Technical Report

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Interconnected Disaster Risks
2020/2021

Locust Outbreak 2019–2021

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Table of Contents

1. Event

The years 2019 to 2021 saw the emergence and spread of a desert locust (Schistocerca gregaria)[1] infestation[2] that reached across the Arabian Peninsula, the Horn of Africa and South Asia. At the height of the upsurge, a total of 23 countries were affected ((World Bank, 2020; FAO, 2020e), with an intensity that made this event the worst locust infestation that Ethiopia and Somalia had experienced in 25 years, and the worst in over 70 years for Kenya and Uganda. The ensuing large-scale loss of vegetation to locust swarms

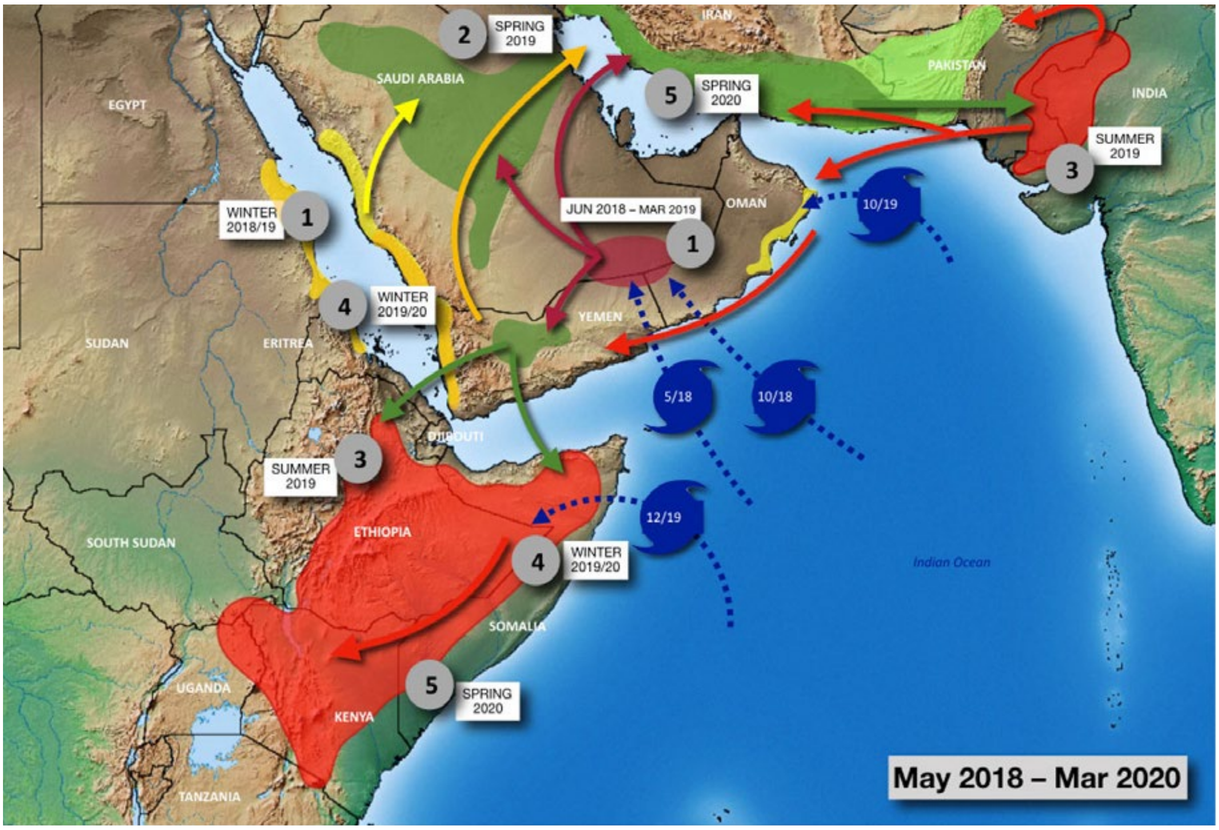


Figure 1: Development and spread of the desert locust infestation between March 2018 and March 2020. Source: FAO/DLIS

1 The term 'desert locust' is generally used here to refer to the subspecies Schistocerca gregaria gregaria, as the second subspecies of the same name, S. gregaria flaviventris, has only been recorded swarming twice (Le Gall and others, 2019).

2 While the term 'locust outbreak' is consistently used in the main report for the sake of simplicity, scientific literature differentiates between a variety of terminology to describe locust presence depending on its intensity: recession (periods without infestations through swarms and bands, locusts are solitarious), out break (high locust densities leading to gregarization), upsurge (infestations of gregarious bands and swarms that persist for several seasons), plague (widespread infestations that persist over years with high intensity) (van Huis and others, 2007). In contrast to the main report, this technical report will use this vocabulary.

not only caused significant economic damages, it also directly threatened the livelihoods and nutrition of an estimated 42 million people already at risk from food insecurity in the predominantly agriculturally-dependent infestation hotspots (FAO, 2021c). Large-scale response measures were implemented to curb the 2019–2021 upsurge, with the Food and Agriculture Organization of the United Nations (FAO) requesting US$312 million in funding (FAO, 2020b) and treating 1.3 million hectares by the end of 2020, with another 0.7 million hectares targeted for treatment in 2021 (FAO, 2020a).

The seeds of this outbreak were laid in 2018 when cyclones brought heavy rainfall to the remote area called 'Empty Quarter' in the Arabian Peninsula, creating prolonged favourable breeding conditions and allowing three generations of locusts to multiply undetected. In January 2019, the first swarms spread into neighbouring Saudi Arabia, Yemen and Iran, where further breeding occurred, creating new swarms that spread out towards the Indo-Pakistan border as well as Somalia and Ethiopia. By autumn and winter 2019/2020, desert locust infestations had spread further into African countries and along the Persian Gulf, reaching as far as northern India in late spring and summer of 2020. While the situation in Southwest Asia was controlled by September 2020, the infestation continued in the Horn of Africa and around the Red Sea, with extensive breeding causing the emergence of new swarms and bands. Cyclone Gati, in November 2020, further created favourable conditions in north-east Somalia and extended the breeding areas in the country. The desert locust infestation raged on in the Horn of Africa and the Arabian Peninsula until early 2021, when the swarms began to decline due to control efforts and unfavourable weather conditions (FAO, undated c). Nevertheless, at the point of writing the infestation has not been entirely overcome and, for example, favourable weather events or a lapse of vigilance and control of current hatching in Ethiopia, Somalia, Saudi Arabia and Yemen could re-ignite the upsurge (FAO, 2021a).

2. Impact

Direct impacts

While data on the total damages caused by the 2019–2021 locust upsurge was not yet available at the time of writing, an FAO brief from April 2020 estimated that in Ethiopia alone 200,000 hectares of cropland had been damaged by locusts, causing a cereal loss of over 3,562,856 quintals and leading to a 50 per cent price increase for cereals compared to 2019 (FAO, 2020d). This, combined with the effects of COVID-19 on food systems, heightened food insecurity across affected regions. Xu and others (2021) calculated that 878 million tons of cereal production was heavily affected by the locust upsurge, estimating a cereal production loss of 5.5 per cent in 2020 and 14.9 per cent in 2021 in the affected regions. They predict an output loss of up to 90 per cent in North and West Africa, and up to 70 per cent in East Africa in 2021.

