rapid response, capacity building at national, regional and international cooperation. It will also contribute to the Bottom-up Economic Transformation Agenda (BETA), the vision 2030 and sustainable development goal number 2 (SDG 2), of increasing food and nutritional security and reducing poverty and hunger.



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The development partners included the World Bank through the Emergency Locust Response Program (ELRP), Food and Agriculture Organization (FAO), International Centre for Insect Physiology and Ecology (icipe), and Centre for Agricultural and Biosciences International (CABI). Regional bodies included desert locust Control Organization for Eastern Africa (DLCO-EA), Intergovernmental Authority on Development (IGAD), and International Red Locust Control Organization for Central and Southern Africa (IRLCO-CSA).

The Ministry is indebted to the local public and private collaborators, that included Multi-Institutional Technical Team (MITT), Sector Technical Working Groups (SWAG), Council of Governors (COG), Joint Agriculture Sector Consultation and Cooperation Mechanism (JASCOM), County Governments, Kenya Agricultural and Livestock Research Organization (KALRO), Kenya Plant Health Inspectorate Service (KEPHIS), Pest Control Products Board (PCPB), Kenya Defence Forces (KDF), National Youth Service (NYS), Kenyatta University, University of Nairobi, Agrochemical Association of Kenya (AAK), 51° Limited, Private Sector, Kenya Forestry Service (KFS), LEWA Conservancy, National Drought Management Authority (NDMA), Somali Lifetime Organization (SOLO), farmers and pastoralists among others.

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## LIST OF ABBREVIATIONS AND ACRONYMS

<b>BETA:</b>	Bottom-up Economic Transformation Agenda
<b>CABI:</b>	Centre for Agricultural and Biosciences International
<b>COG:</b>	Council of Governors
<b>CHV:</b>	Community Health Volunteers
<b>DL:</b>	Desert locust
<b>DLCO-EA:</b>	Desert Locust Control Organization for Eastern Africa
<b>EC:</b>	Emulsifiable Concentrate
<b>EHS:</b>	Environmental and Health Safety
<b>ELRP:</b>	Emergency Locust Response Program
<b>FAO</b>	Food and Agricultural Organization
<b>FSNWG:</b>	Food Security and Nutrition Working Group
<b>GIS:</b>	Geographic Information System
<b>GoK</b>	Government of Kenya
<b>icipe:</b>	International Centre for Insect Physiology and Ecology
<b>IFAD:</b>	International Fund for Agricultural Development
<b>IPM:</b>	Integrated Pest Management
<b>IRLCO-CSA:</b>	International Red Locust Control Organization for Central and Southern Africa
<b>IT&amp;FK:</b>	Indigenous Technical and Farmer Knowledge
<b>JASCOM:</b>	Joint Agriculture Sector Consultation and Cooperation Mechanism
<b>KAF:</b>	Kenya Air Force
<b>KALRO:</b>	Kenya Agricultural and Livestock Research Organization
<b>KDF:</b>	Kenya Defence Forces
<b>KFS</b>	Kenya Forestry Services
<b>KEPHIS:</b>	Kenya Plant Health Inspectorate Service
<b>MITT:</b>	Multi-Institutional Technical Team
<b>MoA&amp;LD:</b>	Ministry of Agriculture and Livestock Development
<b>NDLCC :</b>	National Desert Locust Command Centre
<b>NDMA:</b>	National Drought Management authority
<b>NDVI:</b>	Normalised Difference Vegetation Index
<b>NYS:</b>	National Youth Service
<b>PCPB:</b>	Pest Control Products Board
<b>PPPs:</b>	Public-Private Partnerships
<b>RAMSES:</b>	Reconnaissance and Management System of the Environment of Schistocerca
<b>RCMRD:</b>	Regional Centre for Mapping of Resources for Development
<b>SOLO:</b>	Somali Lifetime Organization
<b>SWAG:</b>	Sector Technical Working Groups
<b>ULV:</b>	Ultra Low Volume
<b>UON:</b>	University of Nairobi
<b>VMS:</b>	Vehicle Mounted Sprayers
<b>WHH:</b>	Welthungerhilfe

## TERMINOLOGIES

**Recession.** During recession periods, desert locusts are present at low densities and do not cause significant crop damage. Hopper bands or adult swarms are rare if not absent.

**Outbreak:** An occurrence when locust numbers increase by concentration, multiplication, and gregarization over several months. Outbreaks are localized or restricted to certain habitats, and the early stages of an outbreak are generally unobserved. However, when left unchecked, outbreaks can lead to the formation of bands and swarms.

**Upsurge:** A phenomenon when an initially small population dramatically expands due to successful breeding over multiple generations. With each successive generation, the proportion of locusts in bands or swarms increases until few scattered individuals remain. Several simultaneous outbreaks followed by at least two generations of transient-to-gregarious breeding are likely to lead to an upsurge.

**Plague:** Periods of one or more years with heavy and widespread locust infestations. They occur amid favourable breeding conditions when control operations are unable to stop a series of outbreaks from developing into an unmanageable upsurge. The area in which plagues occur cover approximately 29 million km<sup>2</sup>, nearly twice the size of the recession area.

**Recession area:** The native desert locust habit that occupies Sahel region in the Sahara Desert, Maghreb area in the north of Africa, Arabian Peninsula and Indo-Pakistani countries.

**Migratory/Transboundary pests:** Pests that traverse international boundaries in a short time in search of food and suitable breeding places posing a significant threat to food security, trade, and livelihoods of people in the affected countries, and generate huge losses of crops and pastures. They include locusts, armyworms and the quelea bird. The pests usually concentrate as swarms (locusts), infestations (armyworms) or flocks (quelea birds)

**Solitary phase:** The pest appears in low numbers/densities and behave as individuals. Gregarious phase: The pest form dense and highly mobile bands of larvae/hoppers or adult swarms which behave as an entity.



# 1.0. INTRODUCTION

## 1.1. Background

The desert locust, *Schistocerca gregaria* (Foskar) is a transboundary pest that belongs to a group of short-horned grasshopper family Acrididae comprising 10,000 species naturally occurring in desert environments and shrubby areas. Desert locust is considered to be the most dangerous migratory pest species due to its ability to reproduce rapidly, migrate long distances and devastate vegetation. They attack all crops and rangeland vegetation in large parts of Africa and Asia (Showler and Lecoq, 2021). The damage caused by desert locusts on farms, pastureland and forestry is a threat to national and regional food and nutrition security, and socio-economic systems. It causes damage in over 60 countries in Africa, the Middle East, and Southwest Asia regions that account for approximately 10% of the world's human population.

Desert locusts differ from other grasshoppers because of their ability to change their behaviour, morphology, appearance, and ability to form bands or swarms in response to environmental conditions and widespread green vegetation. They transform from a harmless solitary individuals to destructive gregarious form (Figure 1). They occur within geographically restricted outbreak areas (recession areas) from which swarms escape to breed and initiate plagues in the surrounding invasion areas. Their behaviour and migratory patterns are influenced by weather patterns such as rainfall, temperature, wind direction and speed, edaphic factors and condition of vegetation.



Figure 1: showing the desert locust in solitary and gregarious phases

The desert locusts usually occur as isolated individuals in low numbers scattered throughout the deserts (recession areas) of North Africa, the Middle East, and Southwest Asia. They survive in isolation by seeking shelter on sparse annual vegetation and laying eggs in moist sandy soil after intermittent rains. The recession area covers approximately 16 million km<sup>2</sup> in about 30 countries (FAO, 2015). When heavy rains fall suitable environmental conditions are created in the recession area enabling them to multiply rapidly to increase in number. The rapid increase in numbers on a local scale leads to gregarization. If unchecked, this leads to formation of hopper bands and later, swarms which migrate from recession to the invasion areas. Kenya lies in the invasion area and receives locust swarms in their gregarious phase.

Adult desert locusts are passive fliers that rely on wind direction and speed. They can fly 100-150 km a day at a height of 2,000 m above sea level, invading millions of square km. A single km<sup>2</sup> of desert locust swarm is estimated to contain between 40 to 80 million locusts. A single adult locust is estimated to consume fresh food, equivalent to its body weight (two grams) per day (Dandabathula et al., 2020). It is thus estimated that a single km<sup>2</sup> swarm of about 40 million adult gregarious locusts can consume approximately 80 metric tonnes of vegetative biomass, the vegetation considered sufficient to feed 35,000 people in a day.

