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A SCOPING PAPER ON THE ONGOING DESERT LOCUST CRISIS 2019-2021+

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A SCOPING PAPER ON THE ONGOING DESERT LOCUST CRISIS 2019-2021+

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ABBREVIATIONS AND ACRONYMS

AML	African Migratory Locust
CCA	Central Asia and the Caucasus region
COVID-19	Coronavirus Disease 2019
CRC	Commission for Controlling the Desert Locust in the Central Region
DLCO-EA	Desert Locust Control Organization for Eastern Africa
EHS	Environment, Health and Safety
EIQ	Environmental Impact Quotient
EMPRES	Emergency Prevention System
ETOP	Emergency Transboundary Outbreak Pests
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
GLI-ASU	Global Locust Initiative of Arizona State University
ha	hectares
IGR	Insect Growth Regulator
IOD	Indian Ocean Dipole
IPPC	International Plant Protection Convention
IRLCO-CSA	Red Locust Control Organisation for Central and Southern Africa
kg	kilograms
ML	machine learning
OCHA	Office for the Coordination of Humanitarian Affairs
PEA	Pesticide Environmental Accounting
PPE	personal protective equipment
PRG	Pesticide Referee Group
RTE	real-time evaluation
SADC	Southern African Development Community
TCA	True Cost Accounting
TMG	TMG Think Tank for Sustainability
ULV	ultra-low volumes
UNU-EHS	United Nations University Institute for Environmental and Human Security
USAID	United States Agency for International Development
USD	United States Dollar

EXECUTIVE SUMMARY

Against all expectations the Desert Locust upsurge that began in 2019 is still ongoing also at the beginning of 2022. The upsurge continues to profoundly threaten vast regions, especially the Horn of Africa and Western Asia, with already vulnerable regional rural livelihoods and food security put at further peril. Given that due to climate change, conditions favouring desert locust outbreaks will likely occur more frequently and in intensity, this Scoping Paper calls for renewed global governance. In an interconnected world facing unprecedented events and disasters, it is pivotal to instill and coordinate innovative early warning and outbreak prevention systems both at the global and regional level to increase resilience in times of the climate crisis.

Key messages:

1. There is increasing evidence that meteorological shifts (higher temperatures in the Indian Ocean) due to climate change have played an important role in the scale and severity of the 2019 desert locust upsurge.
2. With climate change likely to lay the foundations for more frequent and possibly more intensive outbreaks, the status quo of the distribution of responsibilities of countries and regional and global level needs to be reviewed and adjusted. This equates to better and more rapid coordination, within the realm of superior governance, which is urgently needed in the name of early warning and control, and resilience. Several independent evaluations of the unfolding of the crisis and management methods to date, all underscore this key message.
3. The importance of climate for new patterns and regional distributions of outbreaks of pests and diseases has to be recognised. Prevention and management of transboundary pests and diseases need to be integrated into climate change adaptation and resilience efforts.
4. As in past locust upsurges, the current transboundary outbreak has resulted in millions of litres of highly toxic pesticides being unleashed into the environment, mainly as a measure of "last resort" by countries to mitigate transboundary swarms. It is an imperative to understand the "true cost" of the current desert locust campaign, not just the fiscal costs, but also the expected prohibitive costs to the environment and to

human health caused by such toxic pesticides. In other words, making the invisible costs visible. Once monetised, a compelling case can be made to the multilateral system for creating better global governance and investing in the underpinning early warning and control systems, so that harmful pesticides could eventually be relegated to redundancy.

5. In this respect, and under the domain of effective global governance, it is paramount to put due emphasis on the much-needed political processes in defining roles, responsibilities, and the requisite actions to be undertaken jointly with all stakeholders. In doing so, the potential to optimise on crises prevention collaboratively, also through investing in management systems will be realised, so that the world is better prepared for future outbreaks of locusts and other transboundary pests.
6. TMG's work on locusts should serve as an exemplar to reshape our thinking about transboundary threats considering climate change and how the interplay of science, infrastructure, management strategies and a global governance model can lead to a more resilient future.

INTRODUCTION

"The Horn of Africa is facing the worst desert locust crisis in over 25 years, and the most serious in 70 years for Kenya. The current situation – is set to become a regional plague…. which represents an unprecedented threat to food security and livelihoods in the region and could lead to further suffering, displacement and potential conflict."

Food and Agriculture Organization of the United Nations (2021)[1]

As the quote above shows, the desert locust crisis 2019-2022 continues with locusts still profoundly threatening vast regions while the campaign to control locust outbreaks endures. We recognize the fact that it is very difficult to maintain early warning systems as they exist to date "online" over many years in the absence of prospective threats – or during periods of "recession". Due to several reasons that include a lack of adequate funding, efforts to operationalise early warning systems at the beginning of the crisis came too late.

1 http://www.fao.org/emergencies/crisis/desertlocust/intro/en/

Looking at the bigger picture, the ongoing crisis points to new root causes and therefore to new challenges and questions. One indication might prove to be especially worrisome because of its structural nature: the impact of climate change, which could result in more frequent and intense locust outbreaks. Researchers suggest that "global warming is likely the main cause of locust plague outbreak in recent decades driving egg spawning of up to 200,000–400,000 eggs per square meter."[2] This view is shared by the United Nations University Institute for Environment and Human Security (UNU-EHS) *"Interconnected Disaster Risks"* report which recognizes the recent desert locusts upsurge as **one of 10 interconnected disasters** in 2020-2021 alongside COVID-19, the bleaching of the Great Barrier Reef, the Artic heatwave, Amazon wildfires and more.[3] The aforementioned report highlights the link to climate change warning that "conditions favouring desert locust outbreaks will likely occur more frequently in the future".

If ignored, in the advent of new outbreaks the livelihoods of many could again be jeopardised, and the attainment of development objectives and the stability of entire regions threatened. Desert locusts have plagued humankind throughout history; yet, the current plague in conjunction with global warming, rapid population growth, poverty, conflict, resource deficiencies and other stresses demands a major rethink of how future crises are prevented and managed. Therefore, even with increased funding, a "business as usual" mindset will not adequately tackle the problem. A new type of early warning system with innovative technologies, including prevention and early action measures with less toxic or nontoxic pesticide interventions need to be conceived. This should be accompanied by a governance structure adapted to the new combined challenge of climate change and outbreaks of desert locusts and other transboundary pests.

2 Peng W, Ma NL, Zhang D, Zhou Q, Yue X, Khoo SC, Yang H, Guan R, Chen H, Zhang X, Wang Y, Wei Z, Suo C, Peng Y, Yang Y, Lam SS, Sonne C. A review of historical and recent locust outbreaks: Links to global warming, food security and mitigation strategies. Environ Res. 2020 Dec;191:110046. https://doi.org/10.1016/j.envres.2020.110046 Epub 2020 Aug 22. PMID: 32841638

3 Interconnected Disaster Risks. [Authors: O'Connor, Jack; Eberle, Caitlyn; Cotti, Davide; Hagenlocher, Michael; Hassel, Jonathan; Janzen, Sally; Narvaez, Liliana; Newsom, Amy; Ortiz Vargas, Andrea; Schütze, Simon; Sebesvari, Zita; Sett, Dominic; and Yvonne Walz]. United Nations University – Institute for Environment and Human Security (UNU-EHS): Bonn, Germany. interconnectedrisks.org

From 2019 onwards, swarms of desert locusts have forced affected countries into emergency mode. Understandably, these countries have tried whatever means deemed feasible to mitigate the crisis, increasingly with the use of highly toxic and therefore hazardous pesticides. Some of the chemicals used (such as broad-spectrum insecticides) are banned in the European Union (EU); these types of insecticides harm the environment and decimate natural enemies of locusts so that subsequent generations of locusts are less susceptible to the population control functions of natural predators to mitigate outbreaks. This provokes an anthropogenically-driven vicious cycle which can be broken only if better ways to detect an arising crisis at the earliest possible stage are effectively deployed and, coupled with the development and consistent use of less harmful alternatives to highly hazardous pesticides, would eliminate the need for harmful interventions. This calls for early warning systems already in place to be made more timely in terms of responsiveness and control during the critical window of locust breeding, as well as more accurate and sustainable, thereby safeguarding livelihoods and food security. Harnessing new technologies is key.

Importantly, the desert locust is not the only species that is a cause of concern for rural livelihoods and food security. Although current international attention and this scoping paper are mostly concerned with the desert locust (*Schistocerca gregaria*), there are several species of locusts that have, in parallel, produced outbreaks around the world. These should not be ignored since they pose a similar destructive threat and need to be managed before crisis ensues. In Annex 1, the reader is informed about more than ten other locust species that have recently threatened terrestrial environments and crop and livestock production around the world. Some of these species might expand their range in the near future, potentially reaching regions that are not traditionally considered as outbreak areas such as in Asia and Europe. For instance, researchers warn that the Italian locust "may benefit from global warming and enlarge its range or become a more serious pest in West Palearctic."[4] As temperatures rise and extreme weather events intensify, species of locusts might become more serious pests and control measures will need to be given higher priority.

4 Agronomy | Free Full-Text | Locust and Grasshopper Outbreaks in the Near East: Review under Global Warming Context (mdpi.com)

If we take a step further and consider plant and livestock pests beyond locusts, the need for novel and adaptive management strategies becomes even more urgent. Climate change is predicted to affect the spread of pests and give rise to the emergence of new invasive pests as well as the frequency and intensity of their outbreaks. In 2021, the International Plant Protection Convention Secretariat published the *"Scientific review of the impact of climate change on plant pests – A global challenge to prevent and mitigate plant pest risks in agriculture, forestry and ecosystems"*;[5] this review warns that a single, unusually warm winter may be sufficient to assist the establishment of invasive pests which otherwise would not be able to establish themselves. According to the Food and Agriculture Organization of the United Nations (FAO), "Some pests, like the **fall armyworm** (which feeds on a number of important food staple crops, including maize, sorghum and millet) and **Tephritidae fruit flies** (which damage fruit and other crops), have already spread due to a warmer climate. Others, such as the desert locust (the world's most destructive migratory pest), are expected to change their migratory routes and geographical distribution because of climate change."[6]

Thus, we suggest that further research into the link between climate change and transboundary pests such as (but not limited to) the desert locust is urgently needed not only to fully grasp the interconnectivity and better manage future locust outbreaks but to prevent other emerging risks, as identified by the UNU-EHS report:

1. increasing societal challenges for disaster risk management
2. conflict escalation
3. escalating biodiversity crisis
4. exacerbation of social inequalities

5 IPPC Secretariat. 2021. Scientific review of the impact of climate change on plant pests – A global challenge to prevent and mitigate plant pest risks in agriculture, forestry and ecosystems. Rome. FAO on behalf of the IPPC Secretariat. https://doi.org/10.4060/cb4769en

6 FAO - News Article: Climate change fans spread of pests and threatens plants and crops, new FAO study

Of note, some countries afflicted by the desert locust outbreak such as Yemen and Ethiopia, are also currently affected by conflict. For example, the Ethiopian conflict that began in November 2020 continues to hamper desert locust control in northern regions. This might ultimately lead to more conflict as desert locust swarms heavily affect the regional agricultural sector which is the foundation of the regional economy and social stability.[7] Furthermore, control operations may lead to additional conflict, and in September 2021, FAO gave a worrisome example reporting that in Yemen, beekeepers objected to locust control spraying operations as pesticides would severely harm their bees (as well as other pollinators).[8]

These examples prompt the question: in the long-run, are we really pursuing the most efficient as well as effective control strategies, including whether we have to further accept the long-term effects and costs (beyond fiscal outlays)? TMG Think Tank for Sustainability (TMG) has a record in true cost-accounting (TCA), and we have started to look into the situation in a more holistic and in-depth manner, especially with respect to environmental and human health, with a view to promote higher levels of sustainability and resilience. It is therefore of utmost importance that we learn from the still ongoing crisis in terms of early warning, monitoring and cooperation not only to prevent outbreaks of this highly destructive transboundary pest, but also to protect livelihoods and promote stability, all in the name of increased resilience.

The fiscal costs of the current campaign could run into United States Dollar (USD) 1 billion, as suggested by the incremental increases in the current donor appeal, now extended to the end of 2021 (and possibly beyond). However, understanding the “true cost” of the ongoing campaign – which could be billions of USD, by factoring-in fiscal costs, crop and livestock productivity losses, the cost to the environment, biodiversity and human welfare – should set the grounds for an agenda geared towards a new paradigm of early warning and outbreak prevention.

7 Ethiopian Conflict Hampering Desert Locust Control, UN Says - Bloomberg

8 Microsoft Word - 210908DLupdateE.docx (fao.org)

NO PROGRESS WITHOUT PROCESS

The question is how to organize the required process with fresh ways of thinking, and as a result, to conceive a new “business model“ for handling locust crises? If the scope of the necessary transformation means establishing novel ways not only to manage crises, but also to build resilience for communities as well as environmental assets, the multilateral system will need the active support of Member States. The German Federal Ministry for Economic Cooperation and Development is therefore funding this activity with the goal of identifying new and improved sustainable pest control options for more resilient livelihoods, protecting the environment and ultimately enhancing food security.

The initial evaluations and comments from the United States Agency for International Development (USAID) and FAO concerning the ongoing campaign as well as the UNU-EHS report will surely allow profit from their findings. As a Think Tank for Sustainability, TMG will nevertheless strive to ascertain the root causes of the locust crisis, build on the analysis of first responses (which involve preliminary rounds of discussions with different actors), to eventually form recommendations for the necessary steps towards transforming our current handling of transboundary pests at the global dimension.

There is an imperative to make early warning systems and necessary early action more effective; that means to systematically analyse how the digital revolution can guide the design of a profoundly more effective monitoring and early warning and control system, including integrating the novel challenges arising from climate change. The opportunities afforded by modern information and monitoring technologies to tackle the likelihood of more frequent pest outbreaks in the future, especially in light of climate change, need thorough analysis as well as broad and inclusive consultative processes with a primary focus on desert locusts and beyond to include other threats. We therefore consider this scoping paper a contribution to the debate on resilience in times of crises, **recommending to focus on “resilience – digitalization – governance”** and the necessary research and consultatory processes to work towards a new paradigm of handling transboundary pests and its successful implementation.

The structure of this paper is as follows: Chapter 1 provides an assessment of the salient features of the ongoing desert current campaign, especially its origins and how the international community as well as afflicted countries have responded. Chapter 2 cites evidence from the three already mentioned preliminary evaluations of the current campaign, in which the critical findings and recommendations are discussed in the context of moving the agenda forward. Chapter 3 picks up on an important question raised in the evaluations which concerns the important need for monitoring environmental and human health impacts of the harmful pesticides used in the campaign; by using a survey of the pesticides deployed so far, the concept of TCA is introduced, which aims to enumerate on these impacts. Chapter 4 focuses on the central findings of the paper, sets the stage for discussion, raises several key questions and proposes tangible guidance for prioritising the next steps that aim at building a more resilient world in the face of future transboundary pest outbreaks. Finally, Chapter 5 provides concluding remarks.


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CHAPTER 01

AN OVERVIEW OF THE ONGOING DESERT LOCUST CAMPAIGN (2019-2021+) FROM AN INTERNATIONAL PERSPECTIVE

1.1 INTRODUCTION

Desert locusts (*Schistocerca gregaria*) are classified as *biphasic* – a term referring to the ability to take on two completely different forms. In their *solitary* form, they are benign and pose no threat to crops but under particular environmental and meteorological conditions, they transform into *gregarious* insects, in which their exoskeletons turn electric yellow, and they exhibit swarming behaviour, devouring vegetation and crops in their path.