While the threat of hunger was most pronounced in the Horn of Africa and Yemen, which were already struggling with food insecurity (Huang, 2020), losses caused by locusts were also significant elsewhere, with India estimating that over 200,000 hectares of crops were damaged when locusts invaded the country in 2019/2020 (Kapil, 2021). Vegetation loss to locusts does not only affect crops, however. Livestock are also impacted by the destruction of their fodder, endangering the livelihoods of pastoralists. In 2019 alone, Kenya reported the productivity loss of up to 30 per cent of its pastureland (CropLife Africa Middle East, 2020). As livestock's health declined to the point of starvation, many households were forced to attempt to sell their animals in order to buy food. However, the aforementioned 2020 analysis of FAO found that livestock prices remained low in comparison to the spiking food prices, meaning that livestock owners selling off their assets still faced food insecurity (FAO, 2020d).

Indirect impacts

The large-scale intervention to control the locust upsurge is credited with preventing an estimated $1 billion in damages (FAO, 2020a), but has brought adverse effects of its own: ninety per cent of combating agents used in control campaigns during the 2019–2021 upsurge were chemical pesticides, including agents that are banned in the European Union and United States. These are not only effective against locusts but also cause high mortality in non-target species, thus harming local biodiversity, reportedly poisoning livestock and even endangering human health (McConnell, 2021; Smith & Kayama, 2020). Locust control most often utilizes ultra-low volume (ULV) formulated pesticides, which do not require being mixed with water and reduce the amount of pesticides required for spraying. Commonly used chemical pesticides for desert locust control are organophosphates such as Chlorpyrifos, Malathion and Fenitrothion, as well as pyrethroids, in particular Deltamethrin. These fast-working insecticides are sprayed on to locust bands and swarms as well as the vegetation, poisoning the individuals both through direct contact and secondary contact as they move through and feed on vegetation (FAO Pesticide Referee Group, 2014). However, none of these agents attack locusts specifically. On the contrary, a wide range of non-target species across the food chain are affected. Affected species include many that are beneficial to humans, such as pollinators and indeed livestock, which farmers have reported being poisoned by pesticide residues after spraying. For example, while Fipronil – an agent that persisted particularly long in the environment after spraying – has been largely disbanded from use due to its severe impact on ecosystems, other aggressive pesticides are still in use (Smith & Kayama, 2020; Nasike, 2021). This also raises concern for human health in heavily sprayed areas, as for instance Fenitrothion has been linked to changes in the human hormonal system (Tamura and others, 2001) and there is corroborative evidence that Chlorpyrifos impacts brain development, especially in children (Rauh, 2018). While less harmful alternatives exist, these are not yet widely in use, especially under the difficult procurement conditions posed due to the COVID-19 pandemic. Nevertheless, fungus-based biocides were used for locust control in Somalia, and later also in Kenya and Ethiopia (CropLife Africa Middle East, 2020; FAO, 2020c).

Emerging risks

Though the locust upsurge is currently receding, its impacts are likely to be felt for some time, and not only in the shape of pesticide residue and related biodiversity loss. Despite 307,000 households being targeted with anticipatory action and/or in-kind or cash livelihood-recovery interventions by the FAO (FAO, 2020a), the combination of the locust invasion and the COVID-19 pandemic has depleted household assets and destroyed livelihoods, leaving many farmers unable to recover in the near future (Smith & Kayama, 2020). To cope with the 2003–2005 desert locust outbreaks, 90 per cent of household heads were forced to go into debt in the most affected countries (Melvin, 2020). Resource competition under these conditions can also potentially escalate existing conflicts, which are prevalent between farmers and pastoralists in many of the affected areas (Smith & Kayama, 2020). While it is too early to begin to measure long-term impacts of the 2019–2021 outbreak, evidence from previous locust upsurges indicate far-reaching effects. Analysing the effects of the 2003–2005 locust infestation in Mali, Conte and others (2020) found that the drop in food security (due to both speculative/anticipatory price effects and actual harvest losses caused by the infestation) had a detrimental effect on foetal development, and also affected the children's health after birth (Conte and others, 2020). Studying effects in the same country, de Vreyer and others (2015) showed that the 1987–1989 locust plague had a significant impact on the educational outcomes of children, with many rural children being forced to drop out of school or experiencing a drop in educational achievement during the plague (de Vreyer and others, 2015). Such outcomes may significantly affect the future lives of children who were exposed to a locust upsurge, shaping both individual life paths and communities, as for example migration and reduced educational attainment also affect future gender equality. Similarly, long-term health effects caused by the pesticides used to curb the 2019–2021 upsurge have not yet been discovered, but may possibly emerge, particularly in children and pregnancies carried during the treatment. In this way, locust infestations can destabilize rural communities across the areas they affect, undoing much of the development previously achieved (Kassegn & Endris, 2021). We can therefore assume that the effects of the 2019–2021 locust upsurge will be felt long after it has subsided.

The 2019–2021 desert locust outbreak will also not be the last in this and surrounding regions. The tropical storms and rainfall that created the conditions triggering the locust infestation are ocean warming due to climate change, indicating that conditions favouring locust outbreaks may occur more frequently in this region in the future (Salih and others, 2020; Stone, 2020). This gives cause for concern, especially considering that locust management capacities in this region proved inadequate to control the 2019–2021 upsurge (see section 4, Root causes).

3. Drivers

Considering the scope of the 2019–2021 locust upsurge, questions arise concerning how such an infestation could be allowed to spread this far. This section therefore seeks to explain the factors that contributed to this event in addition to the root causes that are outlined in the following section. Not only were the areas where the outbreak first emerged extremely remote and consequently hard to monitor, but conflict and insecurity in both Yemen and Somalia also rendered some breeding areas inaccessible even after they had been identified, and Yemen's civil war disrupted its existing locust management system to the point that it was unable to functionally respond to the upsurge (Al Batati, 2020; Showler and others, 2021). Connected to the extreme rainfalls, East Africa had also suffered large-scale flooding, causing displacement and the loss of crops and livestock, as well as a regional infestation of the Fall Armyworm (Waruru, 2019), which exacerbated the effects of the desert locust infestation and overstretched response capacities (Kassegn & Endris, 2021). However, the most devastating factor exacerbating the 2019–2021 infestation was the COVID-19 pandemic.

Spreading rapidly across the globe, the COVID-19 crisis disrupted societies, economies and individual lives at all levels. Its impact on food chains increased food insecurity, heightening the vulnerability of households to the impacts of locust swarms (FAO, 2021c; Xu and others, 2021). However, acquisition and distribution of staff, technical equipment and combating agents were all impeded by the COVID-19 pandemic, as containment measures hindered expert teams from travelling and supply chains, including for pesticides, were disrupted (Byaruhanga, 2020). This significantly slowed response implementation, in particular as stockpiles of equipment were lacking in the affected countries (see section 4, Root causes). In previous upsurges, affected households could alleviate their situations by seeking alternative income sources through family members migrating to other areas, usually cities, where jobs are available. However, travel restrictions due to the COVID-19 pandemic prohibited migration, severely limiting coping strategy options. In Kenya, for example, some households strongly affected by the locust outbreak reportedly turned to illegal charcoal burning to generate income in order to compensate for lost harvests and livestock (Smith & Kayama, 2020), with detrimental environmental effects. The cumulative economic and social impacts of the COVID-19 pandemic are thus likely to exacerbate the long-term effects of the locust upsurge indicated in the impacts section.