## 1.2. Local names of desert locusts in Kenya

Locust is known by several names across different communities in Kenya. The names include Ngige (Aembu), Hanle (Ajuran), Awanes (Borana), Kwethethe (Giriama, Kichonyi), Awanis (Gurreh), Lmaati (Ilchamus, Samburu), Cheprengeny (Kalenjin), Ngie/Kitooli/Kinene (Kamba), Kipererer (Keiyo), Ngigî/Ndaraîki/Itono (Kikuyu), Kipreng'eendet (Kipsigis), Zizinge/Zighe/Chisikeh (Luhya), Ongogo (Luo), Llmaat/Ormaati (Maasai), Ngigi/Ngige (Meru and Tharaka), Chereng'eendet (Nandi), Panzi (Pokomo), Ngiige (Orma), Talam (Pokot), Ayah (Somali), Nzige (Swahili), Zighe (Taita), Talamonik (Tugen), Emase (Turkana), and Chingige (Kisii).

## 1.3 Behaviour and Life cycle of Desert locust

### 1.3.1 Behaviour

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

Unlike other species of locusts, the desert locust portrays polyphenism phase, which is a reaction to population density linked to several transformations in morphological, behavioural, physiological and anatomical traits. When the

numbers are low, the pest is harmless solitary individuals. When the population is high, they are very destructive gregarious swarms. The transition from harmless solitary to gregarious phase starts with an outbreak within a limited area due to a sudden high amount of rainfall leading to increased green vegetation in native habitats, which in turn is conducive for rapid breeding.

### 1.3.2 Life cycle of Desert locust

The desert locust undergoes incomplete metamorphosis with three developmental stages namely the eggs, hoppers/nymphs, and the adult and the duration of the life is about 2-6 months.

#### Eggs

The eggs are laid in pods in the moist sandy soil at a depth of about 10 cm in desert-like conditions. Each egg pod is laid at an interval of 7-10 days. The gregarious females lay 2-3 egg pods, each with about 60-80 eggs while solitary females mostly lay 3-4 pods, each pod contains 100-160 eggs. The rate of egg development is dependent on soil temperature and moisture. At optimum temperatures of 32–35°C, the incubation period takes 10–12 days.

#### Nymph/Hoppers

There are 5 instars in gregarious population and 5-6 instars in solitary individuals. In each instar, there is substantial increase in the size of the nymph and the colour of the solitary hopper is green throughout all instars. However, for the gregarious phase, they have characteristic black and yellow colour. The nymphal stage lasts between 24 and 95 days depending on temperatures. The fifth and sixth instars hoppers moult into fledglings for gregarious and solitary phase, respectively.

## Adult

The fledglings are mature-like desert locust adults that are incapable of full flight which do not moult any further but gradually increase in weight. Their wings gradually become hard and are able to fly. Locusts in this condition are called immature adults. The adults will become sexually mature in 3–4 weeks if conditions are suitable. Young, immature, gregarious adults are pink in colour, while the older ones are dark red or brown. The mature adults become bright yellow. Mature adult locusts live for 3-5 weeks, depending on weather conditions.

Under optimal temperatures of 32–35°C, the locust completes the life cycle in about three months. However, the entire life cycle can last about 3 to 5 months.

## 1.4. Myths and beliefs associated with invasion of Desert Locusts in Kenya

In the 2019-2021 period, the findings of the survey indicated that Kenyan communities hold diverse myths and beliefs about what caused desert locusts invasions. The invasions were associated with a range of myths and beliefs that reflect the communities' deep connection with the land and their reliance on agriculture for sustenance. Some communities perceive the invasion as a forewarning of impending famine, drought, or hunger. Conversely, others believe that desert locusts have the power to halt rainfall, increase the spread of diseases among humans and livestock, and even cause deaths.

Some Kenyan communities associate the presence of desert locust with positive outcomes such as the anticipation of plentiful rainfall, bumper harvests, and abundant food production. These beliefs likely stem from the understanding that locusts can contribute to soil fertility through their droppings and the idea that their presence signifies a cycle of abundance in nature. However, some communities hold mixed beliefs, recognizing that while desert locust invasions may bring temporary benefits, they can also result in subsequent disasters such as crop destruction, death of livestock, disease outbreaks and spread.

Beliefs from the Kamba, Kalenjin and Luo communities often interpret desert locusts as symbols of the end-times or divine punishment. In some communities, locust plagues become historical milestones, with older generations referring to events as "before" or "after" such an occurrence. For instance, phrases like "he was born when the locusts came" are common. In the Kikuyu tradition, ages or age groups are sometimes measured based on significant events like locust invasions, such as "Kyangige" marking years like 1927 and 1932. This underscores the intricate tapestry of myths and beliefs woven around desert locusts in Kenya (Van Huis, 2022).

## 1.5. Genesis and development of 2019-2021 desert locust upsurge

In early 2019, desert locust upsurge developed from breeding areas in the Arabian Peninsula, Southwest Asia, and East Africa particularly in the Horn of Africa. The origin of the upsurge was attributed to two tropical cyclones named Mekunu (May 2018) which passed over the Arabian Peninsula's Empty Quarter and created ideal locust breeding conditions. Cyclone Luban followed in the same region in October 2018 enabling successful breeding late in the year. The induced cyclonic rainfall caused landslides and floods and created desert lakes between the dunes in "Rub al Khali" (Empty Quarter Desert). These exceptional showers created favourable ecological conditions for desert locust breeding, which lasted from June 2018 to March 2019, equivalent to at least three breeding generations. In December 2019, Cyclone Pawan struck Somalia and created a rare late season wet conditions. By the end of the month, swarms had spread westward into Kenya, Djibouti, and Eritrea. Locust swarms continued to form and matured across East Africa. Late March rainfall created favourable conditions that caused further breeding in Ethiopia, Kenya, and Somalia.

The countries that were affected by the 2019-2021 upsurge included Iran, Pakistan, Yemen, Saudi Arabia and Oman in southwest Asia, Ethiopia, Somalia, Sudan, Eritrea and Djibouti in the horn of Africa region. South Sudan, Uganda, Tanzania and Kenya were also affected in the East Africa community region.

Previous desert locust outbreaks in the horn of Africa were observed in the countries along the Red Sea, with infestations primarily concentrated in Saudi Arabia and to a lesser extent in Ethiopia, Egypt, Eritrea, Northern Somalia, Sudan and Yemen. The desert locust invasion in Ethiopia and Somalia was described as the worst in 25 years, whereas Kenya faced its most significant outbreak in 70 years. This was attributed to the favourable conditions of heavy and unusual precipitation, temperature, and vegetation that supported the pest's feeding for survival and development.

**Table 1: Recent infestation of Desert Locust**  
Year(s) Countries/Regions Affected Stage of Infestation

Year(s)	Countries/Regions Affected	Stage of Infestation
1986–1989	Northwest Africa, West Africa, Mediterranean, Near East, Southwest Asia, East Africa	Plague
1992–1994	Red Sea Basin, Southwest Asia, West Africa	Upsurge
1994–1996	West Africa, Red Sea Basin, Southwest Asia	Upsurge
1996–1998	Saudi Arabia, Egypt, Eritrea, Ethiopia, Northern Somalia, Sudan, Yemen	Upsurge
2003–2005	West and Northwest Africa, Sudan, Saudi Arabia, Egypt, etc.	Upsurge
2006	Eritrea, Mauritania, Niger	Outbreak
2007	Yemen, Ethiopia	Outbreak
2008	Western Sahara	Outbreak
2009	Mauritania	Outbreak
2012	Libya, Sudan	Outbreak

Year(s)	Countries/Regions Affected	Stage of Infestation
2013	Eritrea, Northern Somalia, Sudan, Yemen	Outbreak
2014	Sudan, Eritrea (Red Sea coast), Saudi Arabia (Red Sea coast)	Outbreak
2016	Saudi Arabia (Red Sea coast), Yemen, Mauritania, Sudan, Eritrea	Outbreak
2018–2020	Eritrea (Red Sea coasts), Sudan, Ethiopia, Kenya, Yemen, Oman, Saudi Arabia, South Sudan, Uganda, United Arab Emirates, Egypt, Somalia, Iran, India, Pakistan	Outbreak

## 1.6. Desert locust invasion waves in Kenya

Desert locust invasion of 2019-2021 affected many countries in the Greater Horn of Africa. First wave of desert locust swarms of immature and mature locusts first arrived in Kenya through Mandera and Wajir from Ethiopia and Somalia in December 2019. Heavy rains over the preceding short rainy season (October–December) created a conducive environment for locust breeding. The surviving adults matured and bred resulting in the first generation of hoppers in Kenya between February and March 2020. In March, the swarms had reached Kenya's borders with Uganda and Tanzania. In Kenya, the swarms invaded 20 Counties which included Mandera, Wajir, Marsabit, Garissa, Isiolo, Meru, Samburu, Baringo, Kitui, Embu, Laikipia, Machakos, Turkana, Tana River, Tharaka Nithi, Murang'a, Nyandarua, Nakuru, Nyeri and Kirinyaga. Owing to relatively infrequent desert locust invasion over the last 70 years, the country's preferred control strategy remained grounded in

emergency response approaches. To control the spread, there was an intensified ground hopper campaign led by a group of trained National Youth Service servicemen. Though the hopper campaign was relatively successful, surviving hoppers fledged and immature adults in March and April 2020.