To set the stage, the following concepts[9] are of importance in framing the paper and to assess the performance and ultimate cost (fiscal, environmental and human health) of the current campaign:

9 Showler, A.T.; Ould Babah Ebbe, M.A.; Lecoq, M.; Maeno, K.O. Early Intervention against Desert Locusts: Current Proactive Approach and the Prospect of Sustainable Outbreak Prevention. *Agronomy* **2021**, *11*, 312. https://doi.org/10.3390/agronomy11020312

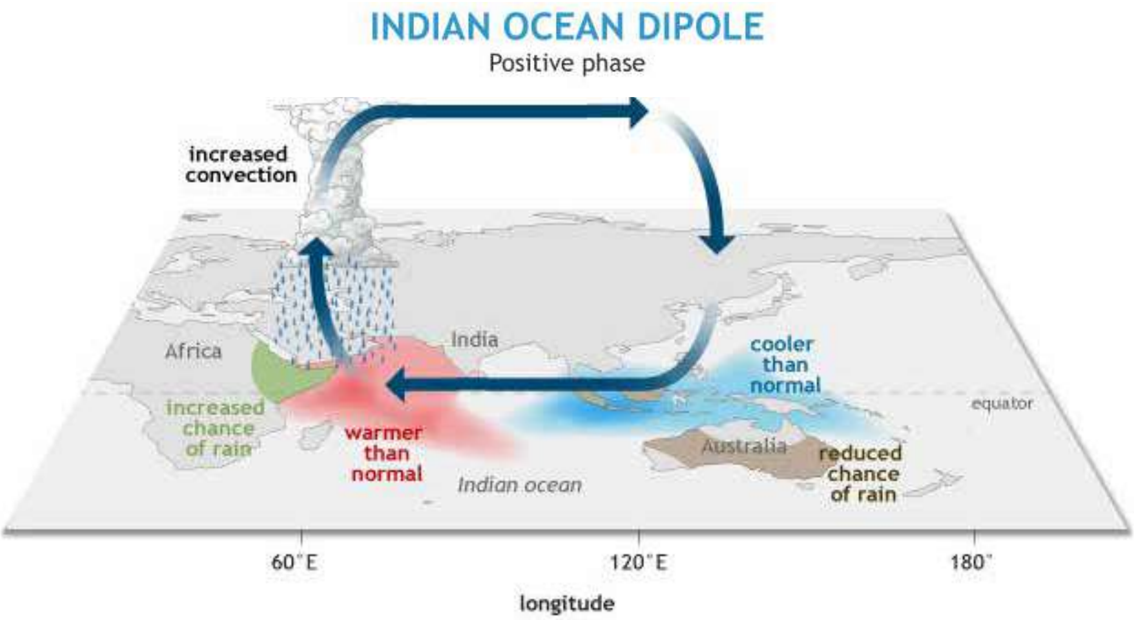
- **"Outbreak Prevention"** – advanced surveillance methods for early warning, detection and methods to halt swarm formation/gregarization, especially through the destruction of breeding grounds. Fiscally prudent, with negligible environmental impact.
- **"Pro-action"** – pesticide action towards dissipating swarms from developing into upsurges and plagues. Both fiscal, environmental, and human costs become a concern.
- **"Reaction"** – expansive pesticide action towards protecting crops and livelihoods; "the last resort". Fiscally expensive and exceptionally harmful to the environment and human health.

1.2 HOW DID THE CURRENT DESERT LOCUST CRISIS BEGIN?

1. Given the ideal meteorological conditions for destructive locust outbreaks to occur - periods of sustained heavy rainfall that succeed periods of sustained dryness/drought, the origins of the current crisis can be traced back to an irregular oscillation of the Indian Ocean Dipole (IOD), colloquially known as the "Indian Niño". The role of the IOD has enabled the exact origins and critical events of the current desert locust crisis to become better understood.
   In a nutshell, the IOD governs sea surface temperatures in the Indian Ocean and in the 'positive phase' the western Indian Ocean becomes warmer relative to the eastern part of the ocean, which can trigger cyclones and extreme rainfall. The IOD was in a positive phase from June to December of both 2018 and 2019. In October 2019, the dipole reached its highest positive level in 40 years.
2. The Arabian Peninsula – the land mass between East Africa and Asia comprising Saudi Arabia, Yemen, Oman, Kuwait, Qatar, Bahrain and the United Arab Emirates – was struck by unusual and severe cyclones between 2018 and 2019. When the first storm – Cyclone Mekunu – hit the Arab peninsula in May 2018, it filled a vast desert in Saudi Arabia - Rub al Khali, also known as the "Empty Quarter", with freshwater lakes.[10] The moisture caused lush vegetation to grow in the habitually barren environment, attracting desert locusts to search for food in the area

10 https://www.carbonbrief.org/qa-are-the-2019-20-locust-swarms-linked-to-climate-change

FIGURE 1 **METEOROLOGY DRIVES DESERT LOCUST UPSURGES**



Source: NOAA Climate.gov

and provided them with an optimal breeding ground. Upon reaching a threshold density – sufficiently high numbers in a given area – the desert locusts switched to their gregarious form, in which they began to swarm, escalating into a transboundary threat.

By the time a second cyclone hit the same region in October 2018, a critical point was reached in which the locusts started to multiply rapidly, increasing their numbers exponentially in just a few months.[11]

Following a particularly mild winter, locusts survived in large numbers, and in the summer of 2019, the insects began to migrate from the Arab peninsula into the Horn of Africa.

3. As the locusts moved through East Africa, the region was also hit by unusually wet conditions (with precipitation 300 percent higher than normal)[12] as well as more cyclones – allowing the swarms to grow even

11 https://www.nationalgeographic.co.uk/environment-and-conservation/2020/02/plague-of-locusts-has-descended-east-africa-climate-change-may

12 https://reliefweb.int/report/south-sudan/east-africa-food-security-outlook-november-2019

larger. Overall, the Horn of Africa was hit by eight cyclones in 2019, the largest number in any year since 1976.

As well as providing the conditions needed for vegetation growth, the cyclones provided winds that enabled the locusts to travel rapidly over long distances, at small energetic cost, yielding more energy for them to reproduce. By the end of 2019, there were swarms recorded in Ethiopia, Eritrea, Somalia, Kenya, Saudi Arabia, Yemen, Egypt, Oman, Iran, India, and Pakistan. Figure 2 provides a geographical snapshot of the countries and regions affected by the desert locust since 2019.

FIGURE 2 **A) LOCUST AFFECTED COUNTRIES 2019-2021 (JUNE)**

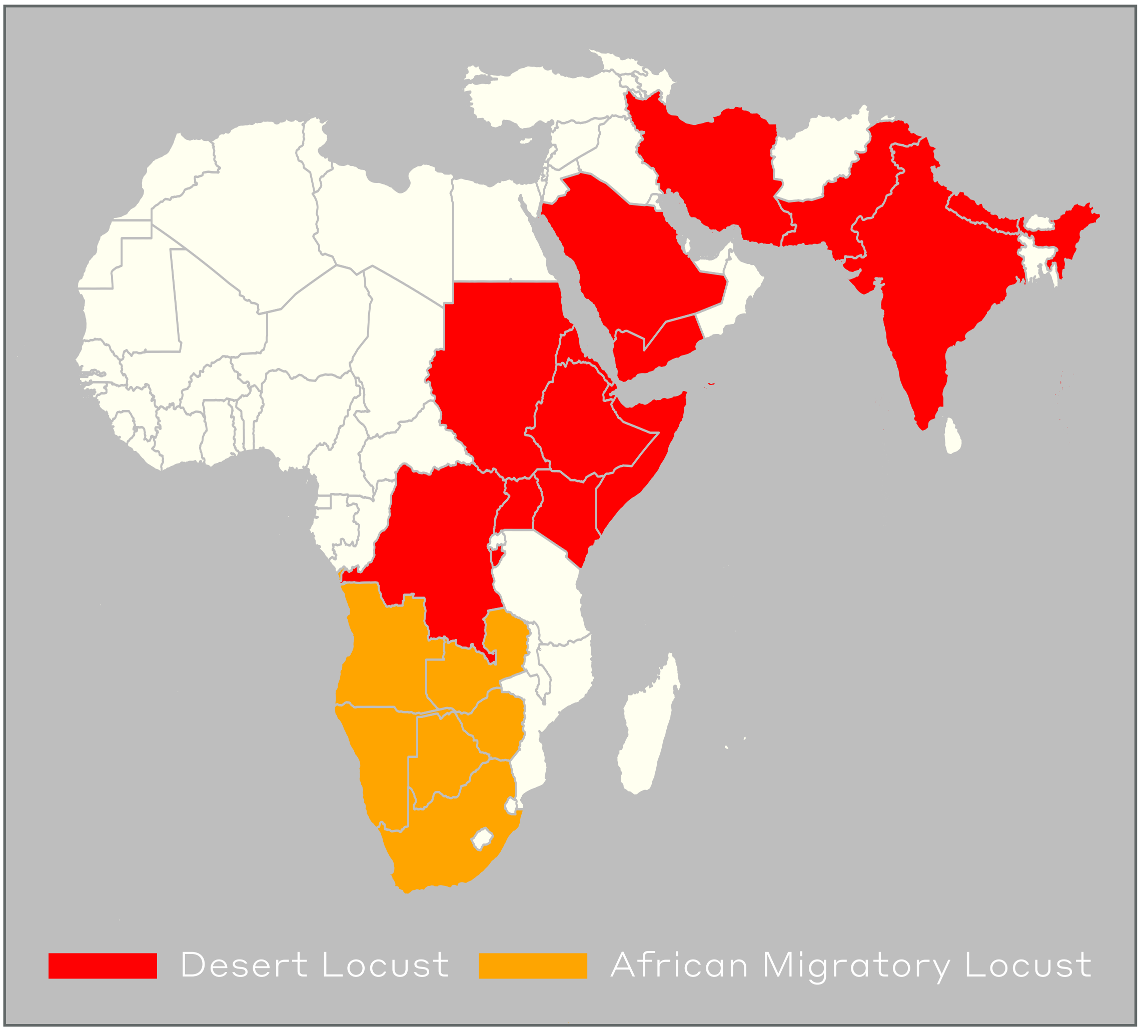
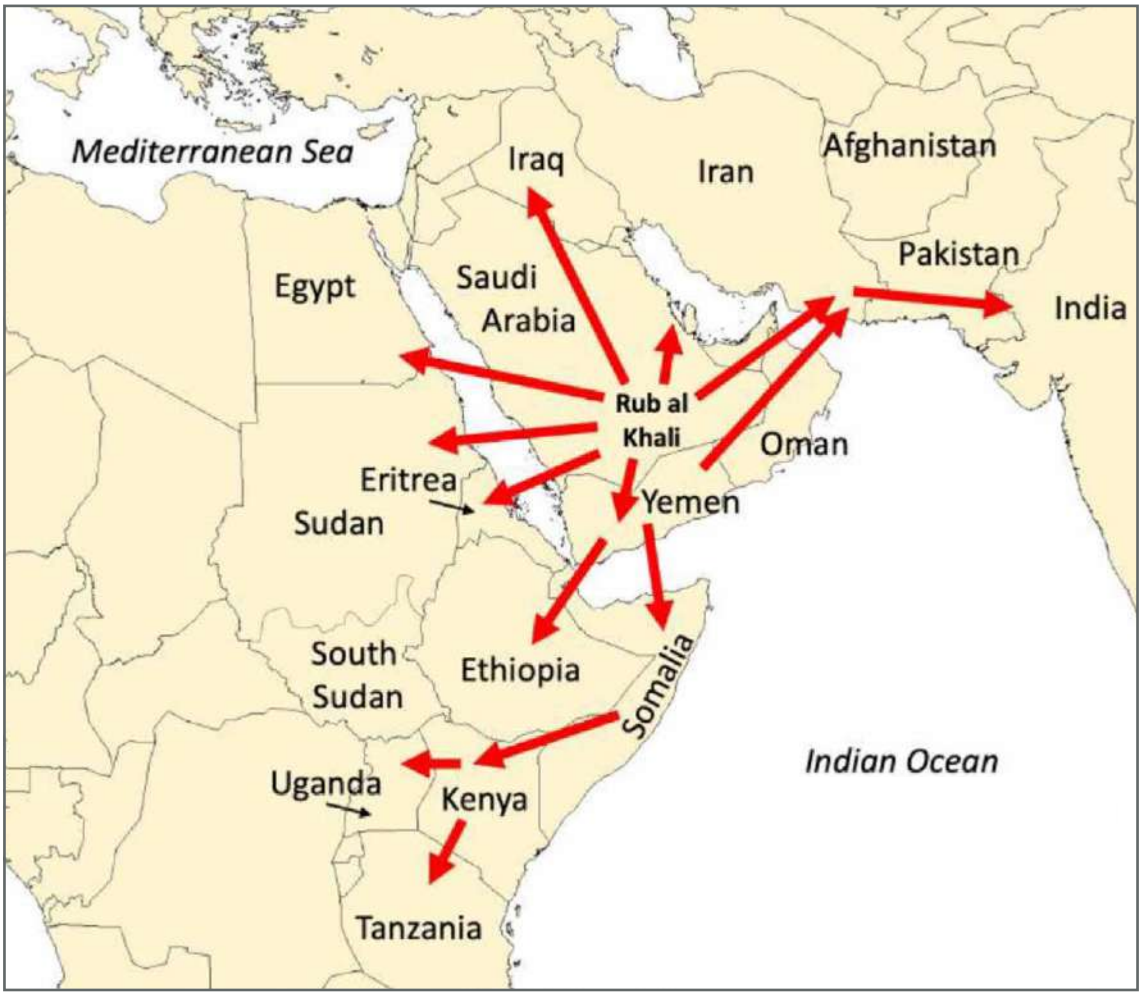


Figure 2 continues on the next page >>

FIGURE 2 **B) ORIGINATION OF DESERT LOCUST SWARMS**



Source: A) Author B) Showler, et.al., 2021 Creative Commons Attribution License

The chronology of events above arguably suggests that the most culpable factor in allowing the crisis to transpire was in the unfortunate failure to detect[13] multiple generations of unprecedented breeding.[14]

13 Central & Eastern region outbreaks (May 2018 to present) (fao.org)

14 Showler, A.T.; Ould Babah Ebbe, M.A.; Lecoq, M.; Maeno, K.O. Early Intervention against Desert Locusts: Current Proactive Approach and the Prospect of Sustainable Outbreak Prevention. *Agronomy* **2021**, *11*, 312. https://doi.org/10.3390/agronomy11020312

While this took place in Saudi Arabia's "Empty Quarter", an additional factor was civil war in Yemen,[15] which severely hampered (conventional) monitoring and (conventional) surveillance operations and possibilities for intervention. At this point, we need to reiterate that the fight against the COVID-19 pandemic not only overshadowed the locust crisis, it also hampered the conventional control of locust outbreaks that relies heavily on the presence of ground teams, which were severely constrained due to the pandemic restrictions. Also, supply chains and logistical operations for essential equipment (including pesticides) were negatively affected by this.

Apart from the overarching problems due to the global pandemic, FAO points to a number of reasons for the difficulties in successfully combatting desert locusts in the "Frequently Asked Questions" section[16] of the Locust Watch website:

- the extremely large area (16-30 million sq. km) within which locusts can be found;
- the remoteness and difficult access of such areas;
- the insecurity or lack of safety (such as land mines) in some areas;
- the limited resources for locust monitoring and control in some of the affected countries;
- the undeveloped basic infrastructure (roads, communications, water and food) in many countries;
- the difficulty in maintaining a sufficient number of trained staff and functioning resources during the long periods of recession in which there is little or no locust activity;
- political relations amongst affected countries;
- the difficulty in organizing and implementing control operations in which the pesticide must be applied directly onto the locusts; and
- the difficulty in predicting outbreaks given the lack of periodicity of such incidents and the uncertainty of rainfall in locust areas.

