ISSN (Print): 2788-8320 ISSN (Online): 2788-8339

JOURNAL OF SOCIAL RESEARCH DEVELOPMENT
www.jsrd.org.pk editor@jsd.org.pk

THE ECONOMIC IMPACT OF DESERT LOCUST INFESTATIONS IN PAKISTAN AND THE ROLE OF TECHNOLOGY-ENABLED CONTROL

Saadullah Shaukat[1]

[1]A level Student, Westminster Academy, H-8/4, Islamabad, Pakistan. Email: saadshaukattss@gmail.com

KEYWORDS

desert locust; *Schistocerca gregaria*; Pakistan; food security; economic impact; early warning; drones; pest management

ARTICLE HISTORY

Date of Submission: 14-06-2026
Date of Acceptance: 17-07-2026
Date of Publication: 19-07-2026

ABSTRACT

In Pakistan, desert locust (Schistocerca gregaria) infestation is a common issue. The country is along the migratory path of the insect and also has sizeable breeding grounds in its own territory. In the 2019-2020 heightened surge, these swarms reached Sindh and Punjab, and the government had declared a national emergency in January 2020 and the initial assessment found damages in excess of 115,000 hectares. Official Pakistani data, FAO and World bank reports and published research has been used in this study to look into the impact of locust outbreaks on the economy. The channels covered are crop and input losses, rural income, food security, livestock feed, government spending, agricultural supply chains and poverty. There is a difference between reported damage and scenario estimates of damage, which ranged from PKR 205 billion to PKR 464 billion based on the assumed level of damage and type of crops. The paper also gives a summary of traditional control methods and the potential contribution of digital technologies. The CropShield prototype, which combines geotagged field reports, mapping, spread modelling and drone mission planning, is discussed as an example only, since it has not been tested in the field. The findings show that the cost of an outbreak depends mainly on how early it is detected and controlled. Continuous surveillance, quicker field response and data sharing with neighbouring countries are likely to cost less than large emergency campaigns launched after swarms have spread.

2026 Journal of Social Research Development

Correspondence	**Saadullah Shaukat**
Email:	saadshaukattss@gmail.com
DOI	https://doi.org/10.59075/jsrd.v7i5.643
Volume/Issue	**7(5), 2026, 245-260**

Introduction

Agriculture is central to Pakistan's economy. The sector produces food for the population, gives work to a large part of the rural labour force, provides raw material for textiles and food processing, and contributes to export earnings. For this reason, a serious fall in farm output affects other sectors as well (Government of Pakistan, Ministry of Finance, 2020; World Bank, 2020c). Desert locusts can cause such a fall. A swarm can eat the vegetation of a large area in a short time and move on before control teams reach it.

The desert locust is difficult to control because its behaviour depends on conditions. In normal years it remains at low numbers and causes little damage. After good rainfall, however, its numbers can increase over several generations, and the insects change into a gregarious form that gathers into swarms and travels long distances with the wind. FAO describes it as a migratory pest that can feed on almost any green plant. Pakistan has large arid and semi-arid regions as well as sits on the migration route for the southwest Asian migration route, making it vulnerable to the swarms on its borders and to the breeding taking place within the country (FAO, n.d.-a; Sultana et al., 2021). This risk became clear with the upsurge in each of the 2019-2020. According to the FAO report, control operation was initiated in February 2019 after locusts were found in Balochistan and the infestation spread to Sindh and Punjab. The federal government declared a national emergency on 31st January 2020. The initial assessment was that over 115,000 hectares were damaged with the outbreak regarded as an urgent threat to food security and crop cultivation (FAO, n.d.-a; Government of Pakistan, Ministry of Finance, 2020).

It's difficult to put an economic value on such an outbreak. Damage that was actually observed is not the same as losses calculated under an assumed damage rate. Both are different from the losses that could occur if control fails, and from the indirect effects that follow a drop in farm output. The World Bank also looked at the problem broadly. Its 2020 Locust Emergency and Food Security Project dealt with food security, livelihoods and economic stability, not just pest control (World Bank, 2020a, 2020c).

The study addresses four questions:

1. How do locust infestations affect Pakistan's economy?
2. What was the 2019–2020 outbreak a reflection of in the economy and institutions of the country?
3. What are the most appropriate conventional control methods to decrease future losses? How can technology be used to facilitate early detection, improved coordination and more effective control?