Aerial control efforts were up-scaled to control adults from the 1st generation. Despite the control effort, remaining immature adults moved to Marsabit and Turkana where conditions favoured their maturation and breeding. These adults matured and bred in mainly Marsabit and Turkana counties with a few breeding areas sighted in Samburu and Isiolo counties. These resulted in the country's second generation of hoppers in April and May 2020. The ground team intensified the hopper campaign and surviving hoppers that fledged were decimated by a strong aerial team.

Second wave of swarms were preceded by a drift of swarms that came to Kenya before the projected dates. First swarms of this drift came through Mandera on 7th November 2020 and moved southwards to Wajir, Garissa and Kitui counties. These swarms later moved and settled in Taita Taveta, Tana River, Lamu and Kilifi counties where they bred. Hoppers that emerged from the breeding were controlled by mid-February 2021 through ground control operations undertaken by Kenya Defense Forces (KDF) and National Youth Service servicemen (NYS).



Swarms of the second wave arrived in the country on 21st December 2020 through Mandera and Wajir counties and later through Garissa and Marsabit. These swarms moved to the neighbouring counties and by mid-January 2021, they had spread to Isiolo, Samburu, Embu, Meru, Kitui, Machakos and Tana River counties. Desert Locust swarms had spread to 23 counties by the end of March 2021. The affected counties included Mandera, Wajir, Garissa, Tana River, Lamu, Kilifi, Taita Taveta, Kitui, Machakos, Kajiado, Embu, Meru, Tharaka Nithi, Laikipia, Nyandarua, Murang'a, Baringo, Elgeyo Marakwet, Isiolo, Samburu, Marsabit, Nyeri, and Makueni. All second wave DL swarms remained immature until mid-April 2021. The aerial campaign was supplemented by ground control in areas where swarmlets roosted in settled areas.

The third wave comprising a small swarm of mature adults arrived in Rhamu Dimtu, Mandera county on 1st November, 2021, and moved about 100 km west towards Moyale. The swarm is thought to have come from northeast Somalia and migrated south along the Ethiopia/Somalia border during three days of unusually strong and persistent northerly winds as suggested by sightings in eastern Ethiopia and central Somalia as well as by a trajectory model. This wave caused no significant economic damage to crops and pastures. The swarms drifted to Ethiopia due to changes in climatic conditions.



## 2.0. MANAGEMENT OF DESERT LOCUSTS IN KENYA

The 2019-2021 desert locust invasion was the worst in 70 years and it greatly affected northern Kenya. The invasion was a severe food security threat to 3 million people in at least 28 of the 47 counties reported. The national government of Kenya, responded to the pest attack through strategic management measures to contain the resulting adverse effects in collaboration with county governments, and other development partners. The Ministry of Agriculture and Livestock Development through the Plant Protection and Food Safety Directorate (PP&FSD) worked closely with the Food and Agricultural Organization (FAO) and Desert Locust Control Organization (DLCO-Eastern Africa) on both aerial and ground surveillance and control operations in the affected counties.

### 2.1. Campaign organization and coordination

#### a) Establishment of infrastructure and assets

##### i. Establishment of regional bases

A National Desert Locust Command Centre (NDLCC) at the MOA&LD Headquarters Nairobi was established to coordinate local, regional and international operations on desert locust matters. Eight regional temporary bases were established to provide rapid response during the first and second desert locust invasion waves (Table 2, Figure 2). Additional temporary regional bases were established and already established bases either activated or deactivated depending on the magnitude of the invasion.

For example, the Lamu base was established while the Masinga, Mandera, and Marsabit temporary bases were reactivated to coordinate desert locust surveillance and control during the second wave invasion. These regional bases ensured effective management of the current and any possible future desert locust invasions. However, for the Mandera base there were insecurity challenges, political interference and lack of cooperation from the community which hindered surveillance and control efforts.

Table 2. Desert locust regional base locations and regional clusters

S/N	Base Location	Regional clusters
1.	Garissa	Garissa and Tana River
2.	Isiolo	Isiolo, Meru, Samburu, Laikipia and Nakuru
3.	Lamu – Witu	Kilifi, Lamu and Taita Taveta
4.	Mandera	Mandera
5.	Marsabit	Marsabit
6.	Masinga - Machakos	Embu, Tharaka Nithi, Kitui, Makeni, Machakos, Kajiado, Murang'a and Kirinyaga
7.	Turkana - Lodwar	Turkana, Baringo and West Pokot
8.	Wajir	Wajir

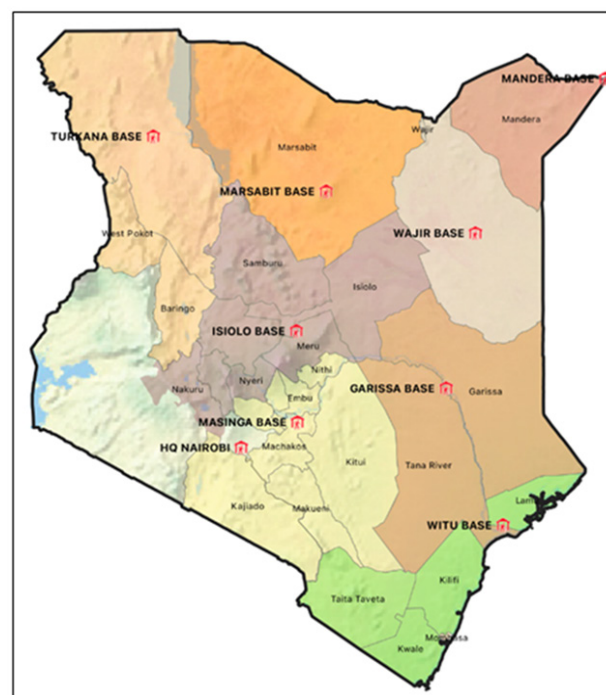


Figure 2. Map of Kenya showing the locations of temporary field control bases  
Source PP&FSD, 2021

## ii. Composition of the regional bases

A regional base consisted of a base manager, junior consultant/liaison officer, Environmental and Health Safety (EHS) officer, nurse, storekeeper, loaders and security personnel who were responsible for the general operations of the base. The operations included communication and coordination with the national command centre, County governments and other bases on DL situation reports, surveillance and control. The EHS officer ensured that the control teams operated in accordance with the established FAO EHS standards. There was a nurse to monitor the pesticide contamination levels in the spray teams and provide any necessary medical assistance.

During the DL campaign, the storekeeper was in charge of records keeping of the pesticides, equipment, requisition and issuance of materials for operations. The loaders assisted with loading and offloading pesticides and equipment. A security guard was present at all times.

### iii. Communication mechanism

The NDLC was set up to ensure effective and efficient coordination and flow of resources and information from all stakeholders. The communication chart is as shown in Figure 3 below.

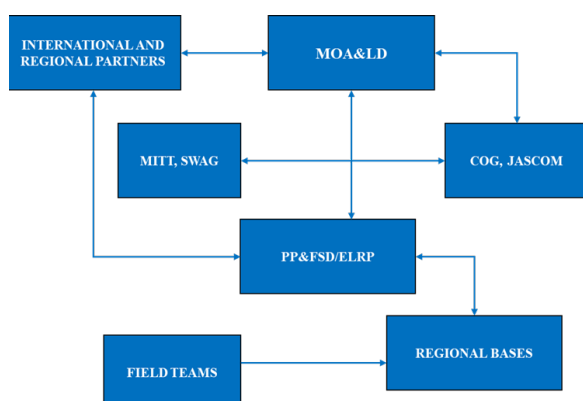


Figure 3. Communication chart during response to the 2019-2021 DL upsurge

The Ministry of Agriculture and Livestock Development in collaboration with stakeholders, conducted surveillance, control and livelihood restoration of persons in the affected areas. The stakeholders included the Multi-Institutional Technical Team (MITT), Sector Technical Working Groups (SWAG), Council of Governors (COG), Joint Agriculture Sector Consultation and Cooperation Mechanism (JASCOM), The public institutions were Kenya Agricultural and Livestock Research Organization (KALRO), Kenya Plant Health Inspectorate Service (KEPHIS), Pest Control Products Board (PCPB), Kenya Air Force (KAF), National Youth Service (NYS), Kenya Forest Service (KFS), Agrochemical association of Kenya, University of Nairobi, Kenya Defence Forces (KDF), National Drought Management

Authority (NDMA). The private agencies included (Somali Lifetime Organization (SOLO), Lewa Conservancy, among others). International organisations included the Desert Locust Control Organization for Eastern Africa (DLCO-EA), International Red Locust Control Organization for Central and Southern Africa (IRLCO-CSA), Food and Agriculture Organization (FAO), International Centre for Insect Physiology and Ecology (ICIPE), Centre for Agricultural and Biosciences International (CABI) among others. Various methods of communication which included regular meetings, e-mail correspondences, telephone, and websites, social media, print media, radio and TV broadcasts were used to sensitize and disseminate information on DL.