15 How East Africa is fighting locusts amid coronavirus | Africa | DW | 11.05.2020

16 http://www.fao.org/ag/locusts/en/info/info/faq/index.html

1.3 INTERNATIONAL MANAGEMENT OF THE ONGOING DESERT LOCUST CAMPAIGN

At the international level, FAO has a major role – mandated by its members – to coordinate the monitoring and control of desert locusts. At the heart of FAO's role is its central forecasting and warning service, as well as the coordination of assistance during outbreaks. FAO has described the division of labour in the following way *"the responsibility of controlling locust numbers falls to national governments – with international organisations stepping in during outbreak and crisis situations"*.[17,18]

A deeper look at FAO's role, both historically and currently, in internationally managing desert locust outbreaks is discussed below.

1. FAO, through its members, has also instituted other parallel commissions, such as The Commission for Controlling the Desert Locust in the Central Region (CRC); The Commission for Controlling the Desert Locust in South-West Asia; and The Commission for Controlling the Desert Locust in the Western Region.[19] While these commissions convene regular meetings with their respective Member countries and have been involved in capacity-building,[20] they have limited resources to directly engage in desert locust control.
2. In 1994, FAO launched the Emergency Prevention System (EMPRES) programme,[21] whose objective is to reinforce preventative control capabilities of countries subject to outbreaks and to strengthen regional and international cooperation. The EMPRES programme seeks to reduce regional or transboundary incursion risks, maintain food security and to

17 https://www.carbonbrief.org/qa-are-the-2019-20-locust-swarms-linked-to-climate-change

18 FAO's own role in a typical crisis event is to "call" the emergency and rapidly raise international awareness with the objective of attracting immediate donor funding matching the scale of the crisis. FAO also tasks itself to co-ordinate initiatives on the ground with national and regional bodies, and for funds to be channelled to agencies implementing the necessary ground interventions.

19 FAO regional Desert Locust commissions

20 For example, see http://desertlocust-crc.org/Pages/Bulletin.aspx?DomainId=49&lang=EN&DId=0&I=0&CId=0&CMSId=23&TypeId=49

21 http://www.fao.org/ag/locusts/common/ecg/1344/en/EMPRESbrochureE.pdf

guarantee the preservation of the environment threatened by intensive chemical locust control campaigns.

3. The Desert Locust Control Organization for Eastern Africa (DLCO-EA)[22] was established by an International Convention, recommended by FAO in 1962. Its member countries are Djibouti, Eritrea, Ethiopia, Kenya, Somalia, Sudan, Tanzania and Uganda. DLCO-EA's mandate currently extends beyond locusts to manage threats of other transboundary pests and vectors, such as the fall armyworm.
4. The United Nations Office for the Coordination of Humanitarian Affairs does not divest itself with locust monitoring or control, but it plays a critical role in co-ordinating humanitarian response, especially post-crisis, and also collaborates with FAO in briefing member states.[23]
5. In its capacity as the "lead" agency in monitoring and early warning, FAO manages a number of websites and platforms on the theme of locusts. The main entry point is FAO's Locust Watch:

    - **Locust Watch** (desert locust): Provides regular situation updates by country as well as monthly bulletins. The website contains links to geospatial information on current threats and projections of swarm trajectories.
      http://www.fao.org/ag/locusts/en/info/info/index.html
    - **Locust Hub**: A Geographic Information System data explorer, covering 7-day maps/datasets on Bands, Hoppers, Swarms and Ecology (including condition and density of vegetation and all-important soil moisture maps). (To the best of the authors' knowledge, this is a novel web application, which has been developed and launched amid the current crisis).
      https://locust-hub-hqfao.hub.arcgis.com/
    - **FAO Desert Locust Crisis Page** (FAO Emergencies): Summarises the FAO appeal to donors,[24] provides updates to countries affected and the vulnerable populations within, who have seen their food security status deteriorate. The website also informs of the progress has made in reaching its targets (e.g., acreage targeted for control, crops saved,

22 https://www.dlco-ea.org/

23 https://www.unocha.org/east-africa-locust-infestation

24 http://www.fao.org/3/cb2445en/CB2445EN.pdf

livelihoods protected, transboundary mitigation efforts). The website sets out its funding targets and progress in securing the funding.
http://www.fao.org/emergencies/crisis/desertlocust/en/

- **FAO Dashboard** (desert locust): Latest status of desert locust control operations providing overall snapshots of the current situation, the funding situation, control operations to date, country-specific dashboards and a map of the crisis.
http://www.fao.org/locusts/response-overview-dashboard/en/

6. Bulletins published on the Locust Watch website employ a geographically colour-coded system, in which, regions that are not under threat are termed as **'calm'** and are shaded green, those under **'caution'** are coloured yellow, while those under **'threat'** are depicted in orange, and regions that are perceived to be in imminent **'danger'** of locust upsurges are coloured in red. A perusal of the monthly bulletins archived in Locust Watch for 2018, before and after the cyclones struck the Arabian Peninsula, listed the threat level as green. Only in mid-2019 were several regions (especially the central region covering East Africa) elevated to the orange-threat level. The orange level remained unchanged throughout 2020 and all the way up to the latest bulletin of November 2021 (at the time of writing).[25,26]
7. The Locust Watch also publishes periodic "Desert Locust Briefs"[27] which provide updates to the bulletins. While providing information on the development of swarms, no emergency in the bulletins has been declared to-date (time of writing November 2021), at least not to the scale of the "crisis" – "set to become a regional plague" – that is acknowledged now

25 Example for 2019: Desert Locust Archives 2019 (fao.org); for 2020: Desert Locust Archives 2020 (fao.org); for 2021: Desert Locust Archives 2021 (fao.org)

26 This all being said, FAO defines locust "risk" levels using a further colour scheme, in which "threatened" areas are coloured yellow, and orange is depicted as "serious" which is confusing. It would be useful for the international community to assess these categories in light of the ongoing outbreak and to agree on clear science-based definitions. In addition, the USAID-BHA publishes Emergency Transboundary Outbreak Pests (ETOP) Situation Bulletins on a monthly basis. The bulletins cover the full range of transboundary pests (not just being locust-centric) such as the fall armyworm, African armyworm and Quelea spp. (QSP) bird outbreaks. It is noted that the ETOP relies heavily on information from FAO with regard to desert locusts.

27 Desert Locust briefs 2021 (fao.org)

in the FAO Emergencies home page.[28] The most recent brief (at the time of writing), published on November 11, 2021 depicts the risk as **'serious'** in the central region and as **'calm'** in western and eastern region; the most recent available bulletin No 517 (published 3rd November 2021) describes the central region as **'threat'** whereas eastern and western regions are marked as **'calm'**.[29,30]

In addition, FAO has elevated the ongoing crisis to a corporate priority, and in doing so has also formulated a corporate strategy involving inter-departmental support, as well as attempts to galvanize inter-agency collaboration and action. The strategy,[31] published on the Organisation's Emergencies website [32] is outlined in Box 1.

28 http://www.fao.org/emergencies/crisis/desertlocust/intro/en/

29 Desert Locust briefs 2021 (fao.org)

30 DL517e.indd (reliefweb.int)

31 http://www.fao.org/3/cb2445en/CB2445EN.pdf

32 http://www.fao.org/emergencies/resources/documents/resources-detail/en/c/1364948/

BOX 1

FAO's Strategy[33] to combat desert locusts in the 2020-2021+ campaign

Component 1 – Curb the spread of desert locust focusing only on countries infested or at high risk, or where the fight against desert locust has significantly depleted stocks of pesticides

Component 2 – Safeguard livelihoods and promote early recovery

Component 3 – Coordination and capacity building

- **Applying a range of timely control options adapted to the life cycle of desert locusts**
  - The control of large swarms must be a coordinated effort to avert a major food security and livelihoods crisis as well as to mitigate further spread of the pest to other countries, especially in the Sudan and West Africa.
  - This will mean continuing to provide urgent, large-scale aerial and ground pest control operations as well as surveillance, trajectory forecasting and data collection. During the hopper stages, ground operations are cost-effective and will be prioritized, unless the terrain is too rough and unfavourable for vehicle-mounted sprayers.
  - Once locusts reach adult stage, aerial control operations will be prioritized as they have proven to be successful since March [2021].
- **Anticipating impacts to prevent damages on crops and rangeland by controlling desert locust as early as possible, and therefore protecting livelihoods.**
- **Establishing the crisis as a corporate priority in view of the demonstrated scale, complexity and urgency of the crisis.**

Box 1 continues on the next page >>

BOX 1

FAO's Strategy[33] to combat desert locusts in the 2020-2021+ campaign

- Activating fast-track procedures so that operations can be planned and launched with greater flexibility, including rapid deployment of staff and scaled-up programmes.
- The Organization's current locust response is being handled by the Emergency Centre for Transboundary Plant Pests, which integrates technical and operational capacities under the overall management of FAO's Plant Production and Protection Division and with the Food Chain Crisis – Emergency Management Unit of the Office of Emergencies and Resilience operationally managing the response.
- An additional coordination role and technical and capacity development support are provided by FAO's CRC. Partnering with national governments and key stakeholders to support country capacities that risk being overwhelmed by the scale of the crisis.
- FAO is providing technical and operational assistance for control operations and livelihoods support for the most vulnerable. The partnership with the Intergovernmental Authority on Development, including through the Food and Security and Nutrition Working Group co-led with FAO, has proven to be instrumental in promoting dialogue on desert locust, and harmonizing advocacy and methodologies for damage and impact assessments.
- With regard to partnerships with United Nations agencies, FAO and the World Food Programme have worked together since the beginning of the crisis in various areas, including logistics capacity and opportunities for triangulation of various equipment
- The United Nations Office for the Coordination of Humanitarian Affairs has been and will remain instrumental for coordination, outreach and resource mobilization, including through facilitating access to the Central Emergency Response Fund. The Regional Desert Locust Alliance and the food security clusters are also fundamental entry points for coordination at country level between all stakeholders, including international and national non-governmental organizations.

- Advocating for flexible funding to ensure maximum impact in a rapidly evolving situation, FAO is advocating that resource partners contribute to the Locust Window of the Special Fund for Emergency and Rehabilitation Activities . This mechanism provides FAO with the financial means to react quickly to crises, reducing the time between funding decisions and actions on the ground.

- Engaging with the Global Network Against Food Crises, a partnership created to identify and jointly implement durable solutions to food crises, will be engaged to support coordination, consensus building, and serve as a platform to discuss the most effective programmatic approaches. The Global Network has a key role to play in supporting the uptake and mainstreaming of early warning early action, as well as ensuring lessons learned are utilized, documented and disseminated within the framework of knowledge management.

33 http://www.fao.org/3/cb4925en/cb4925en.pdf

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CHAPTER 02

EVALUATIONS, DISCUSSIONS AND QUESTIONS ARISING FROM THE ONGOING CAMPAIGN

2.1 INTRODUCTION

FIGURE 3 **A SYNTHESIS OF FAO'S INTERNAL EVALUATION ON THE CURRENT DESERT LOCUST CAMPAIGN**

PHASE I	PHASE II	PHASE III
JUNE-SEPTEMBER 2020	OCTOBER-DECEMBER 2020	JANUARY-JUNE 2021
1. Leadership, management, coordintaion and partnership. **2.** Preparation phase prior to January 2020. **3.** Advocacy and operational processes. **4.** Synthesis of results observed in data collection activities so far.	**5.** Output and outcome level results within country case studies. **6.** Management and operational processes. **7.** Extent to which lessons from countries and regions are transferred to other countries.	**8.** Lessons learned after one year. **9.** Recommendations for future upsurges. **10.** Recommendations for continuing desert locust management in the Horn of Africa and elsewhere.

Source: FAO. 2020. Real-time evaluation of FAO's response to desert locust upsurge (2020-2021) – Phase 1. Evaluation Series, 12/2020. Rome

http://www.fao.org/3/cb2437en/CB2437EN.pdf

A - To shed further light on FAO's responses and also respond to public criticism and demands by member states, FAO's own Office of Evaluation was requested to conduct a real-time evaluation (RTE) of the campaign. The evaluation was structured along three phases over the course of twelve months with each evaluation phase covering specific aspects of the response.

The RTE of Phase I (concluded) had two dimensions:

1. **Mutual accountability:** providing an independent assessment of what FAO and its partner organisations have achieved since January 2020, including timeliness and sufficiency of resourcing, efficacy of the operations and the environmental impacts of control operations.
2. **Learning for FAO and all partners and stakeholders** on what has and has not worked, and what should be done to adjust current and future operations.

The overall scope of the three-phase evaluation sought to build an "evidence base" to answer the following questions:

1. To what extent did FAO's leadership, management and technical capacity support a relevant, timely and effective system-wide response to the desert locust upsurge?
2. To what extent was the response coherent with FAO's other operations and those of other actors?
3. What were the positive, negative, intended and unintended results of FAO's actions in terms of food security, livelihoods and resilience of affected households and communities?
4. What have been the enabling factors and limiting constraints on the effectiveness of FAO's response?
5. To what extent did FAO's processes support innovation and learning across the affected regions?

The results of the evaluation of Phase I were published at the end of 2020[34] and are repeated verbatim as follows **(parts of the official findings which are of importance to the inquiry of this scoping paper have been emboldened by the authors):**

34 FAO. 2020. Real-time evaluation of FAO's response to desert locust upsurge (2020-2021) – Phase 1. Evaluation Series, 12/2020. Rome. http://www.fao.org/3/cb2437en/CB2437EN.pdf

- **Conclusion 1.** FAO's regional coordination mechanism has proven effective given the nature of the crisis, but it remains unclear how best to coordinate the livelihood response at this stage.
- **Conclusion 2.** In hindsight, the 2020 appeal was well timed in that it balanced the operational need for early action with the advocacy need for donor engagement. **Questions remain about the best way to turn locust forecasts into early warning and ultimately early action.**
- **Conclusion 3. The production and dissemination of FAO's locust forecast, whilst broadly effective as a warning device at country-level, was not sufficient to sensitize donors to the risks posed by the upsurge in the months leading up to January 2020, and questions arose regarding the internal communication channels between technical and emergency teams.**
- **Conclusion 4.** The wider funding response has been unusually strong in both scale and rapidity.
- **Conclusion 5.** The reputation of FAO's technical capacity on desert locusts has been a critical part of both the donor response and the engagement of locust-affected countries.
- **Conclusion 6.** The pre-existing regional capacity for locust control in the Horn of Africa was significantly lower than in southwest Asia, with concerns raised about the functioning of DLCO-EA and the ability of CRC to raise funds from member states in a timely fashion.
- **Conclusion 7.** National engagement in capacity-building and surge activities varied greatly, with successes observed in Kenya and Pakistan, good progress made in Somalia, despite persistent challenges round data collection and reporting, whilst critical difficulties remained in Ethiopia and Yemen.
- **Conclusion 8.** The quality and breadth of surveillance data is one of the success stories of this upsurge, despite significant gaps existing in certain areas and questions about the sustainability of FAO's desert locust monitoring and forecasting expertise in the longer-term. **Innovations in the use of satellite imagery, whilst still embryonic, demonstrate the potential to improve data collection where access constraints and internet outages present obstacles to traditional approaches.**
- **Conclusion 9.** Control operations have been broadly successful, contributing to the limitation of potentially significant movements from Kenya towards Sudan, in conjunction with supportive meteorological conditions. But problems remain in some countries.

- **Conclusion 10. Procurement and pesticide triangulation was a significant barrier to timely response, with constraints arising from limited market supply** and transport restrictions resulting from the COVID-19 pandemic.
- **Conclusion 11.** Targeting of livelihood protection activities to those most affected by desert locusts has proven challenging in the Horn of Africa, given the number of pre-existing drivers of food insecurity in the region. This could potentially impede the targeting of those most affected by the desert locust upsurge, although it is too early to say at this stage.