Agriculture, ecology, technology, public administration and economics are all involved in locust control and all of these disciplines are utilized in this study. Spraying pesticide is not enough on its

own. An early-warning system is also of little use if field teams do not have vehicles, equipment, authority or funds. The main argument of this paper is that losses can be reduced when the response moves away from reacting to swarms after they spread and towards regular prevention and early action.

Literature Review

Available information on locust outbreaks in Pakistan comes mainly from three types of source. The first type is operational reporting by FAO and the Department of Plant Protection. These reports give the locations where swarms were found, the area surveyed and treated, and the quantity of pesticide used (FAO, n.d.-a). They give a detailed picture of the control work but say little about economic effects.

The second type is official economic and project documents. The *Pakistan Economic Survey 2019–20* reported the first damage assessment and the size of the national response, and it presented the outbreak as a food-security issue (Government of Pakistan, Ministry of Finance, 2020). As part of the World Bank's assessment of the Locust Emergency and Food Security Project, it was concluded that the emergency is a result of food insecurity and poverty in Pakistan, and the livelihood support required and pest control measures were described (World Bank, 2020a, 2020c). Loss estimates are derived from these documents for the most part. They are however, written for planning purposes and make assumptions concerning damage scenarios – not measured damage. The third type is scientific research. In addition to the official reports, the upsurge described by Sultana et al. (2021) gives a peer-reviewed record of how the upsurge developed in Pakistan and their impact. The overall response results in the international arena across Southwest Asia has also been reported by FAO (n.d.-b). These account for the outbreak, and the control campaign, but there are two gaps. First, there are not many studies that incorporate all the economic channels together and estimates of the losses from various institutions are frequently given side by side without an explanation of why the differences. Secondly, there is little discussion on how digital tools could help minimize losses in Pakistan. This study addresses both lacunae. It organizes the evidence by economic channel and takes into account the feasibility of a technology-based system to support the existing institutional response.

Methodology

The approach used in this study is a qualitative study which is conducted to review literature on the desk and secondary data analysis descriptively. Sources were selected because they are directly involved in the upsurge of 2019–2020 in Pakistan. These cover the Pakistan Economic Survey 2019–20, FAO reports on Pakistan and Southwest Asia, World Bank project documents and peer-reviewed research etc. The analysis was done in three stages. The first stage involved identification of the economic channels of locust damage. The second phase involved gathering of data for 2019 and 2020, after which simple ratios, such as the proportion of sampled area that was treated, were determined; places where data was calculated by the author are indicated in the notes to the table. Finally, an expected-loss framework was applied to conventional and technology-based control

measures in the third stage. Reported damage and scenario estimates are kept separate in all parts of the analysis. The CropShield prototype is described on the basis of its unpublished project report and is used only as an example.

The Desert Locust Threat in Pakistan

Schistocerca gregaria is a grasshopper that usually lives alone and at low density. Rain brings fresh vegetation, which gives the insects food and moist soil for laying eggs, and their numbers can then rise over several generations. When they become crowded, they change into the gregarious phase. In this phase the young hoppers move in bands and the adults form swarms. With the help of the wind, swarms can cover long distances and cross national borders in a few days.

Pakistan's exposure is largely a matter of geography. FAO names Pakistan as an important country in the Southwest Asian locust corridor, and World Bank documents state that a large share of its land is linked to breeding or invasion risk. Balochistan is the most important province in this respect, as its dry areas provide breeding sites from which locusts later move to cropland. Sindh and southern Punjab, with their desert areas and irrigated fields, are exposed after that (FAO, n.d.-a; World Bank, 2020c). The main indicators are given in Table 1.

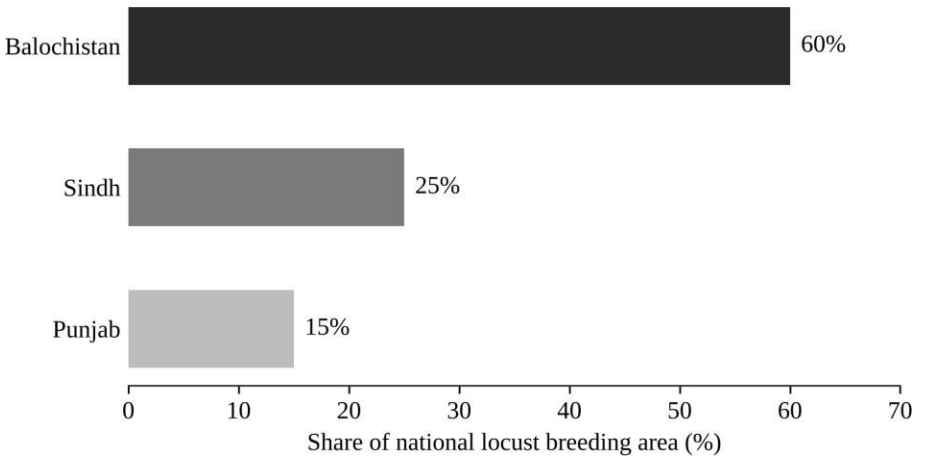
Table 1: Locust Breeding and Susceptibility Indicators for Pakistan