### b) Strengthening regional bases

The establishment of regional coordination bases involved cooperation with County governments, agricultural extension officers, and relevant agencies to ensure communication and information sharing. Kenya received technical expertise, financial and human resources from the World Bank, FAO, and the International Fund for Agricultural Development (IFAD) to support the implementation of control measures.

The support included training of personnel, carrying out ground and aerial surveillance, and the use of technology such as satellite imagery Reconnaissance and Management System of the Environment of *Schistocerca* (RAMSES), remote sensing to identify locust breeding grounds, monitor swarm movements, and assess the severity of infestations to enhance preparedness for rapid control. Trainings were conducted to stakeholders such as farmers, communities, Technical staff from the counties and PPF&SD, NYS, KDF and private sector. The participants were trained on likely breeding areas, locust identification, life cycle, reporting mechanisms, monitoring and surveillance techniques, migration patterns and control measures through awareness campaigns and workshops.

Collaborative efforts facilitated the sharing of information, resources, improved regional preparedness and cross-border control operations. This information was shared with County governments, agricultural officers, and other relevant agencies to support evidence-based decision-making, planning, and resource allocation.

### c) Advocacy and coordination of Desert locust activities

The Ministry of Agriculture and Livestock Development through PP&FSD enhanced advocacy and coordination of the desert locust management at national and County levels .

**Inter-agency coordination:** The Directorate led the coordination efforts through MITT to ensure a synchronised response to the locust upsurge among various government departments and agencies at the national level.

**Advocacy for resources:** The Directorate advocated for increased allocation of resources and support from County governments, Non-Governmental Organizations (NGOs), Community Based Organizations (CBOs), Faith Based Organizations (FBOs) for training, surveillance and availing pesticides and equipment for effective control measures and actual control to address the locust invasion.

**Technical support and capacity building:** FAO and DLCO-EA trained the PP&FSD staff on locust surveillance techniques, pest identification, and control strategies.

**Training and awareness campaigns:** The Directorate conducted training sessions and awareness campaigns at the national and County levels to educate farmers, community leaders, residents and relevant stakeholders on the threat posed by locusts, identification, lifecycle, surveillance and appropriate control measures.

**Information sharing and reporting:** The Directorate facilitated information sharing and reporting mechanisms using the KoboCollect platform, RAMSES, Earth Ranger and establishment of regional bases for decision-making and support resource allocation. The National Desert Locust Command Centre (NDLCC), provided regular updates and bulletins about the status of the locust invasion, control efforts, and precautionary measures.

**Monitoring and evaluation:** The Directorate monitored and evaluated the progress of locust control activities through the Emergency Locust Response Program (ELRP) project, effectiveness of desert locust control operations, impact of interventions, and reviewed data on locust infestations. This contributed to adaptive management strategies.

**Policy and strategy development:** The Ministry contributed towards formulation of policies and strategies to address the locust invasion. The Ministry developed a national action plan and frameworks that outlined the strategies, objectives, and activities for locust control and mitigation. In addition, the Ministry developed Migratory & Invasive Pests and Weeds Management Strategy 2022 – 2027 for the stakeholders involved in the response efforts. In addition, the Ministry of Agriculture provided technical guidance and support to other government agencies, extension workers, and stakeholders involved in locust control activities.

## 2.2. Capacity building for desert locust management

A number of persons were trained on DL management. The participants included mastertrainers, young professionals, Training of Trainers (ToTs), journalists, National Youth Servicemen, scouts, drivers, environmental health and safety personnel, and control teams from the different Counties. The National Youth Service servicemen focused on the scouting and control methods using Emulsifiable Concentrate (EC) insecticides and knapsack sprayers (Table 3).

They were trained on the biology, behaviour and ecology of desert locusts, identification, conducting surveillance, survey process, decision-making on survey type and methods, data collection, reporting, control operations, use of appropriate tools for monitoring and reporting.

Table 3. Number of staff trained on the desert locust control

S/N	Groups trained	No.		S/N	Groups trained	No.
1.	Bukura Agricultural College (Tutors)	10		6.	Master trainers	39
2.	National Youth Service supervisors	20		7.	Scouts	696
3.	National Youth Service servicemen	503		8.	Drivers	11
4.	Young professionals	20		9.	Environmental health and safety	25
5.	Journalists	16		10.	Control teams	20

## 2.3. Monitoring and Surveillance Operations Composition of survey teams

### 2.3.1 Continuous monitoring and surveillance

The survey teams included County extension officers, NYS personnel, scouts, local youths, GoK drivers, young professionals, lead farmers, and local administration representatives from the affected counties.

#### Survey tools and process

Accurate and timely field data is essential for monitoring locust infestations and control operations.

The survey of the desert locust was initiated immediately upon their arrival in Kenya in December 2019. However, there were challenges on surveys and reporting from January to March 2020 due to lack of appropriate survey and reporting tools. During this period, the national government and the County administration used mainly virtual meetings to discuss and make decisions due to the Covid-19 restrictions.

In April 2020 the introduction and distribution of eLocust3 and locust tracking apps enabled a total of 150,086 sets of data submissions to be made during the period preceding June 2021.

The apps that were used to relay the information included:

**a. eLocust3:** eLocust3 application is used to record field observations during survey and control operations. It transmits data via satellite in real time to the national desert locust control center (NDLCCs) for planning purposes. Initially, only one tablet was available and this could not cope with the demand to report on locusts spread in the affected countries. FAO established several partnerships to develop a new suite of modern eLocust3 digital tools to facilitate data collection in the field.

**b. eLocust3m:** In early 2020, FAO partnered with Penn State University and Plant Village to develop a simple smartphone application for crowd sourcing and use by those who may be less knowledgeable about locusts for collecting basic data on locust presence and control. In 2021, “pro” option was added so that trained national locust teams could use it during survey and control operations for recording details about the rainfall, ecology, locusts, control and safety. This development and effort led to better planning and implementation of field operations by PP&FSD staff through the bases and allowed FAO’s Desert Locust Information Service (DLIS) to provide more accurate situation assessments and forecasts.

**c. eLocust3g:** FAO DLIS worked with Garmin to customize their handheld In Reach Explorer®+ GPS device for use by teams to collect basic locust and control data. Kenya received 100 units from FAO of which 42 units were activated and used in remote areas since data is transmitted by satellite. It has a tracking feature which was activated during deployment of ground and aerial teams to track their movement.

**d. EarthRanger:** 51 Degrees Limited was contracted as a partner to assist the national authorities and FAO to manage the aerial survey and control operations. The EarthRanger system was customized and adapted for use as a digital control tower to keep track of operations of the aerial assets and to issue their daily tasks. Data collected by the ground teams using eLocust3, eLocust3m and eLocust3g was automatically fed into EarthRanger and the latest information/maps generated for decision making. During the 2019-2021 desert locust campaign, FAO for the first time deployed a digital strategy to make aerial operations more efficient; a strategy which proved to be extremely effective in managing aircraft while reducing the usage of pesticides.

**e. Locust Watch (formerly locust hub):** All frontline countries affected by desert locusts have a centralized NDLCC responsible for monitoring their territory. Kenya had two nationally-designated locust information officers that used a customized Geographic Information System (GIS) developed by FAO for management and analysis of field data and remote sensing imagery. All eLocust3 and EarthRanger data automatically flow into the national GIS, where the officers merged them into a centralized global Locust Data Cube. At FAO headquarters, DLIS combined field data with RAMSES, remote sensing imagery of rainfall, green vegetation, soil moisture, 80-year of historical data, and several models to assess the prevailing situation and forecast its developments. This gives countries updates, alerts and provides monthly bulletins as part of the global desert locust early warning system that FAO has been operating since the 1940s.