4. Root causes

Ecological causes of locust outbreaks

Locusts are a type of grasshopper distinguished by their ability to transition between two different phases – the solitarious and the gregarious phases – based on population density. At low densities, solitarious individuals avoid each other except for mating and are inconspicuous to humans both through their muted behaviour and their camouflaged colouring. When the population reaches a critical density, however, locusts undergo a dramatic transformation in both appearance and behaviour. Developing bright colouring, gregarious individuals actively seek each other out, forming juvenile 'hopper bands' and adult swarms (Verlinden and others, 2009). Gregarious desert locust swarms can cover over 1,000 square kilometres, with between 40 million and 80 million locusts amassing in each square kilometre (FAO, 2020e). While such large swarms take time to become established, the switch between phases occurs suddenly: solitarious desert locusts become gregarious after only four hours under crowded conditions (Collett and others, 1998). When and where critical population densities for gregarization are reached depends largely on environmental factors. Though the recession area of the desert locust covers 30 countries, and a total of 60 countries can be affected by gregarious swarms (FAO, 2020e), outbreaks generally tend to occur in the same regions, namely areas in which the species breeds during times of low density (Despland and others, 2004). A key factor for suitable breeding areas is soil, as desert locusts prefer sandy substrate with soil moisture between 5 per cent and 25 per cent in the upper layer (Piou and others, 2019). Desert locust eggs develop at temperatures between 15°C–35°C and mature more rapidly as soil temperatures increase (WMO & FAO, 2016). An increase in vegetation can also allow a locust population to increase, but vegetation density also affects the gregarization threshold, as dense green vegetation disperses individuals, lowering the crowding effect (Cisse and others, 2013), while patchier vegetation forces locusts into closer proximity, fostering gregarization (Despland and others, 2000).

Once population density is sufficiently high, juveniles begin to group and form gregarious hopper bands. Incapable of flight, hopper bands are nevertheless very mobile as they often march the entire day under warm and sunny conditions. Desert locust hoppers moult five to six times before reaching the adult stage, and hopper bands are usually made up of individuals at several different stages of development. The area covered and vegetation consumed by a hopper band increases as the individuals develop, and different bands merge together where they meet (Symmons & Cressman, 2001). After their last moulting, the wings of adult desert locusts harden after roughly 10 days, allowing them to become airborne and thus increasing the mobility of gregarious swarms. Desert locusts require temperatures of above 20°C for sustained flight, and travel downwind to preserve energy, making swarm movement highly dependent on weather conditions (Symmons & Cressman, 2001). Under favourable conditions, locusts can travel up to 150 km per day. Swarm size and persistence are also dependent on the prevailing weather conditions, in particular rainfall. Locust swarms consume almost all vegetation in their path, as an adult desert locust can eat its own body weight in fresh food every day (FAO, 2020e); they rely on sufficient availability of vegetation in their path. Rainfall also fosters the maturation of adult individuals, which in turn triggers maturation in the rest of the swarm. The behavioural phase of the mother also impacts the behaviour of the hatchlings, as locusts emerging from eggs laid by a gregarious female are predisposed to also display gregarious behaviour, in contrast to hatchlings from eggs laid by a lone individual. This is caused by the chemical composition of the egg foam (Simpson & Sword, 2008). With sufficient moisture, warmth and vegetation, desert locusts can begin laying eggs only three weeks after maturation, creating new generations (Symmons & Cressman, 2001). Under sustained favourable conditions, locust outbreaks can spread and multiply, affecting several different regions and persisting over years (FAO, 2009a).

Climate change

The trigger for the 2019–2021 desert locust upsurge was a rising frequency and intensity of tropical storms and extreme weather, which both caused and aided the spread of the outbreak. Cyclone Mekunu, in May 2018, first created favourable breeding conditions in the Arabian Peninsula and the subsequent cyclone, Luban, in October the same year, prevented the natural decline of the locust population that would normally occur in the region due to dry conditions, instead resulting in an 8,000-fold increase in the locust population. Cyclone winds further supported the migration of swarms, and unusually high rainfall in affected regions sustained their survival and growth. Both the increase in tropical storms and higher rainfall can be in part attributed to the Indian Ocean Dipole (IOD), which experienced one of its strongest positive phases between October and December 2019. This strengthening of the IOD has been linked to ocean warming due to climate change (Salih and others, 2020; Stone, 2020).

Insufficient management

In the past century, human intervention in locust outbreaks has increased and scaled up, as is clearly visible in the extent and duration of serious locust outbreaks: not only have locust plagues decreased in the last 120 years (Lecoq, 2001), but also while the plagues recorded in the first half of the 20th century lasted roughly between 7 and 14 years, the subsequent plagues since 1965 have all been contained in under 3 years (Le Gall and others, 2019). Scientific and technological knowledge have provided extensive tools and guidelines for locust management; however, their implementation varies, allowing large-scale outbreaks like the 2019–2021 upsurge to occur. Already in 2001, Lecoq wrote that “locust control seems now to depend more on political and institutional choices than on scientific and technological innovations” (Lecoq, 2001). The same sentiment is echoed in a paper published by Lockwood and Sardo 20 years later, who describe the barriers to effective locust management as “economic, political, and cultural understanding” (Lockwood & Sardo, 2021).

In their multi-factor model, Gay and others (2018) showed that cyclic locust infestations can also be predicted through the decrease of awareness among funders between outbreaks (Gay and others, 2018), illustrating the impact that management implementation has on locust populations. Fluctuating political awareness not only affects international funding, it also impacts locust management in the countries at risk. The spatially and temporally erratic nature of locust outbreaks and their spread means that between serious infestations, they are often crowded out of political agendas by topics deemed more urgent, especially if the nation is struggling with poverty and insecurity (van Huis, 2007; Meynard and others, 2020). For this reason, outbreaks can find affected nations unprepared, as illustrated by Kenya’s situation in the 2019/2020 outbreak. As the country had not experienced a severe locust infestation in decades, both institutions and private citizens were not prepared to be hit by the recent outbreak, despite being situated in the distribution and invasion range of the desert locust (Kimathi and others, 2020). This range covers some of the poorest countries in the world (FAO, 2015), posing a serious challenge to effective, consistent long-term management of locust populations in order to prevent severe outbreaks. Such management requires consistent, long-term funding. Despite the known continually-present risk, it is hard for national governments to justify investing significant portions of their limited budgets to locust management, considering that locust outbreaks are rare events for single countries. Most countries in the affected range have provisions for locust

Locust Management Interventions

As both knowledge of desert locust ecology and technological capabilities have increased, more sophisticated and effective forms of locust management have been developed. These can be grouped into three types of intervention: preventative, proactive and reactive control (Showler, 2019).

Preventative control

The most effective method of locust control is the prevention of large infestations, both in damage control and implementation costs. It is based on accurate prediction and close monitoring of likely outbreak areas, followed by swift interventions to decimate the locust population before it reaches its gregarization threshold. Though initial large outbreaks of desert locusts usually occur in known breeding regions in their recession area, these still cover wide, often remote expanses that are hard to monitor. Additionally, favourable conditions in non-traditional outbreak areas can also lead to large infestations, a risk that is increasing as climatic changes create increasingly erratic weather patterns (Salih and others, 2020). While it is not a suitable tool to monitor locust populations directly, rainfall, vegetation cover and soil moisture can be monitored with the help of satellite data, identifying areas where breeding conditions for locusts are currently favourable. Combined with available data on soil texture, temperature and data from previous locust plagues, machine learning and modelling have enabled fairly accurate predictions of increased locust breeding, both of desert locusts and other species (Kimathi and others, 2020). However, it is still necessary to conduct monitoring through survey teams on the ground in the identified areas in order to prevent locust outbreaks, which presents a challenge as the desert locust in particular usually breeds in very remote areas. Where a high density of hoppers or adults is detected, ground teams or drones can spray lethal agents in order to reduce the population and prevent gregarization.