Indicator	Value	Interpretation
Share of national area identified as breeding grounds	38%	Breeding and recession area; the remainder is exposed to invasion
Balochistan's share of the breeding area	60%	Largest provincial share identified by FAO
Sindh's share of the breeding area	25%	Important breeding zone in the south-east
Punjab's share of the breeding area	15%	Smaller breeding share but the largest agricultural exposure
Susceptible area mapped by SUPARCO	161,720 km^2	Rated more susceptible on vegetation, soil and related factors
Total area assessed in the SUPARCO mapping	≈437,900 km^2	Area covered by the susceptibility assessment

Note. Data from FAO (n.d.-a) and World Bank (2020c). Percentages and areas are as reported in these sources.

Figure 1 shows how the breeding area is divided between provinces. Balochistan has 60% of it, which is why outbreaks are usually reported there first. Punjab has the smallest share of breeding area, but it has the most cropland at risk when swarms move east.

Figure 1 Provincial Distribution of Desert Locust Breeding Areas in Pakistan



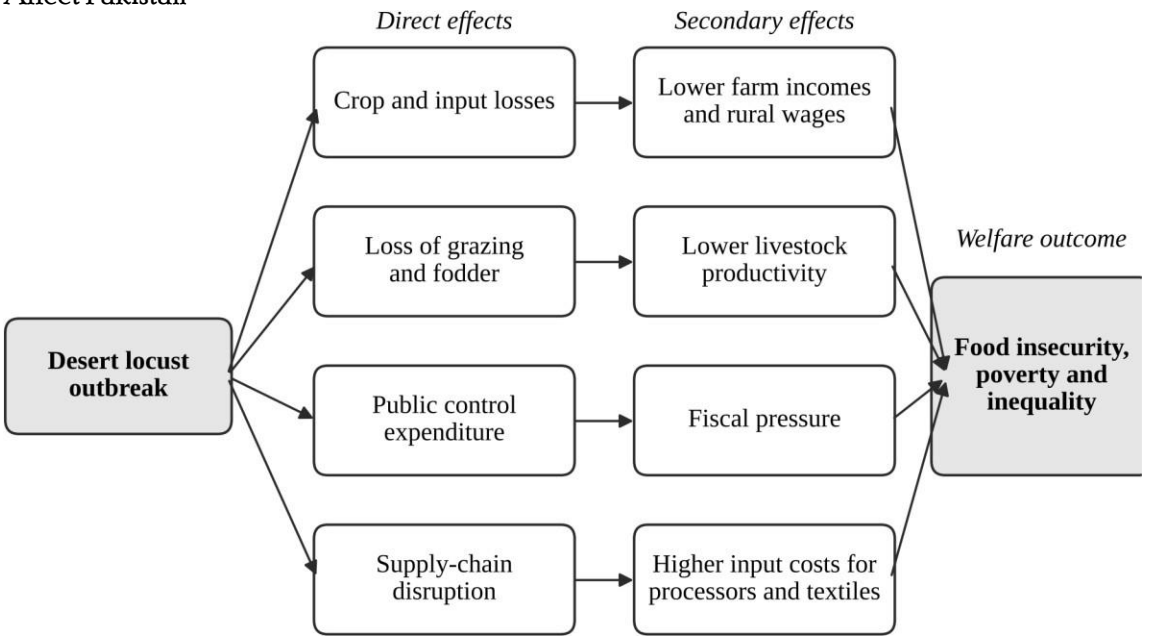
Note. Data from FAO (n.d.-a).

There are several reasons why control is difficult in a conventional manner for locusts. Swarms are fast moving and they can build up rapidly under favourable conditions. They are not restricted by district or provincial boundaries, and much of their breeding grounds is inaccessible to survey teams. Swarms may also be affected by vegetation and the weather, altering the direction of the swarms and areas where breeding can take place within a few days. This is the reason why the response speed has an economic value. A report which arrives several days late is of little value to officials, compared with one sent immediately with precise coordinates and an estimate of swarm size. Spends fuel, pesticide, and time if a control team goes to the wrong place and fuel is wasted as the swarm is continuing to move. Early warning is only useful if it results in immediate action in the field.