### 2.3.2 Capacity building for surveillance teams

The surveillance teams were trained on the following topics;

- a. Desert locust biology and behavior: Ecology, identification, behaviour, life cycle, damage and management strategies. This knowledge helped surveillance teams to understand locust movements, breeding patterns, and preferred habitats.
- b. Training programs: Training sessions were conducted to enhance the skills and knowledge of surveillance teams. These programs covered various aspects of DL identification, field observation techniques, data collection methods, and the use of modern technologies for surveillance, monitoring and reporting.
- c. Data collection and reporting: Standardized protocols for data collection, including population density, stage of development and geographical location.
- d. Use of modern technologies: This involved the use of satellite imagery, eLocust series, RAMSES, remote sensing GIS for monitoring locust movements and identifying potential breeding areas.
- e. Continuous learning and feedback mechanisms: Regular evaluation and performance assessments were implemented to identify areas for further training and development.
- f. Coordination and communication: Strategies for effective communication among surveillance teams, government agencies, and other stakeholders, information sharing systems and communication channels during locust emergencies.

### 2.3.3 Use of indigenous knowledge on Desert Locusts

After the 2019-2021 desert locust invasion, a survey was carried out in the affected areas on the indigenous knowledge the communities relied on for surveillance, monitoring and management. The respondents shared the traditional knowledge, which underscores the need for early warning systems that integrate both traditional and scientific knowledge on desert locusts for effective management of future invasions. This included the following:

#### **Traditional and natural phenomena for likelihood of DL invasion**

The communities relied on their wealth of knowledge and experience in predicting natural disasters, including desert locust invasions. Such natural phenomena include studying stars, examining contents of animal intestines, erratic rainfall and migration of certain species of birds. With these observations, the communities could prepare and take necessary measures to mitigate the impact of locust invasions on their livelihoods. While modern methods have replaced some traditional practices, the insights gained from these observations remain valuable even today. Examples of traditional and natural phenomena relied on to predict DL included:

- a. Presence of specific bird species  
The presence of certain bird species, such as the Red-billed Quelea or the Yellow-billed Kite, in large numbers or displaying unusual behavior was considered a potential sign of an impending DL invasion.
- b. Presence of butterflies and other insects  
The mass movement of butterflies and the presence of specific insects along rivers, especially early in the morning, were considered signs of changing weather, which could bring favourable conditions for pests, including desert locust invasion.

- c. Abnormal winds  
Strong winds blowing in a specific direction, against the prevailing wind patterns, could be a signal of impending pests outbreaks including desert locusts.
- d. Emergence of green vegetation  
The sudden appearance of green vegetation and the presence of large groups of clustered grasshoppers were considered potential indicators of an impending desert locust invasion. These phenomena suggested favourable conditions for locust breeding and population growth.
- e. Aggregation of tree locusts or hoppers  
The clustering and aggregation of tree locusts or hoppers were observed as potential indicators of a desert locust invasion. These aggregations suggested the presence of immature locust populations or ideal breeding conditions for desert locusts.

### **Community initiatives used to communicate impending threats of pests**

The communities used several traditional initiatives to communicate alerts on impending threats, invasions, or outbreaks of desert locusts or other serious pests. These methods included smoke signals, messengers and word of mouth, council of elders meetings, village barazas and gatherings.

These traditional methods were effective in disseminating alerts to the community, enabling them to take necessary precautions and protect themselves from the impending danger. This ensured that the community was well-informed and could respond appropriately.

### **2.3.4 Current means of communicating pest epidemics**

Today modern technologies are being used for communication among countries and communities to enhance effective surveillance, early warning systems, reporting and control of desert locusts. These technologies provide valuable information about locust breeding areas, swarm movements and ecological conditions that support their growth. At present the community's best, most rapid, effective, and efficient method of disseminating information on locust invasions includes:

- i. Community or public meetings.: These forums provide a platform for community members to discuss and disseminate information about locust invasions, enabling immediate feedback and interaction.
- ii. Local media platforms: Local radio stations and TV stations play a crucial role in disseminating information about locust invasions. They have wide coverage and can quickly reach a large audience, providing real-time updates and instructions during such events.
- iii. Mobile phones and SMS: Mobile phones and Short Message Service (SMS) are widely used to disseminate information about locust invasions. Emergency alerts and updates can be sent directly to individuals, facilitating rapid distribution of crucial information.
- iv. Social media platforms: Platforms like WhatsApp, Facebook, X, and Instagram among others are increasingly used to disseminate information about locust invasions. These platforms allow for rapid sharing of updates and instructions to a large audience and encourage community members to share information.
- v. Community Health Volunteers (CHVs): Trained CHVs are valuable resources for disseminating information about locust

invasions, in rural areas, they can provide community members with details on impending invasions and offer guidance on appropriate response measures.

- vi. Public administration and community leaders: Village elders, chiefs, and other community leaders play a vital role in disseminating information about locust invasions. They have established relationships with community members and can provide accurate and timely updates on the situation.
- vii. Community groups and service providers: Self-help groups, extension officers, and other service providers have connections with the community and can assist in disseminating information about locust invasions. They can leverage their relationships to effectively communicate the necessary information and facilitate response efforts.

It is worth noting that a combination of these methods ensured rapid, effective, and efficient information dissemination on locust invasions.

## 2.4. Control operations

Control of the ravaging waves of desert locust invasions was successful through multi-institutional efforts. Different management approaches were deployed by the diverse players. There were several factors that influenced the choice of control method. Such factors that informed the methods of control used during the 2019-2021 upsurge included;

- a. Size of infestation. Smaller populations of desert locust required less resources and such were for instance controlled using hand-held and knapsack sprayers. When the infestations were high, more resources and different methods were deployed such as motorized, vehicle mounted sprayers and spray aircraft.

- b. Stage of growth of desert locust. The life stage of the desert locusts was considered in the choice of management methods to prevent locusts from migrating to other areas or reproducing. For instance, for hoppers rapid ground controls were used while the immature adults, which are the most destructive stage and mobile, require urgent control. Further, the adults which had reached sexual maturity had to be controlled to prevent them from reproducing.
- c. Location/site. Control strategies in most of the infested areas followed the general principles. However, where the hopper bands or adult swarms were close to special areas (built-up environments, water bodies, ecologically sensitive and protected areas), a suitable method in consultation with relevant authorities and communities, would be agreed upon for the benefit of both the environment and the ecological community. For example, biological control methods were used in protected and ecologically sensitive areas.
- d. Accessibility to infested areas. In situations where the infested areas were not accessible due to rugged terrain and insecurity, special methods and equipment were applied such as aerial spray.
- e. Availability of resources: Depending on the available options for control of the infested areas, a suitable or near optimal method or equipment was deployed.

### 2.4.1. Ground and aerial control operations

The government implemented interventions during the desert locust upsurge, employing a range of control equipment and products to combat the infestation. Both ground and aerial control operations were used in the control of the desert locust. Aerial spray equipment was very useful in the control operations. Aircraft equipped with specialized spray systems were deployed to target locust swarms in vast areas. Ground equipment, including Vehicle Mounted Sprayers (VMS), Ultra-Low Volume (ULV) sprayers, and handheld sprayers, were used for more localized and precise control measures. The pesticides were applied in varied formulations, such as emulsifiable concentrates (EC), ULV formulations, and Biopesticides. The spray teams calibrated the equipment to ensure accurate application of the appropriate volumes. These interventions helped mitigate the effects of the desert locust upsurge on agricultural areas and rangelands.

#### Aerial equipment used

The Government of Kenya (GoK), Food and Agriculture Organization of the United Nations (FAO), Desert Locust Control Organization of East Africa (DLCO-EA) and International Red Locust Control Organisation for Southern Africa provided aircraft for aerial surveillance and control as follows.

Table 4: Number and type of aircraft used in the control of desert locust

SR NO	Type of Aircraft	Organization	Quantity
1	Fixed wing	FAO	3
2	Fixed wing	DLCO-EA	2
3	Fixed wing	GoK (KFS, KWS & KDF)	3
4	Fixed wing	Lewa Conservancy	1
5	Rotary wing/ Helicopter	IRLCO-CSA	1
6	Rotary wing/ Helicopter	FAO	3
7	Rotary wing/ Helicopter	GoK (KDF)	1

#### Ground equipment used

Ground control equipment was deployed to various bases to support DL management in affected counties. They included 102 Motorized sprayers, 9 Vehicle Mounted sprayers (VMS) distributed in the bases as follows (Marsabit 2; Isiolo 2; Masinga 2; Wajir 1; Garissa 1; Witu 1), 6 KDF land rovers mounted with sprayers (2 at Witu Base and 4 at Garissa Base), 200 Handheld ULV sprayers, About 1,100 Knapsack sprayers, 200 Camping tents donated by the FAO and One (1) drum crusher.

## Control products and volumes used

The MoA&LD in collaboration with the FAO and other stakeholders carried out control operations to manage the DL invasions between 2019 and 2021. To contain the situation, coordination, planning, purchase and delivery of pesticides to the affected counties were executed. In addition, the ministry strategically established eight control bases in Wajir, Isiolo, Turkana, Marsabit, Lamu, Mandera, Masinga, and Garissa and deployed resources to the affected areas in order to coordinate ground and aerial control operations.