Proactive control

Where locusts have already formed gregarious bands or swarms, swift intervention can still contain the outbreak. Close monitoring is necessary to enable containment, as gregarious individuals and first groupings of locusts must be reported immediately so that control measures can be deployed before the outbreak grows and spreads to other areas. While remote sensing and drone surveillance play an important role in proactive control, field monitoring is also necessary in order to pinpoint emerging bands or swarms. Professional ground teams patrolling likely outbreak areas are necessary for desert locust containment as the species usually breeds in remote areas, but easily accessible channels for the public to report high densities of locusts or the sighting of gregarious individuals are also beneficial. Once a band or swarm has been found and identified as a threat, swift intervention to destroy it with lethal agents can prevent it from growing, laying or moving to other areas (Showler and others, 2021; Cadmus and ICF 2020).

Reactive control

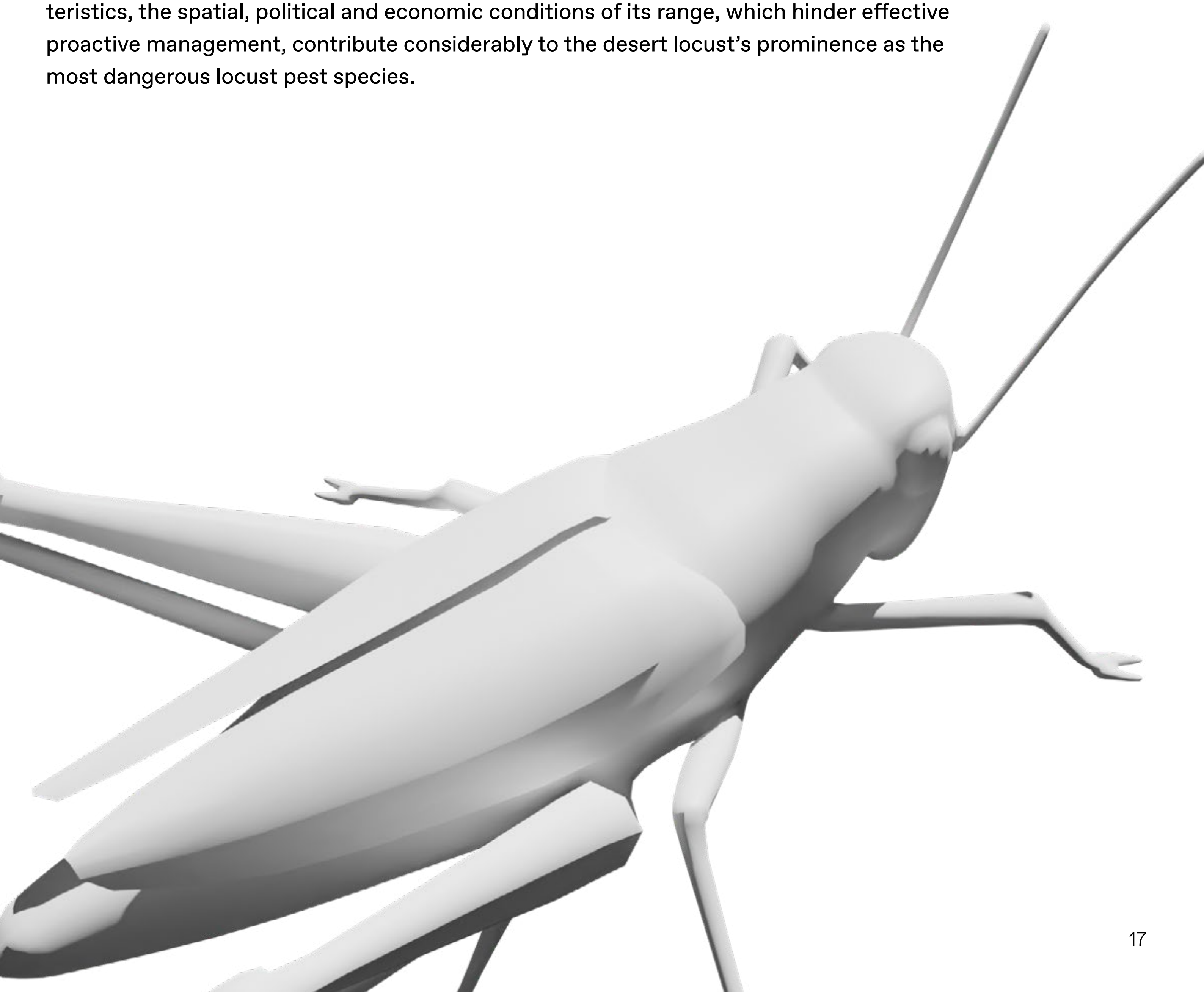
When outbreaks are not recognized and dealt with in time, bands and swarms grow in size and hopper bands develop into adult swarms. The high mobility of flying locusts, as well as mature adults breeding and laying eggs where environmental conditions are suitable, means that infestations can at this stage spread over whole regions, multiplying and creating new, separate swarms. Control interventions must be similarly large-scale, with lethal agents often being brought out with the help of vehicles and small planes and helicopters. In order to effectively mobilize resources for response, the movement of swarms can be tracked through observation and satellite data, making their position and direction of flight available to the relevant actors. As swarms travel with the wind and environmental conditions strongly impact their activity, as well as the development and survival of new generations, the dynamics of the infestations can also be predicted using weather data. Though this further improves control measures, large-scale damage is unavoidable when locust upsurges have become this established, and it takes months to years for large-scale infestations to be controlled (Showler 2019; Zhang and others, 2019; FAO 2020b).

included in their national policies on agriculture – such as Kenya's Pest Management Plan, which is supported through the Kenya Climate Smart Agriculture Project (KCSAP) funded by the World Bank (Kiyeon, 2015; Republic of Kenya, 2020) – and deploy national locust control units to some extent (Commission for Controlling the Desert Locust in the Central Region, 2018; FAO, undated a). However, the issue of locust management is complicated by the high mobility of locust swarms, which means that the countries where an outbreak originates may actually suffer less from the event than neighbouring nations. In order to pool resources and coordinate mitigation and response efforts, cross-border cooperation for locust management has been created, with varying degrees of effectiveness (van Huis, 2007). Aside from the political and diplomatic challenges inherent with cross-border cooperation, funding remains an issue for regional networks. The most important functioning regional organization, the Desert Locust Control Organization for Eastern Africa (DL-CO-EA), comprising eight African member states, was owed over $10 million in membership fees in 2020, crippling the organization's resources and capacities to respond to the 2019–2021 outbreak (Roussi, 2020).