How Locusts Affect the Economy

Locusts affect the economy through several connected channels, as shown in Figure 2. An outbreak first causes direct losses in crops, grazing land, public budgets and supply chains. These losses then lead to secondary effects on income, livestock, government finances and industry. In the end, the heaviest burden falls on food security and on poor households.

Figure 2 Conceptual Framework of the Economic Channels Through Which Locust Outbreaks Affect Pakistan



Note. Developed by the author from the channels discussed in Sections 5.1–5.7.

Direct crop losses

The most obvious effect is the loss of crops. Desert locusts eat many kinds of plants, and during large outbreaks they damage cereals, cash crops, fruit, vegetables and fodder. In Pakistan, losses in wheat and other rabi crops are a risk to the food supply, while losses in cotton and other kharif crops reduce farm income, exports and agro-processing.

The market value of the damaged plants does not show the full loss. Before a crop is attacked, the farmer has already spent money on land preparation, seed, fertiliser, irrigation, labour, pesticide and machinery. When the crop is lost late in the season, this money cannot be recovered. The real loss is therefore the lost harvest plus the costs that were already spent on growing it.

Household income and rural livelihoods

Rural families earn their income from farming, wage labour, livestock and related services. When crops fail, their cash income drops quickly. Farm labourers also lose work, because there is less harvesting, transport and processing to do in the affected area.

The effect is not the same for everyone. Small farmers with little savings and limited access to credit suffer most. A farmer who loses one crop may have to take a loan for the next season, sell animals or

reduce household spending. In this way, a short-term pest attack can create financial problems that last for years.

The World Bank took this into account in 2020. Its Locust Emergency and Food Security Project aimed to benefit at least six million farmers and farm labourers, and around 30% of them were expected to be women (World Bank, 2020a, 2020b). The project shows that locust control also protects livelihoods and the ability of farmers to produce in future seasons (Table 2).

Table 2Key Features of the World Bank Locust Emergency and Food Security Project

Indicator	Reported value
Project financing	US$200 million
Farmers and agricultural labourers targeted	At least 6 million
Approximate share of women among targeted beneficiaries	30%
Project objectives	Control the outbreak, restore livelihoods, and strengthen food-security monitoring and early warning

Note. Data from World Bank (2020a, 2020b).

Food security and food prices

Large crop losses reduce the food available in local markets. Prices may rise, imports may increase, or both may happen. The result depends on the size of the shortfall, the level of stocks, trade conditions and how well the government can stabilise supply.

Food security is commonly measured through four dimensions: availability, access, utilisation and stability. Locusts affect at least three of them. Lower production reduces availability. Higher prices make it harder for poor households to buy food, which reduces access. Repeated outbreaks make farm income and food supply less predictable, which reduces stability.

Locust damage does not always raise food prices. Stocks and imports can sometimes fill the gap. The risk is higher when an outbreak happens at the same time as other shocks. This was the case in 2020, when the locust emergency overlapped with COVID-19 and households and markets were already under pressure (World Bank, 2020b, 2020c).

Livestock and grazing

Swarms also eat the plants that animals graze on. In pastoral and mixed farming areas, a loss of fodder may force families to buy feed, move their animals, sell part of the herd or accept lower milk and meat production. Livestock is a large part of Pakistan's agricultural economy, so an assessment

that only counts damage to standing crops will underestimate the total loss. Damage to rangeland and fodder should also be included

Public expenditure

Outbreaks are expensive for the government. Funding is required for survey teams, vehicles, pesticides, aircraft/drones, protective equipment, communication, training, and transport and support for farmers. As far as the response, the Federal and provincial government departments along with the National Disaster Management Authority (NDMA) (Government of Pakistan, Ministry of Finance, 2020) were involved in 2019–2020. Spending control should be regarded as "preventive spending." It's not the cost, it's whether it saves an even bigger loss. Swarm destruction with larger spraying efforts likely will not have as great a return if accomplished later than early detection and spraying targeted efforts. The challenge with the investment is that it occurs before the damage is apparent, which makes it more difficult to budget for in a normal budget.