The FAO RTE Phase I produced a number of recommendations that touch on issues surrounding governance, co-ordination and communication; for example:

- **Recommendation 2.** To FAO member countries, senior management and donor liaison teams. Strengthen the FAO-donor relationship regarding threat prioritization and proactive allocation of resources to better translate surveillance and forecast data into coordinated advocacy and preparedness **ahead of time**; whilst simultaneously reviewing internal communication between technical and emergency units.
- **Recommendation 4.** To FAO senior management. Review resourcing for the production of desert locust forecasts, in order to ensure FAO's technical expertise and capacity for surveillance and objective data provision is sustainable for the long-term future.
- **Recommendation 8.** To FAO senior management and desert locust technical division. Devise a strategy for the Horn of Africa regarding sustaining desert locust management capacity beyond 2020 at both country and regional level, including: the capacity to manage desert locust information systems within country without FAO headquarters direct support.
- **Recommendation 9.** To FAO emergency response team. Prioritize coordination of the livelihood protection response with country-level actors, including country food security cluster bodies.

In October 2021, FAO released its internal evaluation of Phase II. However, the conclusions and recommendations of the Phase I evaluation are more relevant to our scoping perspective as it focused on the initial stage to prevent outbreaks through early warning and early action; this aspect seems absolutely critical and therefore forms the pivotal point of this scoping paper.

Some findings of the evaluation of relevance for our work focusing on "pro-actionary" and "reactionary" efforts (as emphasised in Phase II) deserve to be highlighted and are presented *verbatim* in Box 2.[35]

B - In October 2020, the USAID conducted a Programmatic Environmental Assessment on Desert Locust Control and Surveillance, evaluating the foreseeable significant environmental and human health effects of USAID support to desert locust surveillance and control, including assistance to pesticide procurement and/or use.

The USAID evaluation lists several shortcomings in response to the crisis, especially in early-warning, preparedness and effective pesticide control as seen in Box 3. Many of these shortcomings are levelled against governance. **Findings that are of direct and recurring relevance to the questions being asked in this scoping paper have been marked in bold.**

35 Real-time evaluation of FAO's response to the desert locust upsurge 2020–2021: Phase II

BOX 2
Synthesis of the outcomes of FAO's Phase II internal evaluation of the ongoing desert locust campaign

CONCLUSIONS

Effectiveness: FAO made significant contributions across the full spectrum of preparation, surveillance and control of locust swarms and livelihood protection in the Horn of Africa and South West Asia. FAO contributed to the reduction of swarm size and damage to crops and livelihoods assets in the Horn of Africa and South West Asia; and helped to guard against the spread of locust movements into the Sahel. FAO also contributed to reducing the food insecurity of locust-affected households in the Horn of Africa.

Relevance and timeliness: Support was well-tailored to national capacities and food security contexts in most cases. FAO faced some specific challenges in adapting its response to the political contexts in Ethiopia and Somalia. The decision to scale-up livelihoods operations in the third quarter of 2020, while based on good data regarding damage assessments in the region, did impact the utility and relevance of some of the support provided.

Enabling factors and constraints: Some issues were observed in pesticide selection by individual countries, which impacted the effectiveness of control operations. The locust response took place in a uniquely challenging external context. Procurement processes hampered FAO's efforts to ensure timely supply of equipment and pesticides for control operations.

Coordination: FAO performed very well on the coordination of what was a highly complex, multi-component and multi-actor response, including most notably the transparency of its learning processes. FAO was able to build and maintain new partnerships in this response, including with foundations and private actors.

Innovation and learning: The response utilized a number of innovations in survey and control approaches combined with good information sharing between countries; but more could have been done to strategically embed innovation and learning

Box 2 continues on the next page >>

BOX 2

Synthesis of the outcomes of FAO's Phase II internal evaluation of the ongoing desert locust campaign

across contexts. Good efforts have been made to increase the strategic, medium, long-term, learning across contexts and partners, as FAO emerged from the initial emergency phase in 2020. If continued, these efforts will improve the preparedness of the international community to future locust upsurges.

RECOMMENDATIONS

Six priority areas for recommendations from the Phase II evaluation process, with distinct recommendations at the country-level being made for each one:

- country-level training and capacity development
- national locust control architecture
- procurement
- pesticide management
- livelihoods support
- innovation and learning

BOX 3
USAID evaluation of the FAO response (October 2020)[36]

Known Failure Modes and Critical Gaps Leading to Ineffective Control and/or Elevated Environment, Health and Safety (EHS) Risks:

- **Failing to Prevent an Upsurge.**
- Technologies cannot replace scouting in remote locations, which means that poor access to these locations due to insecurity or other reasons presents significant challenges. **However, it should be noted that current satellite imaging technology allows for identification of areas which may have a high probability of supporting significant locust breeding and possible gregarization.**
- Not appropriately heeding early warning signs and mobilizing in advance, allowing an infestation to pass the threshold beyond ready control. For example, in Kenya, the government was taken by surprise by the December 2019 desert locust invasion, as it had not encountered desert locust in 70 years and did not heed warnings.
- **Inadequate Preparedness.**
- Basic infrastructure gaps, including roads, communications, storage facilities, running water, electricity.
- Contingency plans that are too general, lacking detailed actions and processes for mobilization and Standard Operating Procedures.
- Lack of permanent (autonomous/semi-autonomous) locust control units that monitor weather and environmental conditions and carry out regular surveillance and monitoring to identify when conditions are right for locusts to start breeding. Such must have the technical, material and administrative capacity to develop action plans to launch preventive in close collaboration with concerned national authorities. For example, in Ethiopia and Somalia, stakeholders recommended that a desert locust control unit be organized and permanently established at the national level.

Box 3 continues on the next page >>

BOX 3

USAID evaluation of the FAO response (October 2020)[36]

- Maintaining inadequate inventories of critical equipment, e.g., sprayers and personal protective equipment (PPE).
- Limited technical and managerial human resources capacity.
- Long-term research to develop a regional integrated pest management plan.
- **Constraints to Implementation of Safe and Effective Control Campaigns.**
- Climatic conditions (e.g., heavy rains and unexpected severe weather), difficult-to-access and/or remote locations, and unsafe or unfavourable security conditions. For example, in Somalia and Kenya, the location of locust infestation occurred in hard to access remote areas of each country, confounding surveillance and desert locust control.
- **Non-existing or Inadequate planning, coordination, and decision-making mechanisms necessitating their development or revision when an upsurge is already in process.**
- Need for capacity building and training while an upsurge is already in progress.
- Poor infrastructure, including lack of roads, communications, storage facilities, water shortages.
- Limited availability and/or quality of accessible infrastructure and systems to safely store, return, triangulate remaining inventory of used pesticides or dispose of unusable stocks.
- Insufficient supplies and poor supply chain management.
- **Difficulties in using least toxic biological pesticide (e.g., due to mixing, temperature, equipment requirements and availability).**
- **Limited EHS mitigation and monitoring systems.**
- Insufficient amount or quality of appropriate PPE and inadequate training of pesticide applicators and handlers. For example, in Kenya and Ethiopia, where commercial pesticide application services are well developed, many applicators mobilized for ground application were not adequately trained.
- **Somalia, the national ministry of health and local health agencies were not involved in any stage of desert locust control from planning to implementation and monitoring.**
- **Limited ability to address short and long-term adverse impacts on human health.**
- **Limited ability to mitigate and monitor environmental impacts during and post operations.**

36 https://www.usaid.gov/sites/default/files/documents/USAID_EAFR_Locust_PEA_FAO_11-10-20_508_Compliant.pdf

C - Moreover, the UNU-EHS *"Interconnected Disaster Risks"*[37] report, which, as previously noted, recognised the current desert locust upsurge as one of 10 interconnected disasters in 2020-2021,[38] identifies the following key root causes of the desert locust outbreak which confer with the preliminary findings of this scoping paper:

- full environmental costs undervalued in decision-making
- insufficient disaster risk management
- human-induced greenhouse gas emissions
- insufficient national/international cooperation

The report highlights that the opportunity to prevent this disaster was missed:

"Starting in 2018, a series of unfortunate events unfolded that led to this opportunity being missed, allowing swarms of desert locusts to form and spread across 23 countries on multiple continents between 2019 and 2021, devouring their weight in vegetation every day [...] missing crucial intervention points due to regional and local barriers to management led to 23 countries facing serious impacts over food security and livelihoods."

2.2 A PRELIMINARY DISCUSSION OF THE FINDINGS OF THE EVALUATIONS AVAILABLE TO DATE

The FAO RTE and USAID evaluations as well as the UNU-EHS report are so far the most comprehensive documents evaluating the locust crisis. In this section we discuss the findings that are of utmost relevance to the scoping paper.

1. Conclusions 2 and 3 of the FAO RTE as well as those from USAID and the UNU-EHS seem most important to follow-up on, emphasising the shortcomings of early-warning efforts.

37 Interconnected Disaster Risks. [Authors: O'Connor, Jack; Eberle, Caitlyn; Cotti, Davide; Hagenlocher, Michael; Hassel, Jonathan; Janzen, Sally; Narvaez, Liliana; Newsom, Amy; Ortiz Vargas, Andrea; Schütze, Simon; Sebesvari, Zita; Sett, Dominic; and Yvonne Walz]. United Nations University – Institute for Environment and Human Security (UNU-EHS): Bonn, Germany. interconnectedrisks.org

38 Including COVID-19, the bleaching of the Great Barrier Reef, the Artic heatwave, Amazon wildfires and more

2. Conclusion 8 of the FAO RTE might reveal a certain lack of technological awareness on the part of the evaluator, who commended FAO for using "satellite imagery, whilst still embryonic"; remote sensing and earth observation technologies have been used for more than a decade to detect breeding grounds (soil moisture) and feeding grounds (vegetal vigour). The USAID evaluation also confirms this. Nevertheless, in terms of innovation, only **three** Unmanned Aerial Vehicles (drones), are listed in the procurement plan, as well as a limited number of FAO "eLocust" devices – a satellite-enabled tablet to monitor difficult-to-access territory, which allows ground and control teams to identify green vegetation where potential locust incursions could occur.
3. The FAO RTE recommendation 8 deserves comment and perhaps further deliberation in respective governing bodies; in particular, the notion "the capacity to manage desert locust information systems within country **without FAO headquarters direct support**." A well-functioning, early-warning desert locust information system requires significant technical capacities to instil and manage. Equipment costs can be very expensive, but can be reduced by subscription to "cloud processing services", that are capable of ingesting enormous amounts of real time data such as weather and ecological data from satellites to then use machine learning (ML) algorithms to make predictions on locust threats by way of high-probability detection of breeding grounds. It might be an important governance question whether desert locust systems implanted at the country level (or better still at the regional level) would be more effective.
4. A discussion is necessary if countries would need better international support earlier in the outbreak. First studies are coming to the conclusion that countries are concentrating mainly on action on their own territory with little or no action on the prospect of swarms extending beyond their borders.[39] So far, the conclusions of FAO's Phase I evaluation did not remark on the costs of the campaign and have not linked the clear window for earlier detection, which was missed, with huge budgetary cost implications to the campaign.

39 Showler, A.T.; Ould Babah Ebbe, M.A.; Lecoq, M.; Maeno, K.O. Early Intervention against Desert Locusts: Current Proactive Approach and the Prospect of Sustainable Outbreak Prevention. Agronomy 2021, 11, 312. https://doi.org/10.3390/agronomy11020312

5. While pesticides are mentioned in conclusion 10, there is no mentioning of the environmental costs of the pesticides used in the current campaign - several of which are known to be highly toxic to humans and to the environment.
6. The role of FAO EMPRES is **"to guarantee the preservation of the environment threatened by intensive chemical locust control campaigns"**, and just as importantly, this activity was highlighted in the FAO RTE Phase I. Nevertheless, the USAID evaluation highlighted limited environment, health and safety mitigation and monitoring systems and UNU-EHS report noted that environmental costs are undervalued in decision making.[40]
7. While the FAO Strategy appears coherent (see Box 1), the recurrent criticism we see is that the Strategy, published in December 2020, refers to both reaction and pro-action while suggesting the pre-emptive interventions that should have taken place at least 12 months prior. Apart from the size of the funding appeal, the current campaign seems to differ little from past campaigns (e.g., West Africa 2003-2005). For instance, conventional (highly toxic) pesticides are still the order-of-the-day, as well as are vehicle-mounted sprayers, knapsack (backpack) sprayers for ground teams, camping kits, radios, Global Positioning System devices, etc.
8. Revisiting the origins of the current crisis and the preliminary actions taken then by the countries under threat, if early warning signs were heeded in 2018, would an emergency regional summit have supported and guided the afflicted countries better in the choice of optimal interventions to contain the prospect of outbreaks? In order to prepare for future outbreaks, the international community might be well advised to learn from the past as well as the experiences of the still ongoing campaign and strive to find the best possible support formats available today. Lesson learning is critical, and it would be important to avoid that these go unheeded.

40 In November 2021, FAO released three (internal) environmental monitoring reports, split over the period July 2020 to April 2021. However, the reports were restricted to Kenya, and provided details of FAO engagements in training staff in safe pesticide handling. The reports made mention of "rapid assessments" of negative environmental and human health impacts (none were found), but concluded in the final report the need "To undertake internal and external environmental audits at all sites as a mandatory ... requirement for compliance assessment to the environment and health regulations." Also, "Medical examination of the control teams before the next campaign. Baseline AChE (neurofunction) levels should be taken for all control staff (for organophosphates and carbamates)".

9. The problem with regards to timing, (undisputedly a most decisive factor in fighting locusts) is one of the uncomfortable observations that must lead to lessons learnt for a better early-warning system in the future. **A recent paper by Showler et. al. (2021)[41] confirms this:** *"had the initial outbreak in the Rub al Khali of Saudi Arabia (a.k.a. the Empty Quarter) been detected in summer 2018, swarms might not have reached Yemen, the Red Sea coast of Africa, and parts of Iran .... Effective surveillance and control would have eliminated further spread in concert with the substantial control operations that occurred in Egypt, Eritrea, Ethiopia, and Sudan, and other countries adjacent to them (e.g., Tanzania, Uganda). The episode illustrates how a chain of worsening desert locust population events resulted because of unpreparedness ... A timely proactive approach or an outbreak prevention approach in the Rub al Khali, a relatively limited area, would have pre-empted the possibility of an upsurge."* The authors also suggest *"that pro-action and outbreak prevention require more smoothly operating national and regional organizations dedicated to early intervention, technical and funding mechanisms that provide sustainable support during recessions and gregarious episodes, heightened sustained vigilance.... [and] alleviation of impediments*".

2.3 AN OVERVIEW OF THE FINANCIAL SIDE OF THE INTERNATIONAL RESPONSE TO DATE

FAO had initially appealed for USD 270.4 million for the period from January 2020 to June 2021. Citing the "scale, complexity, urgency, capacities to respond and reputational risk", FAO extended its appeal further, from June 2021 to December 2021, for a campaign total of USD 353.4 million. According to the FAO "dashboard" (accessed January 2022), the Organisation has received USD 242.7 million, leaving a funding gap of USD 110.7 million,[42]

41 Showler, A.T.; Ould Babah Ebbe, M.A.; Lecoq, M.; Maeno, K.O. Early Intervention against Desert Locusts: Current Proactive Approach and the Prospect of Sustainable Outbreak Prevention. Agronomy 2021, 11, 312. https://doi.org/10.3390/agronomy11020312

42 Desert Locust Response Dashboard | FAO | Food and Agriculture Organization of the United Nations

"to expand its support for rapid control and surveillance operations in the Greater Horn of Africa and Yemen, Southwest Asia and West Africa and the Sahel ... and [putting] in place anticipatory action, prevent a deterioration in the food security situation and safeguard livelihoods".[43]

Aside from the donor appeal, it is yet unknown how much FAO is investing of its own resources (mostly staff time) to the crisis, nor is the fiscal cost incurred by each country in dealing with the crisis within their borders yet known. Also, the extent of financial support (grants or loans) from other multilateral institutions is outstanding.