On the international level, the FAO, in its many relevant sub-organizations, has become the most important body in desert locust management. The FAO's Desert Locust Information Service (DLIS) serves as the hub for locust monitoring, combining national monitoring data with weather, habitat and satellite data in order to provide up-to-date information on the locust situation and provide predictions up to six weeks ahead, issuing warnings to countries at risk (FAO, undated b). The FAO further holds three regional commissions for desert locust control, the CLCPRO (West and Northwest Africa), the CRC (Central and Eastern Africa, Middle East) and the SWAC (Southwest Asia), where it takes a coordinating role between member states (FAO, 2009b). The FAO's Emergency Prevention System for Transboundary Animal and Plant Pests and Diseases (EMPRES) has been implemented in CLCPRO and CRC countries to foster early detection, warning and response, as well as promoting contingency planning, fostering cooperation between countries and supporting the development of more environmentally-sustainable locust management systems (FAO, 2021b). These commissions have recorded significant success in handling emerging outbreaks in the past, though they too are financially restricted as the implemented measures are self-funded through the member states' national budgets (FAO, undated a). In the case of a severe locust infestation, the FAO therefore also serves as the coordinating body for emergency assistance from outside states (FAO, undated b), while the East African Community secretariat also set aside emergency funds to address the 2019–2021 upsurge (Anami, 2020), as did the African Development Bank (African Development Bank, 2020). However, this level of funding only becomes available once an outbreak has become a crisis.

Funding gaps and political agenda-setting also impact the response strategies implemented in the event of an outbreak. Nations and organizations that lack financial capacities are unable to employ and train sufficient staff, buy and maintain machinery such as pesticide-spraying planes and stock-pile combating agents ahead of outbreak events. This slows response time when infestations emerge, as mitigation efforts are dependent on outside funding that only becomes available in significant amounts once an outbreak is severe enough to attract international attention. Similarly, physical resources such as expert staff, machines and pesticides must be transported to the affected area, which again creates a time gap in response efforts. In particular concerning combating agents, the acquisition urgency that a lack of stockpiles creates limits the choice of agents based on cost and availability. Procurement, transportation and safe storage and disposal of pesticides is one of the most complicated and expensive parts of locust management, making up roughly half the budget for control interventions, though for example the CLCPRO countries have created a stockpile-sharing system in order to utilize the resources in the region more effectively (CropLife Africa Middle East, 2020; FAO, undated a). These factors particularly hamper the adoption of environmentally-friendly biocides as these are less readily available than more established chemical pesticides, because species-specific biocides are only in demand when the pest in question is active, and the interspersed nature of locust outbreaks discourages large-scale production (Grzywacz and others, 2014; McConnell, 2021). Additionally, biocides are most effective when used on hopper bands early in the infestation (Grzywacz and others, 2014; FAO, 2007). The lag in response time caused by under-preparation thus makes biocides less attractive. This is also true from a political perspective: as the active locust swarms have often already done considerable damage at this point, public anxiety concerning this issue is high and politicians are keen to show that they are taking decisive, effective action to combat the threat. For this reason, fast-working pesticides that kill locusts almost immediately after spraying are preferred to fungus-based biocides that take at least a week to take effect, especially as sprayed locusts remain active and mobile at the beginning of this period (Roussi, 2020; Grzywacz and others, 2014). Nevertheless, De Groote and others (2001) found that both local farmers and management donors show significant interest in biological locust control, and biocides have been implemented more broadly in recent years (Kairu, 2020; de Groote and others, 2001).

For the desert locust in particular, access to breeding grounds is a further decisive factor impeding proactive management. Not only are many areas extremely remote and hard to access due to poor infrastructure and limited capacities, but also security issues due to civil unrest and violent conflict render further regions inaccessible to monitoring and response teams (Showler & Lecoq, 2021; Gay and others, 2020; Kimathi and others, 2020), as well as disrupting monitoring systems in general (Meynard and others, 2020). According to Gay and others (2020), the effectiveness of even a well-funded management programme can be cancelled out if only five per cent of its territory is inaccessible. Their model further predicts that the proportion of locust plague years in a given timeframe is higher the larger the inaccessible area is, and multiple no-access areas increase the plague risk even more, as more fronts need to be controlled (Gay and others, 2020). Aside from its ecological characteristics, the spatial, political and economic conditions of its range, which hinder effective proactive management, contribute considerably to the desert locust's prominence as the most dangerous locust pest species.



5. Solutions

Environmentally-sustainable combating agents

As outlined in the section on management interventions, scientific research has provided strong guidelines for effective locust management. Environmentally-friendly biocides to combat locusts are available and have already been used in outbreak control. Making their use more mainstream and biocides in general more accessible for affected countries could improve the sustainability of locust management and help prevent indirect impacts on both ecosystems and humans. Most prominently, fungi that specifically attack Acrididea, the grasshopper family that locusts belong to, were already identified as the most effective environmentally-friendly biocide for locust control in the 1990s, as they do not impact non-target species outside of this group (Lomer and others, 1997). Species of the parasitic fungus Metarhizium, in particular Metarhizium anisopliae var. acridum, have since been used in agents such as Green Muscle and Novacrid, which are in use for locust control (Nasike, 2021; Chen, 2020; Stokstad, 2020). Fungal biocides are usually oil-formulated and can be sprayed using standard Ultra Low Volume (ULV) equipment (de Groote and others, 2001). Similarly to chemical pesticides, locusts can be infected with the fungus both via direct contact through spraying or secondary contact by picking up fungus spores from sprayed vegetation, where the spores can persist for 4–8 days, depending on weather conditions. Other mass-produced biological agents include the parasitic microsporidian Nosema locustae, which attacks insects in the order Orthoptera (Zhang & Lecoq, 2021). Biocides are efficient but do not take effect as quickly as chemical pesticides, as the parasite must grow inside a locust in order to weaken and kill it, a process that takes roughly eight days for fungal biocides. For this reason, parasitic biocides are preferably used to treat hopper bands, as they are less mobile than adult locusts (Stokstad, 2020; FAO, 2007).

Improving chronic locust management

Improving preventative, early-intervention locust management would also help curb the pesticide load associated with outbreaks. The earlier an outbreak is detected and intervention can take place, the smaller the area that requires treatment. Considering the advances in remote monitoring, preventative locust management can now be based on comparatively robust predictions. Deriving, collecting and sharing such information via openly-accessible platforms like the FAO Locust Watch is therefore an important cornerstone of international locust management, and should be continued and extended upon in the future. However, as described in the section on root causes, a key barrier to the successful implementation of preventative control is a lack of resources in many countries in the range of the desert locust. Without consistent funding and commitment, it is not possible to maintain monitoring, in particular ground monitoring, and respond to predictions and outbreaks in a timely enough fashion to prevent serious damages. Raising political awareness and commitment to locust risk management, in particular maintaining it during recession periods, is therefore vital to improving long-term locust management. In order to improve coordination and resource-sharing, the Intergovernmental Authority on Development (IGAD) announced plans to create a further inter-regional coordination platform for desert locust management in March 2021 (CGTN, 2021).

Taking into account global economic inequality and the considerable donations of countries not affected by the outbreak made to the emergency response, involving such donor countries in long-term chronic funding schemes may offer a solution for sustainable locust management. One argument for such a scheme is that regularly contributing small amounts to international locust management would have a less disruptive effect on donor economies than large-scale emergency relief once an outbreak has become established. Considering the scale of damages and intervention costs as well as the increased likelihood of desert locust outbreaks due to climatic changes, maintaining chronic preventative locust management is likely to pose fewer costs overall compared to potential outbreak damages, on top of the significant human suffering that could be avoided.