Agricultural supply chains

Agriculture is used in a number of industries. The textile industry uses cotton as its primary raw material; flour mills and food processors use wheat; fruit and vegetable markets are served by wholesale markets and transport and cold storage. A big crop loss may result in insufficient inputs for the processors or they will have to pay more for the inputs. Businesses in impacted regions might lose customers, and import lanes may become congested. The impact will vary according to the crop affected and the extent of the infestation.

Poverty and inequality

An outbreak disproportionately impacts the poor. A large scale commercial farm will likely have insurance, savings, and other income streams; a small farmer or landless labourer will probably not have any of these. The locust emergency was part of the 2020 project documents released by the World Bank on poverty and food insecurity in Pakistan (World Bank, 2020c). This social cost is largely not reflected in market prices because a poor household suffers the loss of the same rupee much more severely than a landowner, who has the means to withstand it.

The 2019–2020 Upsurge: A Case Study

The 2019–2020 upsurge is the best recent example of how fast the problem can grow. FAO reports that Pakistan started its response in February 2019 after locusts were found in Balochistan. By May and June 2019 swarms had reached parts of Sindh, and later they were seen near Rahim Yar Khan and in Cholistan in Punjab (FAO, n.d.-a). A national emergency was declared on 31 January 2020. The *Pakistan Economic Survey 2019–20* described the spread as the worst in 25 years. It reported that the initial assessment found damage on more than 115,000 hectares of wheat, oilseeds, cotton, gram, fruit, vegetables and grazing land (Government of Pakistan, Ministry of Finance, 2020). Table 3 gives the main events in order.

Table 3 Timeline of the 2019–2020 Desert Locust Upsurge in Pakistan

Period	Development	Detail
February 2019	Department of Plant Protection began operations in Balochistan	Early operations covered Pasni, Gwadar, Turbat, Uthal, Kharan and Dalbandin
May–June 2019	Swarms spread into Sindh and later Punjab	Reports from Nara Canal, Khairpur, Tharparkar, Umerkot and Rahim Yar Khan
31 January 2020	National emergency declared	Response expanded across government
2020	Survey and control scaled up	1.5 million ha surveyed; 390,000 ha treated

Note. Data from FAO (n.d.-a) and Government of Pakistan, Ministry of Finance (2020).

FAO data show how large the 2019 operation was. The Department of Plant Protection surveyed 932,580 hectares in three provinces and treated 300,595 hectares using 150,839 litres of pesticide. About 20,300 hectares of this were sprayed from aircraft (FAO, n.d.-a). These numbers show how quickly the work and cost increase once an infestation is established (Table 4).

Table 4 Desert Locust Control Operations in Pakistan, 2019

Indicator	Reported value	Calculation or interpretation
Area surveyed	932,580 ha	Surveillance across three provinces
Area treated	300,595 ha	≈32.2% of the area surveyed
Pesticide used	150,839 L	Indicates the material scale of the operation
Area treated by aerial spraying	20,300 ha	≈6.8% of the area treated

Note. Data from FAO (n.d.-a). Percentages were calculated by the author from the reported figures and are not official estimates.

Potential losses were much higher than the damage reported during the outbreak. FAO scenario estimates put the possible loss at about PKR 205 billion if 15% of selected rabi crops were damaged. With 25% damage, the estimates were about PKR 353 billion for rabi crops and PKR 464 billion for kharif crops (FAO, n.d.-a; Government of Pakistan, Ministry of Finance, 2020). These amounts show what might have been lost under the stated assumptions. They are not losses that Pakistan actually suffered (Table 5).

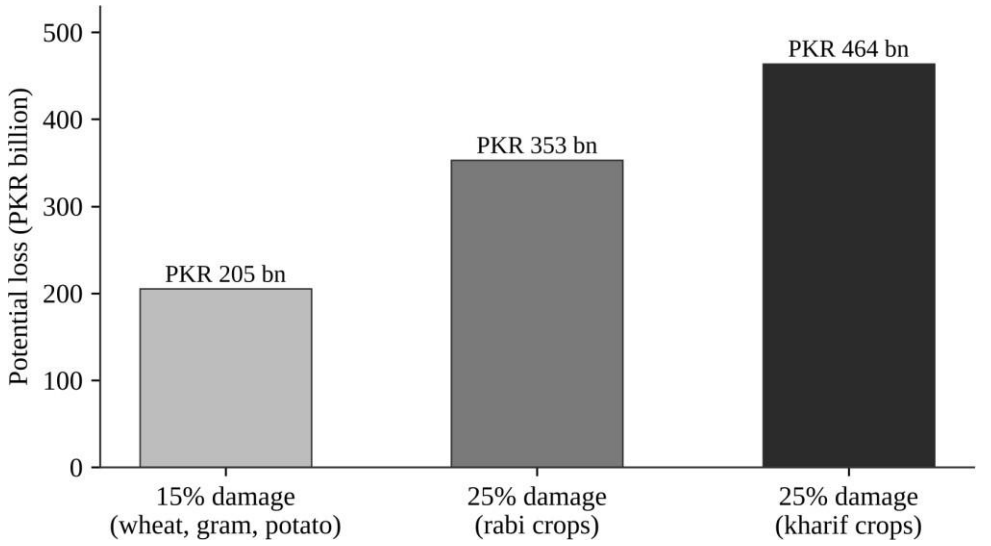
Table 5Reported Damage and Potential-Loss Scenarios, 2019–2020