The current crisis is far from over and the total fiscal cost of the campaign will be known only later; research will be needed to quantify negative environmental impacts of chemical pesticide spraying and the cost to human health.

To corroborate the expected scale of the current campaign cost, the fiscal expenditure of the response during the last major desert locust outbreak in 2003-2005 in West Africa (again involving a blend of pure pro-actionary and reactionary measures), according to the World Bank, increased from USD 1 million in June 2003 to USD 100 million just 14 months later. Ultimately, it cost over USD 450 million to end the 2003-2005 upsurge (USD 900 million at 2021 prices), which also caused an estimated USD 2.5 billion in crop damage.

Fiscal costs must be balanced against the economic benefits of the campaign. In this regard, as of June 2021, FAO claims that 4.3 million metric tonnes (mt) of cereals have been saved from the locust threat which translates to USD 1.3 billion of income saved (USD 300 per tonne of cereals) or the equivalent annual food security of 28.8 million people (assuming 150 kilograms (kg) per person per annum).

As signified by the escalating funding appeal, the lack of outbreak prevention measures based on early-warning and state-of-the-art surveillance, would lead the campaign to becoming potentially very costly, especially with the number of countries affected and with budgetary needs escalating over time. If outbreak prevention succeeded there would be no need for costly aerial and ground operations that involve the procurement of expensive and toxic pesticides.

43 http://www.fao.org/emergencies/crisis/desertlocust/intro/en/

Indeed, the FAO approach to involve a mixture of pro-actionary and reactionary strategies might even prove to be the costliest form of control;[44] therefore, it should be thoroughly and jointly evaluated not only by the donor Member States of FAO, but by all stakeholders and partners.

Finally, returning to the all-important point, while pesticides may be considered a benign solution to thwart crises, environmental and human costs are potentially significant (as discussed later). This points to the option of a "false economy" of chemical pesticide use, that should not be disregarded, and will therefore be one of the focal areas of our work.

44 Showler, A.T.; Ould Babah Ebbe, M.A.; Lecoq, M.; Maeno, K.O. Early Intervention against Desert Locusts: Current Proactive Approach and the Prospect of Sustainable Outbreak Prevention. Agronomy 2021, 11, 312. https://doi.org/10.3390/agronomy11020312

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CHAPTER 03
FIRST STEPS TOWARDS UNDERSTANDING THE DESERT LOCUST CRISIS

3.1 INTRODUCTION

The final point made in the previous chapter leads enquiry into a fundamental issue with conventional locust campaigns, such as the current one, in that little emphasis has been placed on the environmental and human health costs of pervasive chemical pesticide use. That the environment is no longer a free good has been put aside against the need to dissipate the ensuing transboundary swarms. Balancing the costs of the campaign – the true costs – should help understand the response system in place. It should be matched with projections with regards to impacts by climate change, but this is beyond the scope of this paper. To date, what we could do, was to have a first look at the “true” costs of the response system in place.

The fiscal costs of the campaign (donor financing or public expenditures by the affected countries) are straightforward to enumerate through standard book-keeping methods. However, understanding and quantifying the harmfulness of pesticides, or in the parlance of economics “pesticide externalities” is elusive. Nonetheless, identifying these costs is of critical importance. Effective decision-making should always be supported by an evidenced-based approach. Consequently, measuring the environmental and human risks that pesticides pose, in monetary terms ("internalising the externality"), would allow the potential for further resources to be channelled towards developing superior bio-pesticides, pheromones and other environmentally friendly technologies to prevent and control locusts. The evidence would also potentially support further investment in technological innovations in the early warning systems, spurring policy-makers, environmental advocates and the general public towards less invasive action, especially interventions aimed at outbreak prevention.

This part of the scoping paper thus puts into perspective the array of toxic pesticides used in the current campaign and their pervasive use, with a view, *prima facie*, to understand the potential harm to the environment and also to human health and introduces the methodology of TCA building upon the research in Senegal (West Africa) 2003-2005 locust incursion.

3.2 OVERVIEW OF SYNTHETIC PESTICIDES USED IN THE ONGOING CAMPAIGN

Insecticide operations began in March 2020 and by March 2021 officials in Djibouti, Eritrea, Ethiopia, Kenya, Somalia, South Sudan, Sudan, Uganda and Yemen had sprayed 1.8 million litres of pesticides, which could conceivably rise to well over 2 million litres by the year end.[45] With the majority of insecticides applied being synthetic (and of the organophosphate class), concerns have been raised over potential health and environmental impacts.

Predominantly, four synthetic insecticides, namely **chlorpyrifos**, **deltamethrin**, **fenitrothion and malathion** were used in the in the 2020-2021 campaign. The list of pesticides (including Insect Growth Regulator (IGR) Teflubenzuron and biopesticide *Metharhizium acridum* that were used to a much lesser extent) and their respective concentration and coverage are shown in Table 1.

45 A locust plague hit East Africa. The pesticide solution may have dire consequences. (nationalgeographic.com)

TABLE.1 **BREAKDOWN OF MAJOR PESTICIDE USE IN THE ONGOING CAMPAIGN**[50]

PESTICIDE	CONCENTRATION (GRAMMES PER LITRE, G/L)	VOLUME (LITRES PER HECTARE, l/ha)	COUNTRY USAGE
Chlorpyrifos	240 g/l	1 l/ha	Ethiopia, Kenya
Deltamethrin	12.5–17.5 g/l	1 l/ha	All countries under the appeal, except Somalia
Fenitrothion (aka Sumithion)	400 g/l	1 l/ha	Kenya
Malathion	925 g/l	1 l/ha	Ethiopia, Kenya
Biopesticide Metarhizium	5x1010 spores/g	0.05 kg/ha	Ethiopia, Kenya, Somali
Teflubenzuron (Insect Growth Regulator - IGR)	-	-	Somalia

Source: FAO. 2020. Desert locust upsurge – Progress report on the response in the Greater Horn of Africa and Yemen (January–April 2020). Rome. Desert locust upsurge (fao.org)

Many scientists, environmental groups as well as the general media have voiced deep concern over the synthetic pesticides used in the ongoing campaign.[46] The Pesticide Action Network, considers chlorpyrifos, fenitrothion and malathion as "highly hazardous." They are considered acutely toxic, a cholinesterase inhibitor, a carcinogen, a groundwater pollutant, a reproductive and a developmental toxicant.[47] In fact, almost 96 percent of the pesticides delivered so far in the current campaign are scientifically proven to cause serious harm to humans, non-target organisms and biodiversity.[48] Deltamethrin is a synthetic pyrethroid which is especially toxic to bees and fish, though much less so to mammals.[49] Chlorpyrifos, fenitrothion, and malathion are broad-spectrum organophosphates and are also referred to as 'nerve agents' because of their kinship to Sarin gas.

46 A locust plague hit East Africa. The pesticide solution may have dire consequences. (nationalgeographic.com)

47 https://www.pan-uk.org/site/wp-content/uploads/PAN-HHP-List-2021.pdf

48 https://news.mongabay.com/2021/04/east-africa-deploys-huge-volumes-of-highly-hazardous-pesticides-against-locust-plague/

49 A locust plague hit East Africa. The pesticide solution may have dire consequences. (nationalgeographic.com)

Organophosphates kill locusts by attacking their nervous system, but they do not distinguish between pests and other species. While cases of acute poisoning are rare when used at ultra-low volumes (ULV), organophosphates have recently come under heightened scrutiny due to their potential long-term impacts on human, animal and environmental health.[50]

A substantive body of research[51,52,53] (*inter alia*), have connected organophosphates (e.g., chlorpyrifos) with brain damage in children and foetuses. Studies have identified statistically significant reductions in IQ, loss of working memory, autism, attention deficit disorder and motor coordination problems associated with exposure. There is acknowledgement by FAO that organophosphates are amongst the most poisonous pesticides when it comes to human exposure and exposure of non-target organism, for example, birds and pollinators.

In 2016, the U.S. Environmental Protection Agency[54] concluded that there was no safe use for chlorpyrifos, as harmful effects had been recorded at the lowest observable dose and is expected to be banned outright by the current US administration. In 2019,[55] the European Food Safety Authority declared that chlorpyrifos poses "concerns related to human health, in particular in relation to possible genotoxicity and developmental neurotoxicity." In 2020, the European Commission prohibited the use and sale of chlorpyrifos in the

50 https://mcusercontent.com/d53d01de8887e62f430469897/files/e8f49ff5-7d66-42bd-a793-b4d814542438/Review_final.pdf

51 Rauh VA, Garfinkel R, Perera FP, Andrews HF, Hoepner L, Barr DB, Whitehead R, Tang D, Whyatt RW. Impact of prenatal chlorpyrifos exposure on neurodevelopment in the first 3 years of life among inner-city children. Pediatrics. 2006 Dec;118(6):e1845-59. https://pubmed.ncbi.nlm.nih.gov/17116700/ Epub 2006 Nov 20. PMID: 17116700; PMCID: PMC3390915

52 Stephanie M. Engel, James Wetmur, Jia Chen, Chenbo Zhu, Dana Boyd Barr, Richard L. Canfield, and Mary S. Wolff 2011 Prenatal Exposure to Organophosphates, Paraoxonase 1, and Cognitive Development in Childhood. Environmental Health Perspectives 119:8 CID: https://doi.org/10.1289/ehp.1003183

53 von Ehrenstein O S, Ling C, Cui X, Cockburn M, Park A S, Yu F et al. Prenatal and infant exposure to ambient pesticides and autism spectrum disorder in children: population based case-control study BMJ 2019; 364 :l962 https://www.bmj.com/content/364/bmj.l962

54 https://www.regulations.gov/document/EPA-HQ-OPP-2015-0653-0454

55 https://www.efsa.europa.eu/en/efsajournal/pub/5908

EU. That same year, the European Chemicals Agency[56] proposed to add the substance to the Stockholm Convention's list of Persistent Organic Pollutants, a set of chemical substances recognized as "forever chemicals" - **a serious global threat to human health and ecosystems**. Fenitrothion is also banned in the EU.

Teflubenzuron, considered to be among the more benign insecticides because of its mode of action as an insect growth regulator, is still toxic to bees and other beneficial insects as well as other invertebrates and aquatic organisms.

Even FAO's Pesticide Referee Group (PRG) provided (in order of priority) a list of 11 pesticides recommended for use against locusts. Organophosphates were ranked last and the PRG recommended their use only as a *"last resort [method], when rapid control is needed to protect agricultural crops in the immediate environment of a locust population."*

Nevertheless, since the start of the locust plague in early 2020, half of all anti-locust pesticides delivered to East Africa since the beginning of the infestation contained chlorpyrifos. The main reason for its use is cost considerations, being less expensive than alternatives.

Of note, FAO advises that people vacate the treated area for several days while spraying takes place and recommends that the pesticides should be sprayed at ULV,[57] with a buffer zone of 1,500 meters (nearly a mile) from ecologically sensitive areas when sprayed by plane, and 100 meters (330 feet) when sprayed on foot. Locust control staff should wearPPE, and wells and beehives should be covered during spraying. However, USAID found evidence[58] that these guidelines have not been adhered to.

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56 https://echa.europa.eu/list-of-substances-proposed-as-pops/-/dislist/details/0b0236e184e0d70e

57 Despite connotations of the term ULV being less "environmentally harmful", ULV techniques actually use higher concentration of chemicals, thereby increasing killing efficiency. ULV often involves longer application times, with chemical discharge subject to wind drift, with concentrations of active ingredients causing environmental hazards.

58 Desert Locust Surveillance and Control (usaid.gov)

3.3 BIOPESTICIDES AND INSECT GROWTH REGULATORS

Of all the pesticides currently used in the campaign, only one is not considered harmful to non-target organisms and human health (bio-pesticide Metarhizium). The preferred bio-pesticide is based on the fungus *Metarhizium* acridum that targets locusts by competing with them for water and nutrients and is not considered toxic to humans or other species. Locusts start weakening three to four days after being exposed with *Metarhizium acridum*, and do not have the evasive capabilities to avoid natural predators (e.g., birds); however, maximum mortality is only reached after about **two to three weeks**. In addition, *Metarhizium acridum is most effective on early locust instars thus ideally should be used before swarms form*.

Since the start of the 2020 desert locust crisis, FAO and national governments have purchased 12,730 litres of biopesticides; **less than 1 percent** of the volume of organophosphates purchased.

Of the countries afflicted by locust upsurges, only Somalia has primarily relied upon biopesticides and the somewhat more harmful IGRs as can be seen in Table 1.[59]

A major drawback of *Metarhizium acridum* is the length of time needed to eradicate swarms and the need of appropriate climate conditions;[60] high humidity and moderate temperatures (more than 20°C at night and less than 38°C during the day) are required for the fungus to work effectively. In areas where locusts cause massive problems, these climate conditions may not be found.[61]

59 Somalia's choice of biopesticide *Metarhizium* acridum and insect growth regulator – Teflubenzuron is seemingly not only due to environmental concerns. Through dialogue with a pesticide supplier, TMG was informed that conventional pesticides such as chlorpyrifos contain neuro-toxins and are related to some chemical warfare nerve agents, and thus are prohibited in Somalia owing to the ongoing conflict in the country.

60 https://theconversation.com/what-we-found-when-we-tested-a-botanical-pesticide-to-combat-locust-invasions-133105

61 Ibid.

Also, the recommendation to dissolve the fungal spores in diesel, kerosene, or other mineral oils to prevent spraying equipment from becoming blocked, has environmental consequences. While a cheap solution, mineral oils are known to contain toxins and carcinogens[62] that can affect human health. Mineral oils do not degrade easily and can stay in the environment for a long period of time, posing further environmental risk.

Furthermore, only a few field studies are available that demonstrate the effect of the fungus on adult locusts.[63]

Another option has been the use of IGRs (e.g., *Teflubenzuron*) that favours predators of the locust but its active ingredient is also regarded as harmful. IGRs represent **around 3 percent** of the pesticides deployed in the current campaign. A safer option involves spraying natural locust repellents such as neem oil. However, these alternatives tend to be less efficient against mature swarms and have been only sporadically used in East Africa since 2020.

3.4 UNDERSTANDING THE TRUE COSTS OF THE ONGOING CAMPAIGN: THE IMPACT ON THE ENVIRONMENT AND HUMAN HEALTH

True Cost Accounting (TCA) also referred to as Full-cost Accounting, seeks to internalise (measure) negative (and sometimes positive) externalities associated with environmental interventions. Environmental accounting techniques have long been established, and continue to be promulgated

62 Mineral Oils: Untreated and Mildly Treated - Cancer-Causing Substances - National Cancer Institute

63 Exceptions are the studies by "Guoxiong Peng, Zhongkang Wang, Youping Yin, Dengyu Zeng, Yuxian Xia, Field trials of Metarhizium anisopliae var. acridum (Ascomycota: Hypocreales) against oriental migratory locusts, Locusta migratoria manilensis (Meyen) in Northern China, Crop Protection, Volume 27, Issue 9, 2008, Pages 1244-1250, ISSN 0261-2194, https://doi.org/10.1016/j.cropro.2008.03.007." and "D.M. Hunter, A.V. Latchininsky, E. Abashidze, F.A. Gapparov, A.A. Nurzhanov, M.Z. Medetov, and N.X. Tufliev "The Efficacy of Metarhizium acridum Against Nymphs of the Italian Locust, Calliptamus italicus (L.) (Orthoptera: Acrididae) in Uzbekistan and Georgia," Journal of Orthoptera Research 25(2), 61-65, (1 December 2016). https://doi.org/10.1665/034.025.0204" but the latter only focused on nymphs.

under the auspices of the UN's System of Environmental-Economic Accounting – Experimental Ecosystem Accounting (SEEA-EEA),[64] The Economics of Ecosystems and Biodiversity (TEEB) and the Paris Collaborative on Green Budgeting of the OECD.[65]

TCA is building on The Economics of Ecosystems and Biodiversity for Agriculture and Food (TEEBAgriFood), and has been applied to food systems[66] to asses and measure hidden but real costs of agricultural practises such as the use of fossil-fuel -based fertilizer and synthetic pesticides, and the impacts on soil , water, the contributions to climate change and - ultimately - the link to hunger and malnutrition including obesity. These "externalised" costs are in addition to normal production costs, and together they make up "the true cost of food."[67,68]

To gauge the scale of these costs, FAO's latest estimates put the gross value of global (primary) agricultural production at around USD 5 trillion[69] while the annual environmental cost of world food production totals USD 2.1 trillion and the social costs are estimated to be even higher, at USD 2.7 trillion (nearly USD 4.8 trillion in total).[70] Therefore the "true cost" of producing food is near double its fiscal, or pure monetary cost.