References

African Development Bank (2020). African Development Bank Approves $1.5 Million Emergency Grant to Curb Desert Locusts Ravaging East and Horn of Africa. URL: www.afdb.org/en/news-and-events/press-releases/african-development-bank-approves-15-million-emergency-grant-curb-desert-locusts-ravaging-east-and-horn-africa-35060

Al Batati, Saeed (2020). How Yemen's Civil War Played a Role in Africa's Great Locust Swarm: Monitoring and Eradication System Suffers from Lack of Funding. The National, 06 February. URL: www.thenationalnews.com/world/mena/how-yemen-s-civil-war-played-a-role-in-africa-s-great-locust-swarm-1.975183

Anami, Luke (2020). Second Wave of Locust Invasion and Floods to Shake East Africa Economies. The East African, 2020. URL: www.theeastafrican.co.ke/news/ea/Locust-invasion-floods-to-shake-East-Africa-economies/4552908-5540474-w58529/index.html

Byaruhanga, Catherine (2020). How Do You Fight a Locust Invasion Amid Coronavirus? BBC News, 25 April. URL: www.bbc.com/news/world-africa-52394888

Cadmus, and ICF (2020). Desert Locust Surveillance and Control: Programmatic Environmental Surveillance. URL: www.usaid.gov/sites/default/files/documents/USAID_EAFR_Locust_PEA_FAO_11-10-20_508_Compliant.pdf

CGTN (2021). IGAD Member States to Combat Desert Locust Jointly. 2021. URL: https://africa.cgtn.com/2021/03/22/igad-member-states-to-combat-desert-locust-jointly/ /

Chen, Stephen (2020). China's Green Zombie Fungus Could Hold Key to Fighting East Africa's Swarms of Locusts. South China Morning Post, 22 February. URL: www.scmp.com/news/china/science/article/3051819/chinas-green-zombie-fungus-could-hold-key-fighting-east-africas#1616319294279108{"sender":"offer-0-q0JGi","displayMode":"inline","recipient":"opener","event":"resize","params":{"height":564,"iframeId":"offer-0-q0JGi","closeButtonType":"boilerplate"}}

Cisse, Sory, and others (2013). Effect of Vegetation on Density Thresholds of Adult Desert Locust Gregarization from Survey Data in Mauritania. In Entomologia Experimentalis et Applicata, vol. 149, No. 2, pp. 159–65. DOI: 10.1111/eea.12121

Collett, Matthew, and others (1998). Spatial Scales of Desert Locust Gregarization. In Proceedings of the National Academy of Sciences of the United States of America, vol. 95, No. 22, pp. 13052–55. DOI: 10.1073/pnas.95.22.13052

Commission for Controlling the Desert Locust in the Central Region (2018). FAQ on Desert Locusts. URL: www.desertlocust-crc.org/pages/About.aspx?id=127&lang=EN&I=0&DId=0&CId=0&CMSId=7

Conte, Bruno, and others (2020). Ancient Plagues in Modern Times: The Impact of Desert Locust Invasions on Child Health. In Toulouse School of Economics (TSE). URL: www.tse-fr.eu/sites/default/files/TSE/documents/doc/wp/2020/wp_tse_1069.pdf

CropLife Africa Middle East (2020). Desert Locust Control Hindered by Pesticide Procurement. AgriBusiness Global, 01 June. URL: www.agribusinessglobal.com/markets/desert-locust-control-hindered-by-pesticide-procurement/

Despland, Emma, and others (2000). Small-Scale Processes in Desert Locust Swarm Formation: How Vegetation Patterns Influence Gregarization. In Oikos, vol. 88, No. 3, pp. 652–62. DOI: 10.1034/j.1600-0706.2000.880322.x

Despland, Emma, and others (2004). Landscape Structure and Locust Swarming: A Satellite's Eye View. In Ecography, vol. 27, No. 3, pp. 381–91. DOI: 10.1111/j.0906-7590.2004.03779.x

FAO Pesticide Referee Group (2014). Evaluation of Field Trials Data on the Efficacy and Selectivity of Insecticides on Locusts and Grasshoppers: Report to FAO by the Pesticide Referee Group Tenth Meeting, Gammarth (Tunisia), 10–12 December 2014. URL: www.fao.org/3/bu337e/bu337e.pdf

Food and Agriculture Organization of the United Nations (FAO) (undated a). Countries Take Responsibility for Regional Desert Locust Control. URL: www.fao.org/in-action/countries-take-responsibility-for-regional-desert-locust-control/en/

Food and Agriculture Organization of the United Nations (undated b). Desert Locust. URL: www.fao.org/locusts/en/

Food and Agriculture Organization of the United Nations (undated c). Desert Locust – Current Upsurge (2019–2021). URL: www.fao.org/ag/locusts/en/info/2094/index.html

Food and Agriculture Organization of the United Nations (2007). Review of the Efficacy of Metarhizium Anisopliae Var. Acridum Against the Desert Locust. URL: www.fao.org/ag/locusts/common/ecg/1295/en/TS34e.pdf

Food and Agriculture Organization of the United Nations (2009a). Desert Locust Plagues. URL: www.fao.org/ag/locusts/en/archives/2331/index.html

Food and Agriculture Organization of the United Nations (2009b). FAO Regional Desert Locust Commissions. URL: www.fao.org/ag/locusts/en/info/info/891/index.html

Food and Agriculture Organization of the United Nations (2015). FAO Desert Locust Information Service. URL: www.fao.org/resilience/resources/resources-detail/en/c/278608/

Food and Agriculture Organization of the United Nations (2020a). Desert Locust Crisis Appeal – January 2020–June 2021: Revised Appeal for Sustaining Control Efforts and Protecting Livelihoods (Six-Month Extension). URL: www.fao.org/3/cb2445en/CB2445EN.pdf

Food and Agriculture Organization of the United Nations (2020b). Will the Desert Locust Land in Russia? FAO Experts Have the Answer. URL: www.fao.org/russian-federation/news/detail-events/en/c/1295527/

Food and Agriculture Organization of the United Nations (2020c). Delivering Biopesticides in Somalia. URL: www.fao.org/resilience/multimedia/photos/photo-detail/zh/c/1272227/

Food and Agriculture Organization of the United Nations (2020d). Ethiopia: Desert Locusts Drive One Million to Food Insecurity. Ethiopia country office of the Food and Agriculture Organization of the United Nations, 13 April. URL: www.fao.org/ethiopia/news/detail-events/en/c/1270924/

Food and Agriculture Organization of the United Nations (2020e). Five Things You Should Know About an Age-Old Pest: The Desert Locust: Able to Eat Its Own Weight in Food, This Insect Should Never Be Underestimated. 11 May. URL: www.fao.org/fao-stories/article/en/c/1273770/

Food and Agriculture Organization of the United Nations (2021a). Desert Locust Situation Update – 17 May 2021: Hatching and Band Formation Begin in Horn of Africa. URL: www.fao.org/ag/locusts/en/info/info/index.html

Food and Agriculture Organization of the United Nations (2021b). EMPRES Plant Pest and Disease: Managing New Transboundary Threats. URL: www.fao.org/agriculture/crops/news-events-bulletins/detail/en/item/8765/icode/5/?no_cache=1

Food and Agriculture Organization of the United Nations (2021c). The Impact of Disasters and Crises on Agriculture and Food Security: 2021. Food and Agriculture Organization of the United Nations: Rome, Italy. DOI: 10.4060/cb3673en

Gay, Pierre-Emmanuel, and others (2018). Improving Preventive Locust Management: Insights from a Multi-Agent Model. In Pest Management Science, vol. 74, No. 1, pp. 46–58. DOI: 10.1002/ps.4648