During the DL control campaign, the government in collaboration with FAO treated 211,549 ha of locust infested areas all over the country using approximately 357,266 litres of pesticide. FAO and the Government of Kenya (GoK) supplied 198,600 and 158,666 litres of conventional pesticides, respectively. FAO also supplied 400 Kgs of bio-pesticides.

### 2.4.2. Indigenous methods used to combat desert locusts

The battle against the desert locust invasion that occurred in 2019-2021 was an unprecedented challenge in Kenya. This necessitated the affected communities to use various indigenous methods in an attempt to control the DL. Communities have since time immemorial employed such methods against the pest. Some of the various methods used included;

#### a. Scaring technique

Communities deployed the scaring technique through lighting fire using different products such as tyres, old beddings/clothes, twigs mixed with pepper, cowdung, among others to produce smoke and smell as a repellent. Others used loud noise/sound like blowing whistles, shouting, beating drums/metallic objects, hooting, blowing of animal horns, clapping, waving tree twigs to ward off the pest.

#### b. Cultural and physical methods

This involved the use of methods to either repel or kill the DL. They included lighting up bonfires, harvesting unsprayed DL for consumption or killing hoppers and mature adults through beating with twigs

#### c. Botanicals, oils and animal products

In some instances, the communities prepared some plant extracts and animal products for spraying DL as a quick measure of managing their populations. Some of the plants used included the Mexican marigold, neem, pepper/chilli, Acacia senegal, tithonia, golol tree, tobacco, aloe vera, and gamble tree resin extracts. Animal waste such as urine and cow dung were used while others spread/spilled old engine oil on the ground to repel DL.

However, these traditional methods employed were short-term and less effective in the management of large swarms. Some had negative impacts on the non-target organisms and caused environment pollution.

### 2.4.3. Integration of traditional and conventional methods

As part of Integrated Pest Management (IPM) strategies, the communities used physical, cultural, chemical and biological in the control of desert locusts (Figure 4). Integrated Pest Management was adopted since it is an effective and environmentally sensitive approach to pest management. Although chemical control is considered as the last resort, and the most effective in managing most pests under IPM, for migratory pest outbreaks like DL chemical control is the best option to bring down upsurges since they have an instant knockdown effect. However, this method has negative effects on the environment, animal and human health resulting in social, economic, environmental and technical dimensions that need a proper and holistic approach.

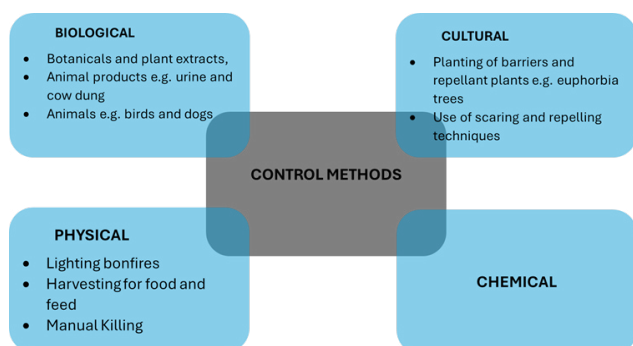


Figure 4. Classification of desert locust control methods

#### 2.4.4. Challenges experienced during control operations and the proposed mitigation measures

The country experienced a number of challenges that hindered effective control efforts in some cases. To address these challenges, the proposed mitigation measures should be considered as detailed below (Table 5).

Table 5. Challenges experienced during the 2019-2021 outbreak and proposed interventions  
Challenges Interventions

Challenges	Interventions
Rough terrain	· Use alternative monitoring, spraying modalities and emerging technologies (satellites and drones) are readily availed
Poor road networks	· Increase and improve road network coverage in the country
Insecurity	· Invest in new and emerging technologies like the use of Unmanned Aerial Vehicles (drones) for surveys, monitoring and control operations
Lack of preparedness	· Invest in Early Warning Systems (EWS) to predict future outbreaks · The need to constantly engage regional and international DL forecasting bodies on shared forecasts · Early preparations when the locust's outbreak is imminent · Continuous training of DL management
Poor network connectivity	· Improve the mobile networks by partnering with telecommunication companies
Poor and inadequate coordination	· Establish coordination mechanisms at all levels · Involvement of all relevant stakeholders in the DL campaign
Inadequate knowledge	· Continued awareness creation · information dissemination · Regular training
Ecologically sensitive areas	· Creating awareness among all relevant stakeholders · Consultation with relevant institutions · Sensitize the communities on the side effects of chemicals
Poor inter-county communication and coordination	· Establish Inter County coordination mechanisms to enable monitoring · Establish a strategic communication mechanism and reporting
Lack of community support	· Sensitizing communities on the dangers and the need for DL control · Creating awareness and capacity building in the communities · Demystification of the traditional misconceptions
Inadequate control equipment & control products	· Timely procurement, supply and distribution of adequate equipment and pest control products on a need basis

Challenges	Interventions
Deployment of management teams	· Preparedness and contingency planning at the County and community level
Inadequate Human resources	· Capacity building · Deployment of the trained personnel to the threatened Counties · Focus based financing approach at all levels · Scheduled periodic simulation drills · Establish and adequately equip a coordination Desk
Inadequate financial resources	· County and national government to budget for an emergency kitty for migratory pests · Purposeful allocation of resources to enable timely preparations and control operations
Poor livelihood restoration mechanisms	· Create a better compensation mechanism to the affected communities
Sexual harassment	· Establish grievance reporting and resolution mechanisms · Awareness creation on Gender Based Violence
Political interference	· Advocating for political goodwill

### 2.4.5. Country perspectives on upscaling best practices based on lessons from the 2019-2021 desert locust control operations

Effective pest control operations rely on a combination of robust strategies and best practices that are constantly refined through experience and evaluation. Some of the views of communities and counties offer valuable insights into the measures that were most effective in mitigating the spread of the pest include;

- i. Application of different approaches in DL management, including indigenous methods
- ii. Continuous training of surveillance, monitoring and control teams on DL management to avail adequate and knowledgeable manpower for DL crisis management
- iii. Community sensitization on the economic and psychosocial implications of migratory and invasive pests, and pre and post-spray action points
- iv. Diversification of resilient value chains for the community
- v. Establishment of effective communication and coordination channels across all relevant stakeholders.
- vi. Establishment of emergency funds for rapid response to invasions
- vii. Enhancement of ground and aerial control mechanisms
- viii. Involvement of technical staff, disciplined forces (KDF, Police, KFS, NNYS), communities and stakeholders in pest management programs
- ix. Multi-sectoral approaches through public-private partnerships (PPPs)
- x. Preparedness and rapid response by involved stakeholders
- xi. Sensitization on modern and conventional methods for detection, early warning and control
- xii. Support of affected communities in livelihood rehabilitation and restoration
- xiii. Timely reporting of pest incidences for effective planning and deployment of management measures
- xiv. Timely procurement of appropriate and recommended DL management equipment
- xv. Utilization of unsprayed DL for food and feeds

## 3.0. ENVIRONMENTAL, HEALTH AND SAFETY (EHS)

### 3.1 Introduction

Due to high use of synthetic pesticides, the desert locust control operations are likely to have high impact on the environment and unavoidably direct and indirect impact on biodiversity. There is also a likelihood of additional impacts on human health, especially those living in environments where the control exercise was done. This chapter seeks to review the EHS considerations done during campaign planning, control operations and post control operations to minimise the anticipated environmental, health and safety risks. In addition the EHS experienced challenges will be discussed and relevant corrective actions taken.

### 3.2 Environmental Health and Safety Guidelines (EHSG) used during the Campaign

Kenya did not have specific environmental health and safety guidelines at the time of infestation and therefore the FAO Desert Locust Guidelines (DLG) number six on Safety and Environmental Precautions of 2003 were used as the reference for all EHS considerations during the campaign. The guidelines provided insight on two broad thematic areas. One, the reduction of environmental and human health risks associated with use of insecticides during locust control. Practical recommendations were given on how to address the risk reduction during the campaign preparation phase, how to implement it during control operations, and how to evaluate it in the post campaign follow up.

Two, the guidelines provided for environmental and human health monitoring during the control operations. such information was essential for improving control techniques by minimising the anticipated EHS risks.