In the context of the ongoing desert locust campaign, the prolific use of synthetic pesticides as a "last resort" or emergency control measure constitutes a major environmental concern as well as harm to human health.

64 The United Nations Statistical Commission adopted the SEEA Ecosystem Accounting at its 52nd session in March 2021.

65 Ecosystem Accounting | System of Environmental Economic Accounting

66 See True Cost Accounting as a Policy Tool | TMG Think Tank for Sustainability (tmg-thinktank.com)

67 See Layout_synthesis_sept.pdf (ctfassets.net) and TCA_Brief1_web.pdf (ctfassets.net)

68 Accelerating True Cost Accounting - Global Alliance for the Future of Food

69 https://blogs.worldbank.org/voices/do-costs-global-food-system-outweigh-its-monetary-value

70 https://www.natureandmore.com/en/true-cost-of-food/what-are-the-true-costs-of-food

3.5 LESSONS FROM SENEGAL 2003-2005: THE FEASIBILITY OF APPLYING THE PESTICIDE ENVIRONMENTAL ACCOUNTING (PEA) FRAMEWORK TO THE CURRENT DESERT LOCUST CAMPAIGN

An approach to estimate the *true cost* of pesticide use, is the PEA framework, which provides a monetary estimate of environmental and health impacts per hectare (ha) application for a particular pesticide. The framework combines the Environmental Impact Quotient (EIQ) method and a methodology for estimating absolute external pesticide costs.

The architects of PEA (Leach and Mumford, 2008),[71] along with other researchers, were sponsored by FAO to apply the PEA-EIQ methodology to the previous major desert locust incursion in West Africa spanning from the years 2003-2005, with focus on Senegal, in which, according to official figures, a total of 750 000 ha in the country were treated by pesticides.[72]

The authors of the Senegal study (Leach, Mullié, Mumford and Waibel), provide a spatial depiction of the regions within the country where pesticide operations took place.[73]

Given practical considerations and constraints in compiling the underlying data in a timely fashion, the approach for the Senegal application depended heavily on standard accounting procedures to measure environmental and health-associated externalities. When data was unavailable, it was sourced from neighbouring countries that share similar economic and agro-ecological contexts.

An admission that the data collection strategy was "second best" was qualified on the expectation that a more comprehensive approach would be later commissioned.

71 Leach, Adrian & Mumford, J.D.. (2008). Pesticide Environmental Accounting: A method for assessing the external costs of individual pesticide applications. Environmental pollution (Barking, Essex : 1987). 151. 139-47. 10.1016/j.envpol.2007.02.019.

72 Leach, Adrian & Mullié, Wim C. & Mumford, J.D. & Waibel, Hermann. (2015). Spatial and Historical Analysis of Pesticide Externalities in Locust Control in Senegal - First Steps.. 10.13140/RG.2.1.4543.1127.

73 Ibid.

For example, since the 2008 study, there is a far better understanding today of the importance of pollinators. Plummeting numbers of pollinators may lead to an entire collapse of ecosystems, so it goes without saying that bees should be valued beyond the marketable price of their products (e.g., wax, honey). Furthermore, in the Senegal study, the environmental impacts to "wildlife" are measured by "loss of revenue associated with recreational tourism to visit wildlife". Tourism receipts alone are not expected to compensate for the destruction of wildlife. Large-scale operations to rebuild wildlife populations and the interim disruption to ecosystems would *a priori* be very costly.

Table 2 provides a summary of the findings for estimating pesticide externalities. Environmental "true costs" constituted the largest component, followed by the costs to human health, which stood as the largest sub component. Geo-referenced data were used extensively to identify the environmental asset subjected to the externality – the quantity and type of pesticide sprayed over a given area, either ground or ariel spraying.

The impact of the loss of beneficial insects to crops, namely pollinators, also stands out, accounting for well over 20 percent of all pesticide externalities. There is little public research available on the recovery rates of bee colonies exposed to synthetic pesticides.[74] The worst-case scenario is Colony Collapse Disorder,[75] in which the effects of pesticide exposure are irreversible.

To verify the findings, especially the robustness of the data sources and the assumptions on valuing the externalities, results from other studies of pesticide externalities were gathered. Using ratios of pesticide external costs to pesticide direct costs (i.e., cost of procurement) from the studies – termed "externality ratios" - the authors applied a stochastic model to form probability distributions to ascertain whether the Senegal findings are consistent. Overall, the model showed that the results from the Senegal study were reasonable compared with other studies. However, these were deemed slightly biased by undervaluing externalities (specifically, a 43 percent probability of arriving at the estimate Euro 8 million total).

74 Francisco Sanchez-Bayo and Koichi Goka (May 20th 2016). Impacts of Pesticides on Honey Bees, Beekeeping and Bee Conservation - Advances in Research, Emerson Dechechi Chambo, IntechOpen, DOI: 10.5772/62487. Available from: https://www.intechopen.com/chapters/50073

75 https://regenerationinternational.org/2021/05/06/world-bee-day-no-pollination-no-life/

TABLE.2 **PESTICIDE EXTERNALITY ESTIMATES FOR THE SENEGAL DESERT LOCUST CAMPAIGN 2003-2005**

I. ENVIRONMENT	
Soil contamination	Euro 1,192,487
Drinking water contamination	Euro 426,820
Obsolete stock disposal	Euro 1,086,797
Wildlife losses (birds)	Euro 28,213
Losses of beneficial arthropods	Euro 15,282
Subtotal	**Euro 2,749,599**
II. HUMAN HEALTH	
Intoxications - public	Euro 2,455,581
Subtotal	**Euro 2,455,581**
III. PRODUCTION LOSS	
Domestic mammal losses	Euro 103,212
Poultry losses	Euro 4,012
Honey and wax losses	Euro 34,265
Pollinator losses	Euro 1,790,112
Fish losses	Euro 201,680
Crop losses (due to heavy contamination	Euro 8,987
Subtotal	**Euro 2,142,267**
IV. DAMAGE PREVENTION COSTS	
Communication	Euro 154,411
Human health monitoring	Euro 124,045
Environmental monitoring	Euro 294,683
Development of alternatives	Euro 133,861
Subtotal	**Euro 707,000**
TOTAL	**EURO 8,054,448**

Source: Leach, Adrian & Mullié , Wim C. & Mumford, J.D. & Waibel, Hermann. (2015). Spatial and Historical Analysis of Pesticide Externalities in Locust Control in Senegal - First Steps. 10.13140/RG.2.1.4543.1127.

In the final step, the EIQ model was employed to estimate externalities per ha of individual pesticides (i.e., spatially distributed costs). This was facilitated by a geo-spatial database that provided information on where spraying took place, the pesticide used and field application rates of the particular pesticide.

As mentioned before, the EIQ calculation can inform decision-makers on which among the choice of pesticides produces the lowest and highest externality per ha, even though the pesticide may be the most or least expensive on the marketplace.

3.6 IS THE PEA-EIQ APPROACH FEASIBLE TO INFER THE TRUE COSTS OF THE CURRENT DESERT LOCUST CAMPAIGN?

As shown by the PEA application to Senegal, the True Costs of the ongoing desert locust campaign extend well beyond the fiscal outlays to procure equipment and to finance control operations. The upsurge of swarms in many of the countries require emergency interventions which almost always entail spraying large areas with synthetic pesticides. These pesticides entail costs, not just in their procurement, but in the extensive harm to the environment and to human health. Monetising these externalities can reveal the extent of harm in a non-abstract tangible manner, as has been shown in the Senegal study.

The PEA-EIQ approach can put monetary estimates on the spectrum of environmental assets that synthetic pesticides impact in a detrimental manner. The approach can also identify, which in the menu of pesticides, are the most environmentally damaging and injurious to human health, either at the aggregate level or normalised per ha.

One of the biggest challenges in achieving results from which meaningful and credible inference can be drawn are the underlying data requirements and the robustness of the assumptions in placing a particular value on the environmental cost of the externality.

Due to poor data availability, the Senegal application utilised a number of proxies/surrogates to make an attempt at credible assessments. As discussed earlier, while some of the valuation methods used by the Senegal study can be subject to criticism, the methodology employed invariably led to significant cost savings since (primary) data collection is often the costliest activity in research and analysis.

The credibility of the analysis was verified by the authors using a stochastic model that took data from other published studies to ensure that the probability ranges of externalities were statistically consistent.

Anticipating data and statistical systems advancement in Senegal (since the 2003-2005 locust incursion) and the current set of developing countries that are being affected, it is hoped that this may present better data alternatives for measuring environmental externalities in a more credible context.

For the task at hand, FAO has also compiled an extensive dataset on spraying operations with the use of geo-referencing, the inventory of pesticides applied and the manner of application (aerial or terrestrial). Other aid agencies involved in the current campaign (such as USAID)[76] which have assisted countries in pesticide procurement also have comprehensive records on pesticide use. It would be critically important to make these data available to the public.

This would enable researchers to identify where, which and how much pesticide has been applied, and to allow them to survey/assess contamination, intoxication and other forms of environmental degradation caused by the pesticide.

To conclude, the TCA framework of the PEA-EIQ is in need of updating. It also needs a fundamental review of how the valuation of externalities can be improved and made more relevant, especially by expanding the PEA-EIQ to encompass more environmental dimensions and to review the weights employed in the EIQ equation. For example, there are other environmental and biodiversity dimensions that could be added to the EIQ, notably, natural predators of locusts such as reptiles, lizards, predatory wasps and flies.

76 https://www.usaid.gov/sites/default/files/documents/USAID_EAFR_Locust_PEA_FAO_11-10-20_508_Compliant.pdf

If these animal populations are reduced by pesticides, then future outbreaks might become more protracted and hence worse. In this regard the continued use of hazardous pesticides might enhance instead of stop a vicious circle of destruction in the afflicted regions.

PEA-EIQ seems highly promising in placing a monetary cost of environmental and human harm. The outputs of the PEA-EIQ framework (see Table 2) provide insight into the "True Cost" of a desert locust campaign and, if extended to the current campaign, could constitute a highly valuable decision-making tool to all those vested in locust control including governments, international agencies, environmental regulatory authorities and environmental action groups.

The approach is a starting point to put a tangible number to something that has always been considered intangible/or conveniently ignored. **Making the invisible costs visible should also spur and legitimize policy-makers, researchers and institutions into investing in a more apt early warning system and outbreak prevention.**

CHAPTER 04

INTERCONNECTED RESPONSES AND EARLY WARNING SYSTEMS: BUILDING A CASE TOWARDS GOVERNANCE FOR RESILIENCE

4.1 INTRODUCTION

As explained in the previous section, the economic costs of disaster management with regards to locust upsurges since 2019 have been staggering. Moreover, the price tag to the environment and to the health of the many and already vulnerable rural dwellers is only now slowly emerging.

Governance and its translation into action, geared towards resilience, human and environmental wellbeing and sustainable management systems call for investment upfront into risk management and action as early as possible - before crisis unfolds. In short, to invest in preventative action instead of inaction. In short, to invest in preventative action instead of inaction.

At the same time, the foundations for best possible effective disaster risk management strategy would be an innovative system that combines early warning with early (preventative) action. But we should not forget the difficulties in keeping systems alert over a long period of time. Yet, this is an imperative, given that we will witness more and more transboundary pest threats in the future under climate change. In this respect we need to make the most of all collaboration options and state-of-the-art technologies.

Acknowledging that our current prevention strategies, being slow to respond, are no longer tenable, we need to elaborate and demonstrate the true costs of the status quo - the visible and mostly invisible costs of the impacts of extensive pesticide applications in handling outbreaks – and more importantly, show new ways of preventing and handling transboundary sustainably. A cursory enquiry into the still ongoing desert locust crisis in the Horn of Africa and nearby countries, and how national responses have unfolded, shows the costs involved to date are nothing short of breath-taking:

- The FAO has upgraded its appeal for regional operations, which is currently set to the tune of USD 351 million[77] (time of writing November, 2021).
- The World Bank estimates fiscal costs of operations and crop losses in East Africa & Yemen at USD 8.5 billion **in 2020 alone**.[78]

A preliminary assessment based on these data, suggest that total fiscal costs (operational costs and crop losses) over 2019-2021 could be a conservative USD 12 billion, excluding environmental and human health costs, which may add an extra 30-50 percent to this estimate based on the Senegal PEA-EIQ study.

The magnitude of these costs is deeply concerning. With the prospect of possibly more locust outbreaks under climate change, it is unjustifiable that countries-at-risk and the donor community might have to incur such sums on a more frequent basis. This inevitably and legitimately leads to the question how to **invest in prevention instead**.

77 http://www.fao.org/emergencies/crisis/desertlocust/en/

78 The Desert Locust Plague: The World Bank Group Response: Development news, research, data | World Bank

4.2 INVESTMENT IN ACTION INSTEAD OF INACTION?

It is worth reiterating that in 2018-2019, Indian ocean anomalies gave rise to an unprecedented number of cyclones which provided the ideal conditions for desert locust breeding. The breeding grounds were left undetected and soon transcended into multiple generations of locust reproduction. The early-warning signs were there, but the much-needed preventative measures such as intervening in the breeding grounds to prevent the ensuing upsurges were not enacted. As noted in a recent article on *Prevention Web*:

"*Despite early warning by (FAO) The Desert Locust Watch agency during the 2019 cyclone season, the invasion could not be stopped in time. Knowledge on the ecology of desert locusts has developed considerably over time, but without international policy* and implementation *cooperation, understanding the species (alone) is not enough*."[79]

As a result of locust breeding being undetected, locusts began to form vast swarms, which soon traversed country borders and culminated in the escalation of a regional catastrophe. We need to explore what kind of early warning system as well as early response system would have lowered operational costs, perhaps even to almost negligible levels (relative to conventional control methods currently being employed), and most importantly would have avoided losses to crops, costs to the environment, biodiversity and human health, especially through the absence of harmful pesticide applications.

Yet, as previously discussed, the costs of highly expensive aerial and ground operations, which involve unleashing massive amounts of highly toxic chemicals into the environment to protect crops and livelihoods, would need to be made fully transparent (i.e., these pesticide interventions also had severe ramifications to the environment and bio-diversity). Remaining crops become subject to chemical contamination rendering them unsafe for consumption, while pesticides are indiscriminate in which insects they

79 Desert locust outbreak highlights gaps in risk governance | PreventionWeb

target for annihilation, such as the all-important crop pollinators, as well as natural predators of locusts, providing further vulnerabilities. There is also a strong likelihood that human health is at high risk, given the lack of or improper use of Personal Protective Equipment (PPE) for those involved in ground operations. Finally, the contamination of water sources and other environmental assets, upon which communities depend, imposes serious health risks. The arid environments in which desert locusts thrive are particularly fragile ecosystems that can be severely disrupted, or may even fail to recover from the impacts of broad-spectrum insecticide application over vast areas.