Measure	Crops covered	Value
15% damage scenario	Wheat, gram and potato	PKR 205 billion
25% damage scenario	Rabi crops	PKR 353 billion
25% damage scenario	Kharif crops	PKR 464 billion
Initial assessed damage (area)	Wheat, oilseeds, cotton, gram, fruit, vegetables and grazing land	More than 115,000 ha

Note. Data from FAO (n.d.-a) and Government of Pakistan, Ministry of Finance (2020). Rupee values are scenario estimates of potential loss, not measured losses.

The three scenarios are compared in Figure 3. The highest estimate is more than twice the lowest, which shows how much the results depend on the damage rate and the crops included.

Figure 3Potential-Loss Scenarios for Major Crops in Pakistan, 2019–2020



Note. Data from FAO (n.d.-a) and Government of Pakistan, Ministry of Finance (2020). Values are scenario estimates of potential loss, not measured losses.

There are also other estimates that should be read carefully. In the event of the emergency spiraling out of control, agricultural losses could exceed US$15 billion, according to an assessment by the Government of Pakistan, cited by the World Bank An estimate of US$2.19 billion for rabi crops and US$2.88 billion for kharif crops at 25% damage level was estimated in a later official technical presentation (World Bank, 2020c). All these numbers are based on different assumptions and time frames and definitions of losses. They should never be summed together and none is a measurement of

actual damage. There is one good lesson that can be drawn from the case. An outbreak's cost is largely related to its early detection and quick containment. Locusts could be prevented from invading the main farming areas if they were surveyed and treated before they enter breeding areas.

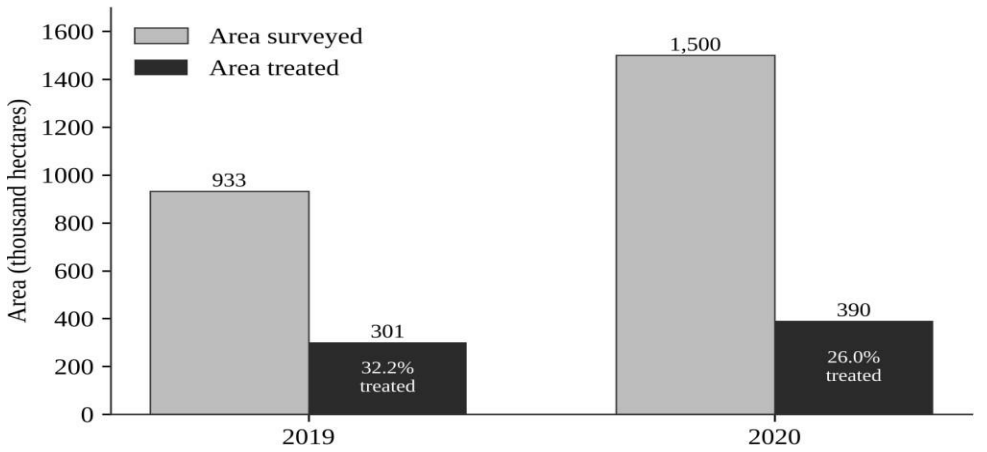
Table 6 Desert Locust Control Operations in Pakistan, 2020

Measure	Value
Total area surveyed	1,500,000 ha
Total area treated	390,000 ha
Area treated by ground vehicles	363,400 ha
Area treated by aircraft	26,600 ha
Share of surveyed area treated	26.0%

Note. Data from Government of Pakistan, Ministry of Finance (2020). The 26.0% share was calculated by the author from the reported totals.