Gay, Pierre-Emmanuel, and others (2020). The Limitations of Locust Preventive Management Faced with Spatial Uncertainty: Exploration with a Multi-Agent Model. In Pest Management Science, vol. 76, No. 3, pp. 1094–102. DOI: 10.1002/ps.5621

Groote, Hugo de, and others (2001). Assessing the Feasibility of Biological Control of Locusts and Grasshoppers in West Africa: Incorporating the Farmers' Perspective. In Agriculture and Human Values, vol. 18, No. 4, pp. 413–28. DOI: 10.1023/A:1015266432589

Grzywacz, David, and others (2014). The Use of Indigenous Ecological Resources for Pest Control in Africa. In Food Security, vol. 6, No. 1, pp. 71–86. DOI: 10.1007/s12571-013-0313-5

Huang, Tina (2020). Which Countries Are Most Vulnerable to Locust Swarms? World Resources Institute, 19 May. URL: www.wri.org/insights/which-countries-are-most-vulnerable-locust-swarms

Kairu, Pauline (2020). Countries Start Trials of Biological Pesticide to Fight Desert Locusts. The East African, 24 June. URL: www.theeastafrican.co.ke/tea/news/east-africa/countries-start-trials-of-biological-pesticide-to-fight-desert-locusts-1443760

Kapil, Shagun (2021). Over 200,000 Hectares Crops Lost to Locust Attacks Since 2019: Agriculture Minister. Down to Earth, 16 May. URL: www.downtoearth.org.in/news/agriculture/over-200-000-hectares-crops-lost-to-locust-attacks-since-2019-agriculture-minister-75965

Kassegn, Andualem, and Ebrahim Endris (2021). Review on Socio-Economic Impacts of 'Triple Threats' of COVID-19, Desert Locusts, and Floods in East Africa: Evidence from Ethiopia. In Cogent Social Sciences, vol. 7, No. 1, p. 1885122. DOI: 10.1080/23311886.2021.1885122

Kimathi, Emily, and others (2020). Prediction of Breeding Regions for the Desert Locust Schistocerca Gregaria in East Africa. In Scientific Reports, vol. 10, No. 1, p. 11937. DOI: 10.1038/s41598-020-68895-2

Kiyeon, KO, ed. (2015). Fire of the Past, Fire in Future. International Wildland Fire Conference. Pyeongchang, Gangwon, Republic of Korea. October 12-16.

Le Gall, Marion, and others (2019). A Global Review on Locusts (Orthoptera: Acrididae) and Their Interactions with Livestock Grazing Practices. In Frontiers in Ecology and Evolution, vol. 7, DOI: 10.3389/fevo.2019.00263

Lecoq, Michel (2001). Recent Progress in Desert and Migratory Locust Management in Africa. Are Preventative Actions Possible ? In Journal of Orthoptera Research, vol. 10, No. 2, pp. 277–91. DOI: 10.1665/1082-6467(2001)010[0277:RPIDAM]2.0.CO;2

Lockwood, Jeffrey A., and Michael C. Sardo (2021). A Swarm of Injustice: A Sociopolitical Framework for Global Justice in the Management of the Desert Locust. In Agronomy, vol. 11, No. 2, p. 386. DOI: 10.3390/agronomy11020386

Lomer, C. J., and others (1997). Development of Metarhizium Spp. For the Control of Grasshoppers and Locusts. In Memoirs of the Entomological Society of Canada, vol. 129, S171, pp. 265–86. DOI: 10.4039/entm129171265-1

McConnell, Tristan (2021). A Locust Plague Hit East Africa. The Pesticide Solution May Have Dire Consequences. National Geographic, 24 March. URL: www.nationalgeographic.com/environment/article/locust-plague-hit-east-africa-pesticide-solution-may-have-dire-consequences

Melvin, Molly (2020). Desert Locust Plague 2020: A Threat to Food Security. Food Unfolded, 02 December. URL: www.foodunfolded.com/article/desert-locust-plague-2020-a-threat-to-food-security

Meynard, Christine N., and others (2020). On the Relative Role of Climate Change and Management in the Current Desert Locust Outbreak in East Africa. In Global Change Biology, vol. 26, No. 7, pp. 3753–55. DOI: 10.1111/gcb.15137

Nasike, Claire (2021). Toxic Pesticides Employed in the Control of Desert Locusts. Greenpeace, 19 February. URL: www.greenpeace.org/africa/en/blogs/13147/toxic-pesticides-employed-in-the-control-of-desert-locusts/#:~:text=Fenitrothion%2C%20Chlorpyrifos%20and%20Fipronil%20are,control%20of%20the%20desert%20locusts

Piou, Cyril, and others (2019). Soil Moisture from Remote Sensing to Forecast Desert Locust Presence. In Journal of Applied Ecology, vol. 56, No. 4, pp. 966–75. DOI: 10.1111/1365-2664.13323

Rauh, Virginia A. (2018). Polluting Developing Brains – EPA Failure on Chlorpyrifos. In The New England Journal of Medicine, vol. 378, No. 13, pp. 1171–74. DOI: 10.1056/NEJMp1716809

Republic of Kenya (2020). Pest Management Plan (PMP) on locust control contigency emergency recovery implementation plan (CERIP). URL: https://documents1.worldbank.org/curated/en/226761584947023230/text/Pest-Management-Plan-on-Locust-Control-Contingency-Emergency-Recovery-Implementation-Plan.txt

Roussi, Antoaneta (2020). Why Gigantic Locust Swarms Are Challenging Governments and Researchers. Nature, 12 March. URL: www.nature.com/articles/d41586-020-00725-x

Salih, Abubakr A., and others (2020). Climate Change and Locust Outbreak in East Africa. In Nature Climate Change, vol. 10, No. 7, pp. 584–85. DOI: 10.1038/s41558-020-0835-8

Showler, Allan T. (2019). Desert Locust Control: The Effectiveness of Proactive Interventions and the Goal of Outbreak Prevention. In American Entomologist, vol. 65, No. 3, pp. 180–91. DOI: 10.1093/ae/tmz020

Showler, Allan T., and others (2021). Early Intervention Against Desert Locusts: Current Proactive Approach and the Prospect of Sustainable Outbreak Prevention. In Agronomy, vol. 11, No. 2, p. 312. DOI: 10.3390/agronomy11020312

Showler, Allan T., and Michel Lecoq (2021). Incidence and Ramifications of Armed Conflict in Countries with Major Desert Locust Breeding Areas. In Agronomy, vol. 11, No. 1, p. 114. DOI: 10.3390/agronomy11010114

Simpson, Stephen J., and Gregory A. Sword (2008). Locusts. In Current Biology: CB, vol. 18, No. 9, R364-6. DOI: 10.1016/j.cub.2008.02.029

Smith, Georgina, and Reuben Kayama (2020). Kenya's Pastoralists Face Hunger and Conflict as Locust Plague Continues: As Herds are Devastated and Crops Destroyed Across East Africa, there are Fears of Violence as Competition for Grazing Increases. The Guardian, 15 May. URL: www.theguardian.com/global-development/2020/may/15/kenyas-pastoralists-face-hunger-and-conflict-as-locust-plague-continues

Stokstad, Erik (2020). In Somalia, an Unprecedented Effort to Kill Massive Locust Swarms with Biocontrol. Science, 12 February. URL: www.sciencemag.org/news/2020/02/somalia-unprecedented-effort-kill-massive-locust-swarms-biocontrol