Key aspects of the DLG6 on Safety and Environmental Precautions have been summarised as below:

- Considerations for choice of control strategy and methods
- Considerations for choice of insecticide
- Considerations for choice of equipment
- Procedures for procurement
- Training of control staff
- Organisation and training of public health staff
- Waiting periods
- Monitoring of treatments
- Efficacy assessment
- Monitoring of human health
- Environmental Monitoring
- Management of empty insecticide containers
- Management of left over insecticides
- External audit of the EHS

### 3.3 EHS Challenges During the Campaign period

Several mitigation measures were put in place to significantly minimise EHS risks during the control operations. Despite the mitigation measures, few environmental challenges that were noted and discussed below:

- a. Presence of dead insects water bodies  
Dead locusts were reported in or near water bodies in Kipsing Village (Isiolo) and Maikona area (Marsabit). Upon investigation, it was established that swarms were treated with Deltamethrin ULV product more than 20 km away. Deltamethrin ULV is known to trigger knock-down but allows insects to recover but with cessation in feeding. The reported locusts died of exhaustion in or near water bodies during the first swarming after recovery, contaminating the water bodies on their way.
- b. Impact on livestock and wild animals  
Cases of abortions of goats and sheep were reported by several farmers during post control interviews done by ELRP in 12 counties. These cases could not be verified as they were not reported to the relevant authorities nor PP&FSD during control operations for investigation. Similar feedback on increased abortion was given by KWS officials in Isiolo County that noted increased abortions of zebra and gazelles after the control activities. Unfortunately, these cases were not reported immediately for further investigations.
- c. During interviews with farmers in some counties, reports of poultry deaths were made. These cases were not investigated further as reports were made long after the control exercise. The failure to report these cases points out to gaps in awareness creation on what farmers should do in case of contamination during the control exercise.
- d. Death of non target organism  
Farmers from various counties where control took place reported cases of migration of bees signified by the number of empty hives. There were no further investigations on these cases as they were not reported on time and therefore can not be attributed directly to the control operation.
- e. Spillage  
While spill management and containment was well managed in most places, there was accidental spillage of pesticides notably in Kitui county and Samburu County, Lkujita village.
- f. In most of the stores there were cases of spillages that were contained by using provided spill kits. The major challenge of spillage was noted in the Kabete store resulting from remnant pesticides that were received from the field for disposal. Few key operational gaps were identified at this:
  - Lack of enough storage of remnant pesticide and empty pesticide containers awaiting disposal
  - Mishandling of the pesticide drums during loading and unloading at the store leading to leakages
- g. Management of empty pesticide containers  
Waste management during the control operations and post control operations was well managed except for few cases of pilferage that were reported where communities store the empty pesticide containers for domestic use. In Wajir an isolated case of burning of pesticide containers was reported. This pointed to inadequate awareness creation especially during the first wave.

- h. Political interference  
Interference of control exercise by politicians was witnessed in several counties and this predisposed the community, control teams and environment to various EHS risks. These cases were noted in Counties such as Samburu Lkujietia area where control sanctioned by a politician was done by the community members without PPEs and using a ULV product in a knapsack.
- i. Failure to withdraw from control areas  
During control activities communication was passed to the people living near or within the controlled areas. In some cases due to excitement or panic, communities failed to withdraw and ended up being contaminated.
- j. Inefficient use of PPEs  
In the early stages of the control exercise there were cases of inappropriate use of PPEs. This changed after awareness creation through capacity building and as the control teams gained more experience.
- k. Poor Handling of expired / obsolete pesticide and empty containers  
Due to the volumes of pesticides used in the control exercise, equally large volumes of pesticides waste containers were generated. All waste was supposed to be brought back to the Kabete main store for temporary storage and eventual disposal. The volumes of wastes received from the counties needed a larger storage area than currently available at Kabete store. This led to storage of pesticides in the open area outside the store, either uncovered or just shaded by a canvas leading to rusting and spillage.
- l. Insufficient Record Keeping on donations and generated wastes  
Records on surveillance, control activities were kept but records on donations and tracking wastes generated till disposal were not kept.
- m. Inefficient management of pesticide donations  
The process of procurement of pesticides for use by PP&FSD was done based on a plan and technical advice from the MITT team and FAO. On the contrary pesticide donations were not accepted based on any laid down procedure or guideline. This led to acceptance of pesticides far beyond the volumes required for control. While this posed huge pressure to the handling and storage facilities in the country, a huge percentage of the product ended up expiring before use.
- n. Managing expired and obsolete pesticide  
There is no clear guidance on how the huge volumes of expired pesticides should be handled. However, FAO recommends that where country regulation allows, products that have stayed beyond shelf life can be tested and shelf life extended for two if the product is found to be active. Unfortunately, PCPB recommends disposal of pesticides once they stay beyond shelf life and testing and extension is not supported by the Kenyan laws.
- o. Supervision of control activities  
Supervision of control activities in the country was done by PP&FSD with support from the FAO. Due to security issues in north eastern parts of Kenya, supervision of control activities was done by the Military. While the Military teams were trained on control operations, security challenges made it difficult to monitor the EHS compliances.

### 3.4 Lessons learnt during the control exercise

1. Develop and action plan to guide renovation of Kabete store structure to ensure that the facility meets all the EHS requirements for a pesticide store
2. Develop EHS standard operating procedures to guide various key EHS processes such a OHS, Waste management among others
3. Continuous training and capacity building of both the technical team and communities
4. Develop a guideline on receipt of pesticide donations

### 3.5 Environmental and health risk reduction and mitigation measures

Although desert locust control operations were challenging and demanding, the control teams adhered to the environmental, health, and safety (EHS) protocols to mitigate potential risks to ecosystems and human well-being. Before initiating any control measures, reconnaissance/risk assessments were conducted to identify, evaluate, and mitigate potential hazards associated with the choice of pesticide, Personal Protective Equipment (PPEs), equipment, sensitization, application method, and time.

Careful consideration was given to pesticide selection, prioritizing products with proven efficacy against desert locusts while minimizing adverse effects on non-target organisms and ecosystems. Sufficient precautions were taken on settled and ecologically sensitive areas where the recommended re-entry period was advised and biopesticides were applied. Furthermore, precise application techniques were employed to minimize pesticide drift and contamination, utilizing specialized equipment such as ultra-low volume (ULV) sprayers to ensure accurate and targeted application.

Several measures were implemented to safeguard the well-being of personnel involved in desert locust control operations. This included training on proper pesticide handling, safety protocols, environmental stewardship, and the provision of appropriate Personal Protective Equipment (PPEs). Environmental audits and continuous field visits were undertaken during exercise, to conform with the regulations, assess effectiveness and detect any adverse environmental and health impacts. This proactive approach enabled swift response and adaptation to challenges, ensuring that control operations remained aligned with EHS protocols and safeguards.

The Government of Kenya minimized the following impacts that may have been experienced on the environment, human, livestock and the control team. These impacts are;

- Loss of diversity - non-targeted organisms such as the beneficial insects, pollinators such as bees and butterflies
- Pollution - air, water, soils
- Human health - pesticide exposure during spraying, handling or any spillage
- Livestock - from feeding on sprayed pastures or pesticide exposure
- Water contamination
- Pesticide residue exposure
- Spray team exposure
- Spray drift and environmental residuals.

### 3.6. Environmental and social audits

Various organizations conducted environmental and social audits with varied findings to assess the impacts resulting from the control operations. These activities included field studies, data collection, community participatory meetings and analysis to comprehensively evaluate the effects on the environment and natural resources at the spray areas. The audits were done by FAO and ELRP. The FAO audit was done immediately after the control operation and corrective action plan developed to close the identified NCRs. The ELRP audit was conducted two years later to evaluate the residual impacts and propose a better way of working.

### 3.7 Guidelines on pesticide use and safety

The guidelines listed below were adhered to during the Desert Locust control operation <https://www.fao.org/3/ca4029en/ca4029en.pdf>, to reduce the risks.

- i. Undertake health assessment of the control team and the proper use of Test Mate ChE and Acetylcholinesterase Assay Kits for pesticide exposure monitoring before and after control operations.
- ii. Wear appropriate protective clothing (cap, goggles, mask, gloves, overalls, and boots) at all steps when handling, mixing, and applying pesticides.
- iii. Always read and follow the instructions on the label
- iv. Use clean, well-calibrated pumps (in good condition) and clean water (where applicable) for mixing the pesticides.
- v. Use the correct quantity/dose during mixing (always follow the instructions on the label)
- vi. Always mix pesticides in an open place to avoid accumulation of pesticide fumes
- vii. Have plenty of clean water and soap at the application site for emergency cleaning
- viii. Mix pesticides using a long stick or stirrer and not bare hands
- ix. Do not spray during windy conditions e.g spraying against wind or when it's about to rain
- x. Do not eat, smoke, drink or breastfeed during the application
- xi. Elderly persons, children, pregnant women and the sick should not apply pesticides
- xii. Mix only the required amount of chemicals to be used
- xiii. Gloves should be removed last when taking off the protective gear
- xiv. Do not leave empty pesticide containers in the field to avoid contamination of the environment
- xv. Do not reuse empty pesticide containers
- xvi. Do not burn pesticide containers because they may give off poisonous gasses.