Tables 4 and 6 and Figure 4 show that the surveyed area increased from 932,580 hectares in the 2019 FAO data to 1.5 million hectares in the 2020 Economic Survey. The treated area increased from 300,595 to 390,000 hectares. The share of surveyed land that was treated dropped from about 32.2% to 26.0%. These two sets of figures come from different sources and periods, so the change should not be taken as a direct sign of better performance (FAO, n.d.-a; Government of Pakistan, Ministry of Finance, 2020).

Figure 4 Area Surveyed and Treated for Desert Locusts in Pakistan, 2019 and 2020



Note. Data from FAO (n.d.-a) for 2019 and Government of Pakistan, Ministry of Finance (2020) for 2020. Treated shares were calculated by the author. The two years come from different sources and reporting periods.

Conventional Control Measures and Their Economic Rationale

Surveillance and early warning

Early warning is the starting point of locust management. FAO's Desert Locust Information Service monitors conditions and issues forecasts at the international level, and national agencies carry out field surveys. Pakistan has also used satellite and GIS data to identify areas at risk (FAO, n.d.-a; World Bank, 2020a). The economic reasoning is simple. Good information reduces uncertainty and helps direct limited resources to the right places. The government does not have to spray every area that might be at risk. It needs to know where the chance of infestation and the likely damage are high enough to justify action.

Rapid field verification

Satellite data cannot take the place of field checks. Survey teams have to confirm whether locusts are present, how dense they are and what stage they have reached, and reliable field data help to avoid false alarms. Digital reporting can support this work. Field officers can send geotagged observations that are checked at a central office, which makes the flow of information faster and more consistent. However, this only works if the data are accurate, mobile coverage is available and staff are trained.

Targeted chemical control

Pesticides are still necessary once locust numbers reach damaging levels. Spraying large areas without clear targets, however, is costly and can harm people and the environment. The aim should be targeted control: the correct treatment, in the correct place, at the correct time. In 2019 alone, more than 300,000 hectares were treated (FAO, n.d.-a). Better targeting could cut the number of unnecessary operations, but the actual savings would have to be measured through field trials and cost–benefit analysis.

Drone-assisted surveillance and spraying

Drones can reach difficult areas, take images and spray small, specific targets. A drone by itself, however, is just a machine. It becomes useful for decisions when its missions and results are linked to confirmed records of where the locusts are.

Farmer awareness and reporting

Farmers are often the first people to see unusual insect activity. If they are trained to recognise the stages of the locust and to report what they see, surveillance can cover a much larger area at little cost. Reports that include location, photographs and time are far more useful to control teams than verbal descriptions.

Technology-Enabled Solutions

Digital tools can help make locust management faster, more accurate and better organised. The most relevant tools are geotagged field reporting, satellite monitoring of vegetation, geographic information systems (GIS), automatic alerts and drone surveillance. These tools give the best results when they are part of clear response procedures and are used by trained staff.

CropShield is a prototype developed by students that shows how these tools could work together (CropShield Project Report, 2026). Field officers or farmers send geotagged reports of locust sightings. The reports are shown on a map, and a simple spread model based on breadth-first search (BFS) estimates which nearby areas the locusts could reach next. Drone missions can then be planned for confirmed or high-risk locations, and the result of each mission is saved for later decisions. The main advantage of the design is that it connects steps that are usually handled separately: detection, checking, prediction, action and record-keeping. CropShield has not yet been tested in the field, and there is no evidence so far that it lowers crop losses or government costs. Before a system like this could be used nationally, it would need testing against data from past outbreaks, field trials, reliable data sources, cybersecurity protection and a cost–benefit assessment. Such technology should assist agricultural officers, scientists and decision-makers rather than replace them.

Institutional and Regional Measures

Technology is just one component of a successful response. Good institutions are also critical. Federal government is headed by the Department of Plant Protection and provincial level is more in contact with farmers under the agriculture departments. There is an opportunity for NDMA to incorporate locust risk into broader disaster planning processes. Forecasts, technical standards and coordination are provided by FAO, and research institutions can study past outbreaks to enhance forecasting. Designated organizations must have well-defined roles in order to trigger an action in response to a warning. Swarms roam across borders, thus Pakistan's risk is related to the conditions in neighbouring countries. In the 2019 outbreak, FAO facilitated the exchange of information across the Pakistan-India border, demonstrating that information sharing is possible despite tensions between countries. Common Reporting Standards, data sharing and joint surveys at borders should be part of regional cooperation, as should agreed communication methods and strategies when outbreaks are fast moving. Formal agreements are required, but a common format of incident data through shared digital systems can be achieved.