To conclude, understanding the interconnectedness of the underlying drivers and risks, needs research, and the findings then need to be translated into the economic realm in order to support and legitimise the necessary shift in paradigm for a new governance system for resilience.

4.3 POSSIBLE INGREDIENTS OF A MORE EFFECTIVE EARLY WARNING SYSTEM

While further research is needed in understanding the interconnectedness of the risks, TMG is starting to look towards innovative solutions for the benefit of the rural populous at-risk from future incursions. There have been rapid technological advances in a host of fields from locust early-warning, detection and to control which, to date, have not been harnessed or at best only partially harnessed in the field. We have therefore identified some key ingredients of an effective early warning system for outbreak prevention:

- Real-time data from satellites as well as from weather intelligence systems, are all-important for early-warning and detection. This would encompass capturing data on soil moisture and texture, ocean temperature (threat of cyclones), vegetal vigour, air temperature and precipitation.
- These data (which could feasibly run in to multitudes of petabytes)[80] would then be continuously fed into ML algorithms, which using "cloud computing" can rapidly process these enormous amounts of data with the objective of accurately predicting locust breeding grounds.

80 One petabyte equates to 1 million gigabytes.

- To give an example, recent research[81] using just soil moisture data ingested by ML algorithms, have predicted the location of locust breeding grounds with a success rate of 90%, and a three week gain in early warning compared to conventional methods used (e.g., ground surveillance).
- An alarm notification could be automatically triggered when the probability of a breeding ground reaches a pre-determined threshold.
- Drones fitted with an array of sensors could be used to verify the predicted breeding ground and once verified, robotic excavators would then be employed to destroy the breeding ground. This set-up would be useful in hard-to-access or remote areas, which characterises the origins of the current locust upsurge.
- And again, during the predicted shortened recessionary periods, the multi-functionality of the technology advocated could assist with other agricultural tasks (e.g., those under the realm of precision agriculture).

4.4 A FIRST INSTITUTIONAL GLIMPSE AT THE ENVISIONED EARLY WARNING SYSTEM

This is the juncture where governance and co-ordination must come into the picture. Duplication of the early warning system by individual countries might be a wasteful disregard of scarce funds, resources and also expertise. While the next desert locust upsurge of such a scale might be years or even decades away, the possibility of smaller scale outbreaks of desert locusts, other locust species and other pest insects is a question of "when", not "if". Early warning must translate into early response in a timely manner. Hence, consultative processes are needed to ensure that all those at risk are united in the management of transboundary pest outbreaks. As recently highlighted in the media, "Like most other environmental disasters, the desert locust outbreak requires several levels of response from governance

81 Piou, C, Gay, P-E, Benahi, AS, et al. Soil moisture from remote sensing to forecast desert locust presence. J Appl Ecol. 2019; 56: 966– 975. https://doi.org/10.1111/1365-2664.13323. Also see Diego Gómez et. al, Prediction of desert locust breeding areas using machine learning methods and SMOS (MIR_SMNRT2) Near Real Time product, Journal of Arid Environments, Volume 194,2021,https://doi.org/10.1016/j.jaridenv.2021.104599.

structures both regional and national."[82] The new way of thinking should also provide different actors with novel business models. Academia, research institutions and the private sector need to be incentivised to participate in the new model, and also need legitimization for investing in public goods. It might take an intense joint effort and therefore an actively facilitated process for different actors to conceive novel formats of private and public partnership for the common public good.

The issue of better understanding the interconnectedness of crises goes hand-in-hand with building response mechanisms that mirror that interconnectedness. As crises are best tackled at the earliest stage possible, the focus should be on **early warning, detection and immediate prevention activities**.

If monitoring at the early stages is the most promising principle, how can that be best put to work? Data from satellites will be key to optimally predict the location of breeding grounds (e.g., soil moisture and other agro-ecological variables).

If breeding grounds have been verified, what options for intervention are available? An example from the United States has successfully shown that ploughing the eggs helps eliminate the locusts – without the use of hazardous pesticides. Could the ploughing even be done remotely in uninhabited areas, possibly with robots, that fitted with appropriate sensors, could be instructed to detect eggs and moisture and start ploughing? While seemingly feasible at the conceptual stage, the technology here is highly experimental and would need to undergo extensive testing in a host of difficult terrains. If robotics were to fail in their task, there could be disastrous consequences; therefore, a fully operative "Plan B" would need to be ready. This could take the form of rotary drone interventions, by which bio-pesticides that are highly effective in eradicating hatchlings and young locusts would be sprayed once they emerge from the soil.

Another decisive question is what would the robots do in the years, perhaps even decades, when there is no upsurge to be detected? As mentioned earlier, they cannot simply remain idle, so, the investment could be connected to investments in small-scale robotic farming in the realm

82 Desert locust outbreak highlights gaps in risk governance | PreventionWeb

of precision agriculture[83] (e.g., for weeding with lasers). The robots of the future could be multi-tasking, and a welcomed added-value feature could be fostering interest in young people and entrepreneurs to engage in robot services to farmers.

Already now there are examples of aircrafts crossing borders (e.g., for spraying pesticides). Remotely deployed robots should be robust in coping with hazardous terrains and they will possibly have to cross country borders. Again, this is an area where governance has to come into the picture as some terrains might be considered sensitive or classified. In these instances, the military could oversee robot operations and even manage operations in conflict zones. In addition, locust control without the use of toxic pesticides could help prevent some conflicts (e.g., with beekeepers that do not want their area of activity to be sprayed), and that might legitimize the effort for cooperation.

What can research do to support respective new governance options? Given that due to climate change desert locust upsurges might deviate from traditional migration patterns (i.e., move further from or within the African continent, impacting regions that are traditional strongholds of agricultural production), knowing more about how climate change can alter the migration of pests, and projecting these dynamics into the future, should further spur the motivation for the respective governance levels to monitor new sources of threats.

In addition, we need more innovate thinking, rather than purely relying on the next technology fix. Research has shown that understanding human-environment feedbacks opens novel management opportunities.[84] Thus, the role of landscape management and nature-based solutions should not be overlooked. For example, researchers have explored connections among

83 Automation of farming processes saves time and energy required for performing repetitive tasks and increasing productivity. This method of farming is known as precision agriculture. Robotics can perform tillage, planting, harvesting, and sowing of seeds to meet crop conditions across the field. The technology also heavily relies on latest technologies in geospatial tools and satellite imagery. https://www.azorobotics.com/Article.aspx?ArticleID=113

84 Word, M. L., Hall, S. J., Robinson, B., Manneh, B., Beye, A., and Cease, A. J. (2019). Soil-targeted interventions could alleviate locust and grasshopper pest pressure in West Africa. Sci. Total Environ. 663, 632–643. https://doi.org/10.1016/j.scitotenv.2019.01.313

land use, soil, plant nutrients, and locusts and concluded that "Land use that promotes soil organic matter and nitrogen may suppress outbreaks."[85] Another research study on a dominant locust of north Asian grasslands, *Oedaleus asiaticus*, concluded that "heavy livestock grazing and consequent steppe degradation in the Eurasian grassland promote outbreaks of this locust by reducing plant protein content."[86] Moreover, while this topic falls beyond the scope of this paper, it is worth noting that locusts could be harvessed sustainably and processed into protein rich locust animal feed, or converted into organic fertiliser to return their high nitrogen levels to the soil.[87]

Furthermore, as mentioned in the previous part of this paper, we should not forget that we remain in a global crisis mode owing to the COVID-19 pandemic, and could harness the emerging mechanisms and structures for public health emergencies towards other transboundary crises such as the desert locusts or fall armyworm. How can this learning process be ensured, and how can it be reorientated towards managing transboundary pests?

This all leads to the overarching question whether our work on locusts could serve as an exemplar to reshape our thinking about transboundary threats in light of climate change and how the interplay of science, infrastructure, management strategies and governance can lead to a more resilient future. What works, what doesn't, what we could improve and what we can learn from all of this should be the pragmatic and reliable guiding principles to move ahead.

85 Ibid.

86 Cease, A. J., J. J. Elser, C.F.Ford, S.Hao, L.Kang, Andj.F.Harrison. 2012. Livestock overgrazing promotes locust outbreaks by lowering plant nitrogen content. Science335: 467-469. Heavy Livestock Grazing Promotes Locust Outbreaks by Lowering Plant Nitrogen Content (science.org)

87 https://thebugpicture.com/

CONCLUDING REMARKS

This scoping paper has examined the various dimensions of the ongoing desert locust campaign in order to better understand the interconnectedness behind the crisis (including the root causes of the crisis), as well as the effectiveness of international governance and where critical knowledge and actionable gaps persist. This study had – as a first step – analyzed the desert locust upsurge from a general pespective to understand the overarching drivers of the situation. Additionally, we have started to initiate partnerships to strive for bottom-up perspectives to complement the more general perspective of this first scoping phase. Our session at the Global Landscapes Forum Climate Conference (sideline event to 2021 United Nations Climate Change Conference, November 2021) was hosted by TMG, the German Federal Ministry for Economic Cooperation and Development, Intergovernmental Authority on Development (Nairobi, Kenya), and Swette Center for Sustainable Food Systems (Arizona State University) and dedicated to the ongoing Desert Locust upsurge and the interconnectedness with the climate crisis.[88] The event brought together ten prominent speakers from a wide

88 Understanding the Interconnectedness Between the Ongoing Desert Locust Crisis 2019-2021+ and the Climate Crisis (globallandscapesforum.org)

range of disciplines and countries to dissect the ongoing crisis and to pave the way forward.[89]

Panelists from some of the hardest-hit countries, namely Ethiopia and Kenya, concurred that the ongoing desert locust crisis warrants scrutiny on many grounds. The panel uniformly agreed that current control strategies are no longer tenable.[90] This session sucessfully demonstrated the need of research partnerships linking global research with regional and local partners.

It seems pivotal to put emphasis on the much-needed political will towards establishing a well-functioning early warning system, integrating the challenges of climate change, bringing resilience into the picture and defining the needed actions jointly with all stakeholders. This will have the potential to optimise crisis prevention and management systems, so that the world is better prepared for future outbreaks of **locusts and other transboundary pests**.

The widely cited UNU-EHS report warns that owing to climate change "conditions favouring desert locust outbreaks will likely occur more frequently in the future".[91] Thus, further research into the **linkages between climate change and transboundary pests** such as desert locusts need to be addressed, not only to fully grasp this interconnectivity for the better management of future locust outbreaks, but to prevent other emerging risks. In order to fundamentally increase resilience in an interconnected world, that is facing unprecedented events and disasters related to climate change, it must be acknowledged that "there are no borders or boundaries that can contain disasters".[92] This necessitates a shift towards a new paradigm that offers a holistic solution to safeguarding food security, rural livelihoods and the environment – in other words a **"package" for maximum resilience**.

89 Highlights and images of main proceedings for 6 November 2021 (iisd.org)

90 https://youtu.be/ax-MutvLwmw

91 Interconnected Disaster Risks. [Authors: O'Connor, Jack; Eberle, Caitlyn; Cotti, Davide; Hagenlocher, Michael; Hassel, Jonathan; Janzen, Sally; Narvaez, Liliana; Newsom, Amy; Ortiz Vargas, Andrea; Schütze, Simon; Sebesvari, Zita; Sett, Dominic; and Yvonne Walz]. United Nations University – Institute for Environment and Human Security (UNU-EHS): Bonn, Germany. interconnectedrisks.org

92 Ibid.

Against all expectations, the campaign has entered 2022 and is still ongoing. These upsurges have and continue to profoundly threaten vast regions, especially the Horn of Africa and Western Asia, with livelihoods and food security at peril. The locust crisis is negatively impacting the substantial investments made by many development organizations in the afflicted regions (e.g., USD 4 billion by the International Fund for Agricultural Development and USD 5 billion by the World Bank. The latter estimates that damages and losses could amount to USD 8.5 billion in East Africa & Yemen **in 2020 alone**)[93] and the upsurges are happening at a time when COVID-19 is placing unprecedented pressure on the countries being affected by desert locust.

A key finding of the paper is that the extent and transcendency of the crisis, that has primarily rested on the customary "pro-action" and "reaction" measures towards locust control, should no longer be tenable; nor should the suspected costly environmental and human health impacts, in which the pervasive and heavy use of toxic pesticides have been the order of the day. The fiscal expense of dealing with locust crises is also no longer tenable, since many of the most economically disadvantaged countries are those that are being significantly affected and have limited budgetary means to deal with the crisis. A new approach is clearly needed, one that is especially geared towards "outbreak prevention" to foster the highest possible resilience to those vulnerable communities facing the greatest exposure.

On prioritising the next steps towards building better global **resilience**, the following are proposed:

i. Ensuring an up-to-date **early warning system targeted towards outbreak prevention**, considering the distinct possibility that climate change will likely spur further locust threats as well as threats of other transboundary pests.
ii. A research agenda for **TCA**, supported by country case study(ies) for ground-truthing to understand the fiscal, environmental and human health costs of using highly toxic pesticides in locust control, specifically in the context of the current desert locust campaign. Furthermore, a

93 The Desert Locust Plague: The World Bank Group Response: Development news, research, data | World Bank

regime shift should urgently be considered in the types of pesticides being currently used.

iii. These important issues will need to be framed within a new type of **global governance model** that is sorely required; this rests heavily on a proposal for a novel format of **public private partnerships** (PPP), driven by a strong business case for protecting and investing in global public goods, as well as partnerships with service providers such as research institutions responsible for technological innovation, all with the objective of safeguarding global public goods towards better resilience.

More precisely:

- A prerequisite for outbreak prevention is clearly the installation of the best possible early warning system. In the case of desert locusts, a system that harvests available data from multiple sources (improved satellite data, weather intelligence systems), which employ **ML** algorithms **to help predict and destroy breeding grounds** supported **by technology such as drones**[94] **and robotics**, with the goal of early action and avoiding the use of **highly toxic pesticides**.
- Such digital innovation already exists, but for the necessary "digital leapfrog" more emphasis is needed to assemble the technology in an optimal manner. Investing in this system is all the more pressing given the widespread consensus that transboundary pest outbreaks could be much more frequent owing to climate change. Around 15 years have passed between the present and last desert locust crisis, but this periodicity can now no longer be assured.
- This is supported by FAO who, just prior to the current crisis, in 2018 submitted a contribution to the UN Office for Outer Space Affairs (UN Spider) for the latter's "Data Application of the Month" on the subject

94 It is noted that many countries have restrictions on private or commercial drones. The following website https://drone-traveller.com/drone-laws-africa/ shows the extent of these restrictions in Africa. However, drones are certainly a functionary element of the military in all countries in the world. An improved regional "governance structure" would permit the use of drones with military collaboration (or with the help of military pilots). At a political dimension, the use of drones could be a populist intervention for safeguarding food security and livelihoods.

of locust monitoring.[95] The application makes strides towards the aforementioned digital leapfrog, in that several modalities for outbreak prevention are presented. As apparently these innovations could not be applied to the ongoing campaign, the necessary support should be identified for future campaigns. Another question to keep in mind is how the challenge of inaccessible areas (e.g., due to conflict), could be overcome? Would a regional governance system come into play?