## 4.0 Livelihood restoration and recovery programs

Over 20.2 million people were facing acute food insecurity due to desert locust invasion in Kenya, Tanzania, Djibouti, Ethiopia, South Sudan, Somalia, Uganda, and Eritrea between January – December 2020 (FAO, 2020). In addition, approximately 1 million Ha of land was affected and hence at least US\$ 138 million was needed for rapid livelihood protection targeting at least 110,000 households.

In Kenya, the Integrated Phase Classification (IPC) maps estimated that more than 1 million people were in a food security crisis especially in arid and semi arid lands (ASALs) counties of Mandera, Wajir, Garissa Marsabit, Isiolo, Laikipia, Samburu, and Turkana (Cosgrove, 2020). In April 2021, the Government of Kenya announced that 1.4 million Kenyans risked starvation, hunger, and acute food insecurity with close to a million people in need of humanitarian food assistance (MoA&LD, 2021).

As a result, the National government through the Ministry of Agriculture and Livestock Development, County Governments, NGOs, and other stakeholders initiated restoration and recovery programmes to safeguard and improve the livelihoods of affected pastoralists and agro-pastoralists during the desert locust invasion. This involved the provision of animal feeds, water, livestock health and nutrition support. Financial assistance and livelihood restoration programs provided support to the affected households, aiding in livelihood recovery. The ministry provided agricultural inputs to facilitate rehabilitation of farms and grazing lands.

Further, the ministry provided cash transfers to some farmers who had suffered significant crop losses due to the desert locust invasions. The financial assistance helped them purchase seeds, restock their livestock and meet their immediate household needs.

Some local NGOs in collaboration with community leaders and business communities raised funds to support the affected families. The proceeds were used to provide emergency relief supplies and financial support for rebuilding livelihoods.

In some pastoralist communities such as Borana, elders reinstated the Dedha grazing system, a traditional practice of rotational grazing management. The system prevented overgrazing and ensured sustainable use of pastureland.

Some farmers diversified crops by planting root crops like cassava, yams, and arrow roots alongside staple grains. In addition, the agro-pastoralists focused on cultivation of leafy vegetables and staple crops, pasture to promote conservation agriculture practices and livelihood diversification such as in Wajir. This diversification enhanced food security and reduced vulnerability of agricultural systems to future pest outbreaks.

Additionally, the Ministry of Agriculture collaborated with national and international agencies in pooling resources, expertise, and technical assistance for overall management and restoration of livelihoods (Table 6).

Table 6: Organizations and the type of support provided

Organization	Support Provided
Plant Protection and Food Safety Directorate (PP&FSD)	<ul style="list-style-type: none"> <li>· Pest control products and equipment</li> <li>· Personal Protective Equipment (PPEs)</li> <li>· Capacity building for DL control</li> </ul>
Food and Agriculture Organization (FAO)	<ul style="list-style-type: none"> <li>· Capacity building for DL control</li> <li>· Livelihood support for 16,300 households</li> <li>· Distribution of relief seeds, fertilizer, livestock feed, and veterinary drugs</li> <li>· Cash transfers</li> <li>· Provision of masks and hand-washing equipment for COVID-19 prevention</li> </ul>
Emergency Locust Response Program (ELRP)	<p>The project supported Livelihood restoration and recovery by provision of resources through micro-projects and sub-projects to communities. Some of the support included:</p> <ul style="list-style-type: none"> <li>· Fodder planting material</li> <li>· Relief seeds</li> <li>· Animal feed and feed conservation materials</li> <li>· Sustainable land management (SLM) approaches</li> <li>· Capacity building for DL control</li> </ul>

Organization	Support Provided
Somali Lifeline Organization (SOLO)	<ul style="list-style-type: none"> <li>· Relief seeds</li> <li>· Capacity building for DL control</li> </ul>
CARITAS	<ul style="list-style-type: none"> <li>· Relief seeds</li> <li>· Distribution of vegetable and legume seeds and fertilizer</li> </ul>
County Governments (COGs)	<ul style="list-style-type: none"> <li>· Extension staff for scouting and DL control</li> <li>· Fuel and vehicle support</li> <li>· Community support</li> <li>· Water for livestock</li> </ul>
Wealthungerhlife (WHH)	<ul style="list-style-type: none"> <li>· Donation of maize and bean seeds</li> <li>· Assorted farm tools</li> </ul>
Dupoto-e-maa (Olkejuado Pastoralists Development Org.)	<ul style="list-style-type: none"> <li>· Training on land rehabilitation</li> <li>· Donation of maize, bean and pasture seeds</li> </ul>
Neighbors Initiative Alliance (NIA)	<ul style="list-style-type: none"> <li>· Donation of assorted seeds</li> </ul>
Participatory Ecological Land Use Management (PELUM) Kenya	<ul style="list-style-type: none"> <li>· Training program on DL control</li> </ul>
National Youth Service (NYS)	<ul style="list-style-type: none"> <li>· Manpower (spray teams)</li> </ul>
Ministry of Interior and National Administration	<ul style="list-style-type: none"> <li>· Coordination of DL control efforts</li> <li>· Provision of security</li> </ul>

## 5.0. LESSONS LEARNT FROM DESERT LOCUST OPERATIONS AND RECOMMENDATIONS

The desert locust management operations served as a pivotal learning experience. Lessons were drawn from early detection, rapid response, control, community engagement, collaboration, capacity building, technological innovations, documentation and strategy development. From the lessons learned, national, County governments and other stakeholders can equip themselves better to face future challenges, ensuring more resilient and sustainable management of desert locust outbreaks. Some of the key lessons learned and recommendations include:

1. Early warning, forecasting, detection, monitoring, surveillance and rapid response are crucial in controlling desert locust invasion. It is important to establish and enhance robust mechanisms integrating indigenous with modern knowledge to enhance effective DL control. Social media platforms can be used to promptly sensitize and report desert locust occurrences.
2. Effective response to desert locust outbreaks required coordination, information sharing, resource mobilization and collaboration among the stakeholders to strengthen partnerships. These included research institutions, NGOs, regional and international bodies among others.
3. Engaging local communities through public awareness campaigns, training programs, information dissemination helped mobilize community participation and contributed to the success of DL control operations. There is a need for further engagement with the local communities and empowering them with knowledge and skills to monitor and control desert locusts.
4. The skilled personnel in desert locust management significantly contributed to the containment of DL. There is a need to conduct continuous training of personnel on biology, ecology, Identification, monitoring, surveillance and control.
5. The NDLCC was important in streamlining the management, resource mobilization and coordinating information flow on DL. The establishment of the call centre was essential in communication DL information and response mechanisms. Regular drills and simulations of locust outbreaks should be carried out to test preparedness and response capabilities.

6. Strategic interventions implemented by the government to employ a range of control equipment and products, and infrastructure helped combat the infestation. Establishing base stations, communication devices such as phones, laptops and cameras and social media platforms, research centers, and storage facilities for equipment and supplies. Additionally, deploying sprayers, pesticides, PPE and vehicles among others play a significant role in monitoring locust movements, assessing population densities, and implementing timely control measures.
7. Research and innovation played a key role in the management of desert locust. Continuous investment in research and innovation is necessary to improve locust monitoring and early warnings and control methods. Further, it is necessary to encourage collaboration between the public and private sectors to leverage technological advancements and improve the accuracy and reliability of early detection tools.
8. Advance resource mobilization was important in desert locust control. Country-level budget allocations and multi-agency involvement in emergency response initiatives are recommended.
9. The development of data management systems to collect, store, and analyze locust-related data was essential for effective response to desert locust invasion. There is a need to develop robust data management systems using GIS, remote sensing, satellite imagery and data analytics tools to derive actionable insights from the collected data. Additionally, applying advanced modeling techniques to predict locust movements and assess their impact on agricultural areas is recommended.
10. Inadequate documentation of past locust invasions was identified. There is a need to establish comprehensive and centralized systems for documenting and archiving in both print and digital format. This will provide reference and guidance for future locust management strategies.
11. Review and implement policies on early warning systems, collaboration, sustainable pest management, capacity building, resource mobilization and environmental considerations. Development of policies, strategic plan, contingency plan, action plan and technical materials will address desert locust challenges while promoting long-term resilience and sustainability.
12. As part of the measures to enhance preparedness, the government with support from FAO, IFAD, and World Bank developed a five year migratory pest management strategy where all aspects of desert locust management were captured.

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