Stone, Madeleine (2020). A Plague of Locusts Has Descended on East Africa. Climate Change May Be to Blame. National Geographic, 14 February. URL: www.nationalgeographic.com/science/article/locust-plague-climate-science-east-africa

Symmons, P. M., and Keith Cressman (2001). Desert Locust Guidelines: Biology and Behaviour. URL: www.researchgate.net/profile/Keith-Cressman/publication/265217762_Desert_Locust_Guidelines_1_Biology_and_Behaviour/links/563b3ea808ae45b5d285c7fe/Desert-Locust-Guidelines-1-Biology-and-Behaviour.pdf

Tamura, Hiroto, and others (2001). Androgen Receptor Antagonism by the Organophosphate Insecticide Fenitrothion. In Toxicological Sciences: an Official Journal of the Society of Toxicology, vol. 60, No. 1, pp. 56–62. DOI: 10.1093/toxsci/60.1.56

van Huis, Arnold (2007). Strategies to Control the Desert Locust Schistocerca Gregaria. In Area-Wide Control of Insect Pests. Vreysen, M. J., and others, eds. Springer Netherlands: Dordrecht, Netherlands.

van Huis, Arnold, Cressman, Keith, & Magor, Joyce I. (2007). Preventing desert locust plagues: optimizing management interventions. In Entomologia Experimentalis et Applicata, vol. 122, No. 3, pp. 191-214. DOI: https://doi.org/10.1111/j.1570-7458.2006.00517.xCitations: 48

Verlinden, Heleen, and others (2009). Endocrinology of Reproduction and Phase Transition in Locusts. In General and Comparative Endocrinology, vol. 162, No. 1, pp. 79–92. DOI: 10.1016/j.ygcen.2008.11.016

Vreyer, Philippe de, and others (2015). Impact of Natural Disasters on Education Outcomes: Evidence from the 1987-89 Locust Plague in Mali. In Journal of African Economies, vol. 24, No. 1, pp. 57–100. DOI: 10.1093/jae/eju018

Waruru, Maina (2019). Fall Armyworm Attack: Desperation Pushes Kenya Farmers to Danger. Down to Earth, 2019. URL: www.downtoearth.org.in/news/agriculture/fall-armyworm-attack-desperation-pushes-kenya-farmers-to-danger-63525

World Bank (2020). The Locust Crisis: The World Bank's Response: News Factsheet. The World Bank, 01 June. URL: www.worldbank.org/en/news/factsheet/2020/04/27/the-locust-crisis-the-world-banks-response

World Meteorological Organization (WMO), and Food and Agriculture Organization of the United Nations (2016). Weather and Desert Locusts. URL: www.fao.org/ag/locusts/common/ecg/2350/en/2016_WMOFAO_WeatherDLe.pdf

Zhang, Long, and others (2019). Locust and Grasshopper Management. In Annual review of entomology, vol. 64, pp. 15–34. DOI: 10.1146/annurev-ento-011118-112500

Zhang, Long, and Michel Lecoq (2021). Nosema locustae (Protozoa, Microsporidia), a Biological Agent for Locust and Grasshopper Control. In Agronomy, vol. 11, No. 4, p. 711. DOI: https://doi.org/10.3390/agronomy11040711

Xu, Zhitao, and others (2021). The Compounded Effects of COVID-19 Pandemic and Desert Locust Outbreak on Food Security and Food Supply Chain. In Sustainability, vol. 13, No. 3, p. 1063. DOI: 10.3390/su13031063

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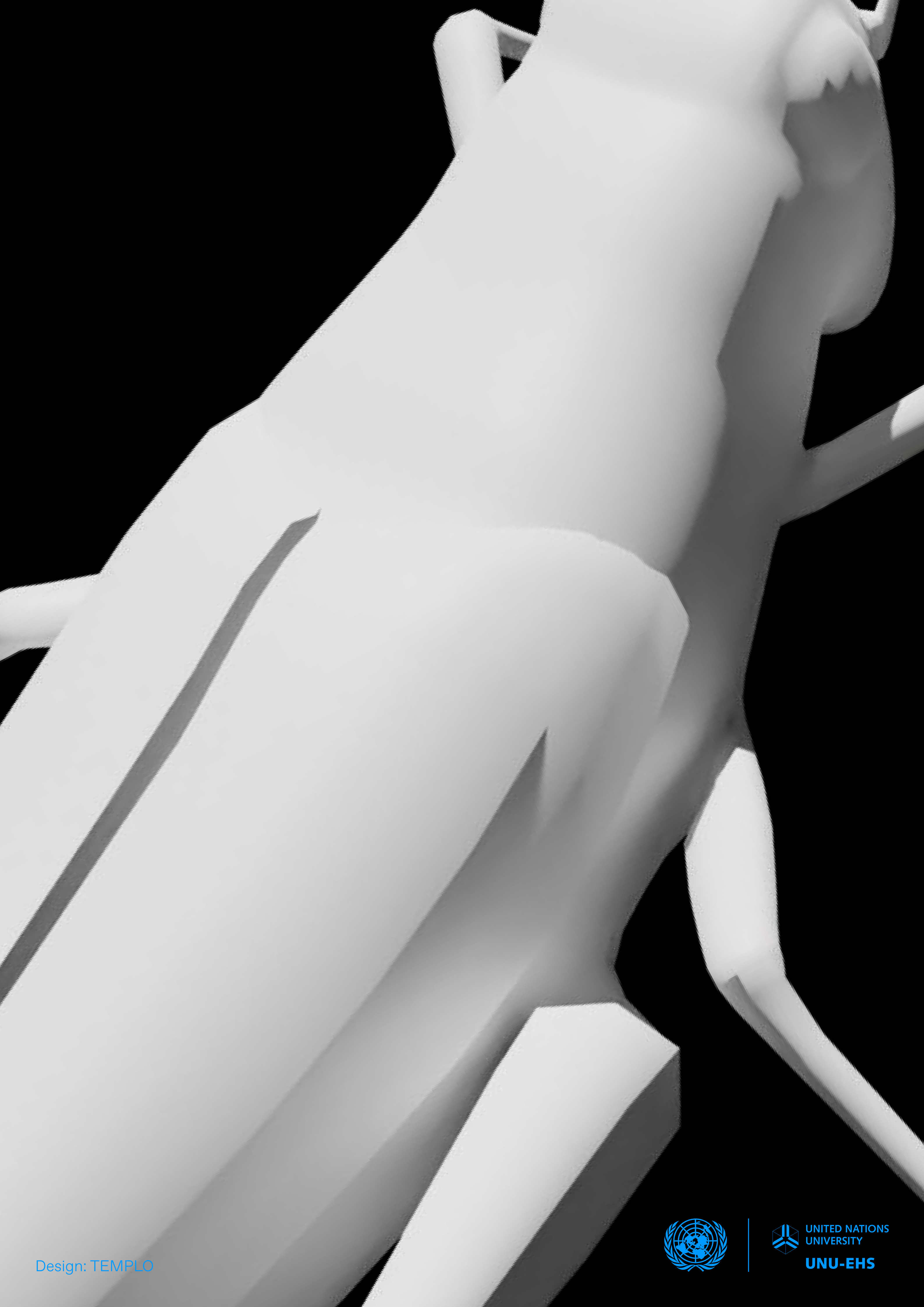

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