- The scoping paper has also placed much emphasis on the environmental and human health impacts of synthetic pesticide use. In the campaign to date, millions of litres of highly toxic chemicals have been unleashed into the environment, seemingly without recourse to monitoring their adverse effects by the agencies mandated to do so, and who are also accountable for the procurement of such pesticides. For this reason, **research** into the "**true costs**" of the campaign by monetising the harm to environmental assets and human health is important, as is strengthening of monitoring activities. Put simply, there is a pressing need to **make currently invisible costs visible**. This includes a strengthened focus on biodiversity loss with all its consequences - from missing predators to economic losses in agriculture because of missing pollinators. The extensive and pervasive use of toxic pesticides may create a vicious circle in which the loss of natural predators will inevitably sustain locust outbreaks to their maximum potential in terms of devastation. Additionally, **country case studies** should provide the necessary ground truthing for the proposed TCA research.
- Upon confirming the true costs and the need for a new type of early warning system geared towards resilience, there is also a pressing need to present a "**business case**" to the private sector responsible for pesticide development and supply. The '(global) public good' nature of locust control requires private investment in **biological** remedies - biocontrol, necessitating the bridging of research and commercial gaps to use against locusts. Consequently, a respective novel format of **PPP geared towards resilience** should be established. This is all the more warranted for pesticide developers/suppliers to be involved when early warning systems fail to detect locust swarms that threaten to transcend country borders, leaving no choice for the affected countries

95 https://www.un-spider.org/links-and-resources/data-sources/daotm-locust-monitoring

but to use harmful pesticides as a "last line of defence" to protect crops and ultimately the livelihoods of their populations.

- These "last resort" pesticides must have the least possible toxicity so that impacts on the environmental and human health are minimal. Substantial research has already been conducted in academia as well as the private sector on safer pesticides, but laboratory experiments need to be extended to the field.
- In addition, a better system of procurement is obviously key for the business case, as there is a need for sufficient biological data to ensure the right specifications and their application.

In all of the above, **governance is key**. It would oversee PPP in the appropriation of a new business model for investing in global public goods that is supported by a strong business case for the private sector, and would better and more rapidly coordinate actions between neighbouring countries, as well as international bodies. This is to avoid countries reacting alone and to protect their interests by controlling the locusts and serve national expectations. In the case of transboundary threats, in order to avoid a transboundary crisis, time is of essence, and "going it alone" must by all means be avoided, owing to the obvious risks of setting forth a regional crisis. Therefore, consultations should start with countries most at risk and involve all stakeholders at all levels of governance.

Ultimately, a **new mindset** is required for handling of future locust crises (including other transboundary pest outbreaks) resulting in a new "business model" for all actors. Given that the scope of necessary transformation in times of climate change requires establishing novel ways to manage threats before they escalate to full-blown crises and building resilience for communities as well as nature's defence mechanisms, the new multilateral system will need the active initiative and support of Member States vulnerable to transboundary pests.

ANNEX 1

OTHER RECENT LOCUST OUTBREAKS

A.1.1 INTRODUCTION

Locust outbreaks in the recent past have not been confined to the desert locust. In virtually all continents, either outbreaks or outbreak threats have been reported. As with the desert locust, these other locust species can easily transpire into transboundary crises. Of concern, is that many of these species are not under the purview of international monitoring agencies.

A.1.2 LOCUST OUTBREAKS AROUND THE WORLD

Coincidentally, unseasonal but conducive weather patterns[96] were also responsible for outbreaks of **African Migratory Locust**, AML (*Locusta migratoria migratorioides*) in 2020, and which continue to afflict large swathes of southern Africa, especially Angola, Botswana, Namibia, Zambia and Zimbabwe.

AML is a tropical species that prefers grasslands in humid areas and are typically found in solitary form in the Okavango Delta, the Chobe wetlands, and the Zambezi plains. Gregarization of these locusts to form swarms is also linked to rainfall, which was heavy in January 2020, and in some cases to irrigation of cereal crops.[97]

Flooding and high rainfall allowed AML to expand the area in which they can lay eggs. Temperature is important for the timing of hatching. As the floods

96 2020-10 - Explainer: what's behind the locust swarms damaging crops in southern Africa - Wits University

97 https://www.wits.ac.za/news/latest-news/opinion/2020/2020-10/explainer-whats-behind-the-locust-swarms-damaging-crops-in-southern-africa.html

receded during the dry winter season, locusts kept breeding and laying eggs due to high soil moisture which contributed to their increasing population densities. At the onset of summer, when temperatures increased, there was a synchronized hatching of eggs and the emerging hoppers came into contact with others in sufficient numbers to cause gregarization and swarm formation.

The affected Member States of the Southern Africa Development Community (SADC) used synthetic pesticides to control AML, but the application of such pesticides on the swarms found in the Okavango Delta posed a serious ecological risk. This called for the use of the bio-pesticide *Metarhizium* which was not available in Southern Africa at the time; FAO managed to assist in its procurement through identifying suppliers in Morocco.

On 30 June 2020, FAO, SADC, and the Red Locust Control Organization for Central and Southern Africa (IRLCO-CSA)[98] concluded that the locust situation was a region-wide **emergency** that requires an urgent response.

In September 2020, FAO published a report,[99] stating that "at least four Southern African countries (**Botswana, Namibia, Zambia and Zimbabwe**) were facing serious outbreaks of AML, threatening the winter crops and the main planting season due to start in October." In the aforementioned report, FAO mentions to have employed "preventive strategies for locust management, relying on early warning and pre-emptive responses. Delaying the response would prove more costly, **financially, environmentally, socially and economically**". Their recommendations included:

- undertake emergency ground spot spraying with environmentally friendly synthetic pesticides;
- medium- to long-term integrated pest management approach that includes the use of bio pesticides, such as **Metarhizium** when environmental conditions are suitable; and

98 It should be noted though, that IRLCO-CSA primarily focuses on the control of a different locust pest: the Red Locust.

99 Southern Africa locust outbreak - September 2020 (fao.org)

- conduct a post-control assessment in all sprayed areas, including an evaluation of human health and environmental monitoring activities.

However, it is unclear as to what FAO regards as "environmentally-friendly synthetic pesticides" (as all synthetic pesticides are harmful to varying degrees) as well as the scope of monitoring environmental and human health impacts to conduct a 'post-control assessment'.

In October 2020, SADC launched a regional appeal for USD 21,168,660 for a coordinated response, including financial and technical support, to address the surging impact of AML in the region. Under this framework, FAO was reportedly working with SADC and IRLCO-CSA to support the governments of the affected countries in the fight against locusts.[100]

A Central Emergency Response Fund grant was provided, but FAO could provide **4,700 kg of synthetic pesticides** and **only 400 kg of bio-pesticides** to treat 150,000 ha against AML. In addition, 500 units of PPE were supplied along with 225 sprayers for manual, vehicle and air control along with training to control agents and guidance to affected communities.[101]

While locust outbreaks by species are seemingly unrelated, AML has received less publicity from the international community, even though close to 18 million people exposed to AML are classified as acutely food insecure (Integrated Food Security Phase Classification - Phase 3+).[102] This figure compares to around 35 million people who are Phase 3+ in desert locust affected countries.

The Emergency Transboundary Outbreak Pests (ETOP) Situation Bulletins published jointly by USAID and the Bureau for Humanitarian Assistance, reported that two outbreaks of **red locust** (*Nomadacris septemfasciat* – found in sub-Saharan Africa) first affected Namibia in early 2020 while the

100 SADC_African_Migratory_Locust_Appeal.pdf

101 Allocation project summary | CERF (un.org)

102 Based on http://www.ipcinfo.org/ipc-country-analysis/ipc-mapping-tool/ for Angola, Botswana, Namibia, Zambia, Zimbabwe, in which the following phases by the Integrated Food Security Phase Classification (IPC) are defined: Phase 1 – minimal; Phase 2 – stressed; Phase 3 – crisis; Phase 4 – emergency; and Phase 5 – famine.

second outbreak, which emerged in mid-2020, affected Namibia again as well as Zimbabwe, Angola and Botswana. As of July 2021, the ETOP Bulletin informed that "scattered populations were reported in Malawi, Mozambique, Tanzania and Zambia".

The **brown locust** (*Locustana pardalina* – indigenous to Southern Africa) – is also known to have formed multiple swarms throughout 2020 and 2021 in Southern Africa, especially South Africa, Namibia and Botswana, causing widespread damage to field crops.

The Global Locust Initiative of Arizona State University (GLI-ASU) reported that the **South American Locust** (*Schistocerca cancellata*) had its largest population upsurge in 60 years in South America, stating "After 60 years of only small sporadic outbreaks of the South American Locust, in 2015 a large upsurge began that caused serious management issues and declarations of national emergencies".[103] This locust species expanded beyond its permanent breeding zone in northwest Argentina to as far as Bolivia, Paraguay, Uruguay and Brazil. These increased populations have continued into 2020, with numerous outbreaks in these countries.While the situation within South America seems to have quietened in 2021, according to the ETOP Bulletin, its "activities are expected to have continued in parts of Argentina and adjacent areas".

In Central Asia and the Caucasus Region (CCA) three locust species sprung into outbreak. According to FAO[104] "**Moroccan Locust** (*Dociostaurus maroccanus*) fledging, mating and egg laying continued in CCA. **Italian Locust** (*Calliptamus italicus*) fledging started in Georgia and in CCA countries. **Migratory Locust** (*Locusta migratoria*) hopper development continued in Azerbaijan, Kazakhstan, Russian Federation and Uzbekistan. [...] In total, more than 600 000 ha have been treated in the CCA region from the beginning of the 2021; this is some 50 percent higher than in the same period in 2020".

103 https://sustainability-innovation.asu.edu/global-locust-initiative/south-american-locust-outbreak/

104 http://www.fao.org/locusts-cca/current-situation/zh/

Moving further afield, outbreaks of the **Yellow-spined Bamboo Locust** (*Ceracris kiangsu*) spread from Laos and Vietnam into the Yunnan province of China in 2020. According to GLI-ASU,[105] "Large numbers of the Yellow-spined Bamboo Locust started causing problems in Laos and Vietnam [...] spreading throughout China's southwestern province of Yunnan. Reports trace the locusts back to a 2013 outbreak in northeast Laos. Swarms have destroyed cropland, particularly [maize] (~3,000 ha) and bamboo trees (~10,000 ha) [...]. Managers have used drones capable of deploying pesticides on the insects, in addition to other management campaigns as the insects were noticed along the border of Pu'er and Laos late June 2020".

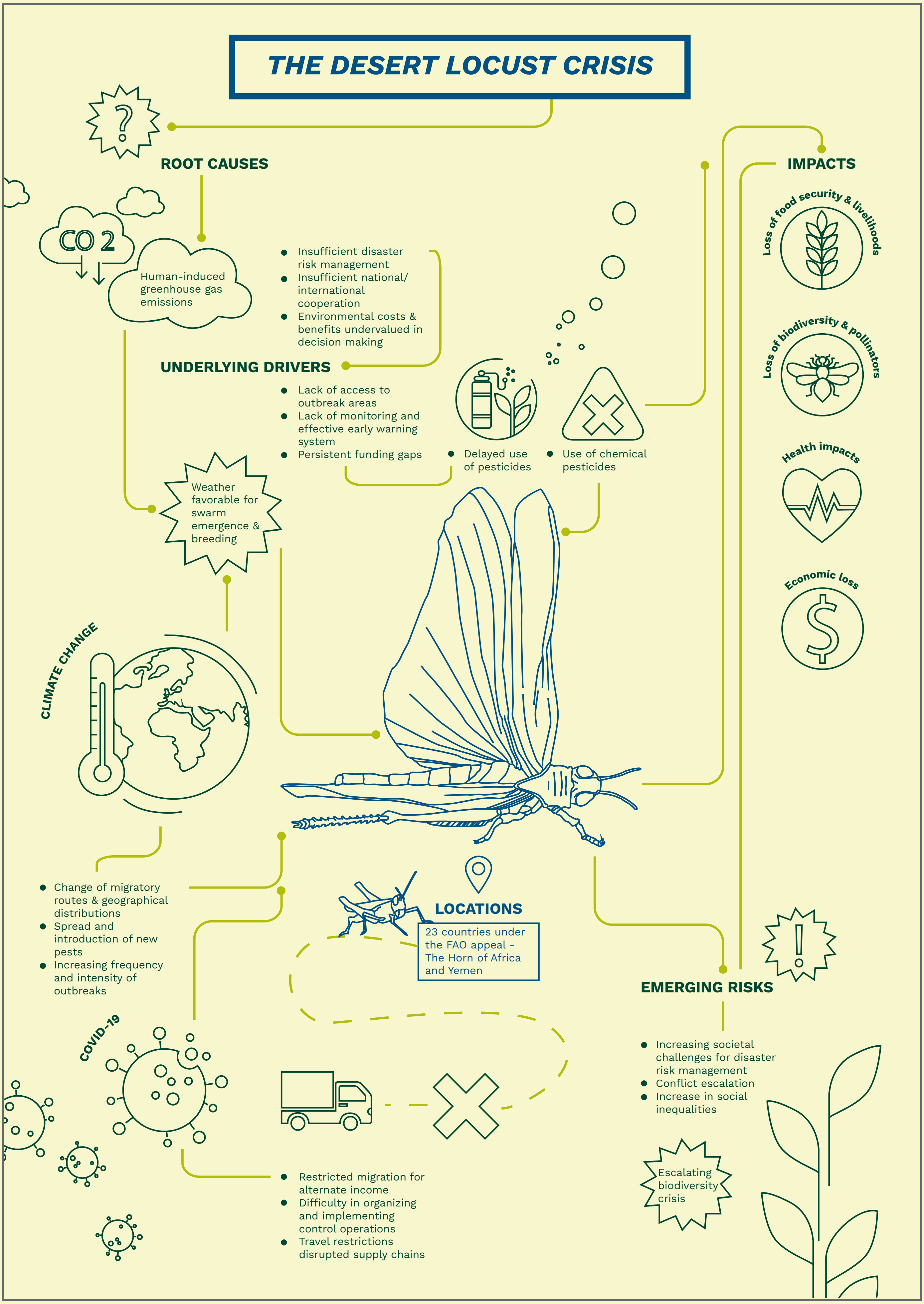
Finally, in Australia in early 2021, once again, climatological conditions provided the necessary conditions for swarm formation of the **Australian Plague Locust** (*Chortoicetes terminifera*). However, while no major outbreak materialised, these populations are of concern according to Australian Plague Locust Commission (APLC).[106] There were significant populations of Australian Plague Locusts in inland south-eastern Australia in summer 2021 (e.g., February 2021).

A.1.3 OTHER LOCUST SPECIES OF ENVIRONMENTAL AND ECONOMIC IMPORTANCE

1. The Malagasy locust (*Locust migratoria capito*) in Madagascar.
2. The Tree Locust (*Anacridium melanorhodon*) mainly in Africa.
3. The Central American Locust (*Schistocerca piceiferons*) distributed throughout Mexico and Central America.

105 https://sustainability-innovation.asu.edu/support-services/news/archive/locust-outbreaks-increase-with-two-additional-species-in-southern-africa-and-china/

106 https://www.agriculture.gov.au/pests-diseases-weeds/locusts/bulletins


THE DESERT LOCUST CRISIS
ROOT CAUSES
CO 2
Human-induced greenhouse gas emissions
UNDERLYING DRIVERS
Insufficient disaster risk management
Insufficient national/ international cooperation
Environmental costs & benefits undervalued in decision making
Lack of access to outbreak areas
Lack of monitoring and effective early warning system
Persistent funding gaps
Delayed use of pesticides
Use of chemical pesticides
Weather favorable for swarm emergence & breeding
CLIMATE CHANGE
Change of migratory routes & geographical distributions
Spread and introduction of new pests
Increasing frequency and intensity of outbreaks
COVID-19
Restricted migration for alternate income
Difficulty in organizing and implementing control operations
Travel restrictions disrupted supply chains
LOCATIONS
23 countries under the FAO appeal - The Horn of Africa and Yemen
IMPACTS
Loss of food security & livelihoods
Loss of biodiversity & pollinators
Health impacts
Economic loss
EMERGING RISKS
Increasing societal challenges for disaster risk management
Conflict escalation
Increase in social inequalities
Escalating biodiversity crisis

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