The Economics of Prevention

It is not about whether locust control is costly or not, but rather whether the cost of prevention is less than the damage to be incurred in case of failure. This can be represented in the short form: Expected Loss (no intervention) = P (severe outbreak) × Economic damage (1) Net benefit (expected) = Expected loss avoided – Cost of surveillance and control (2) Full application of the framework would involve direct losses of the crops as well as indirect losses of livelihoods, livestock,

food prices and public spending (where available). It should also take into account uncertainty in both the probability of an outbreak and the size of the damage. In this context, early warning may be expected to succeed well, as a measure could be implemented before an infestation occurs. According to FAO (n.d.-b), the international assistance provided during the upsurge, in 2020-2021, prevented an estimated loss of approximately 4.5 million tonnes of crops and saved the livelihoods of an estimated 41.5 million people in the countries affected. The figures are for the entire area and should not be interpreted as savings per se for Pakistan. An appropriate cost benefit analysis for Pakistan should be made between various strategies. These include basic field surveillance, enhanced satellite surveillance, drone surveillance, integrated digital command system, and all of these. Indicators would include the cost per hectare surveyed and treated, response time, false alarm rate and crop damage avoided and the impact on farmer income.

Limitations and Risks

These limitations and risks of the technology-based approach to locust management are also summarized below.

• **Data quality.**

The best a prediction model can be is as good as the data it uses. The forecasts will be incorrect if the field reports are incorrect or late, no matter how advanced the model is!

• **False confidence.** A BFS model can indicate what areas are connected but it is an untested model of locust migration and does not consider wind, vegetation or breeding conditions. • Drone operations. In reality, battery life, maintenance, weather, network coverage, and payload restrictions and aviation rules limit the use of drones.

• **Pesticide use.** With a better targeting, there will be less spraying wastage, however, the selection of the pesticide and where to spray requires agronomic and regulatory knowledge, which software does not provide. In the digital era, cybersecurity and data governance are essential topics. A nationwide early-warning system would keep sensitive operational data. It would have to be user authenticated, role based, encrypted, and have audit records. • Institutional capacity. An alert is of no use if there is no one to respond. Technological solutions are not the solution to the problems of inadequate employees and equipment. There are some limitations to this study. The figures are based on secondary sources which report numbers during varying time periods and apply varying definitions; so the numbers do not necessarily lend themselves to direct comparisons. Actual losses are not estimated by the study, and the talk of the CropShield is based on an unpublished prototype report, not on field data.

Policy Recommendations

This analysis has resulted in seven priorities for Pakistan's long-term locust strategy: 1. Make surveillance continuous. Monitoring in low risk years should be maintained and not increased

during an emergency. 2. Develop a national data platform to link field observations, satellite observations, weather data, previous swarm activities and swarm control missions. 3) Enhance the capability of responding rapidly to infestations in high-risk areas; teams should be able to reach infested sites without delay. 4. Broaden the use of drones to survey, map and, as legally and technically feasible, spray. Each Mission to a confirmed Incident record. 6. Create wind-tuned, vegetation, rainfall, temperature, terrain, and observation-based forecasting models that are tested. Simple prototype algorithms should simply be used as a beginning. Include farmers, using mobile reporting, farmer awareness raising and identification guides to ensure a greater number of observations are reported to the authorities. Improve regional cooperation by frequent information exchange with neighbouring countries and international locust-monitoring organisations.

Conclusion

Desert locusts cause direct damage to crops, but they also have a significant economic impact. Losses harm farm income, food availability and these effects trickle down to farm labour, the livestock business, food markets, government budgets and related industries. The scale of these losses were demonstrated in the 2019-2020 surge. The damage was reported in more than 115,000 hectares, surveyed area from 932,580 hectares in 2019 to 1.5 million hectares in 2020 and ranging from PKR 205 billion to PKR 464 billion potential losses (FAO, n.d.-a; Government of Pakistan, Ministry of Finance, 2020). Losses are different for institutions due to the different crops, time periods and damage assumptions used, and should be interpreted with caution. Nevertheless, they have demonstrated that the expenditure on surveillance and control was warranted. This study's overall economic finding is that the role of prevention and early response is an investment. Surveillance, forecasting, field checks and targeted control minimise the risk of a local infestation escalating to a national problem. Drones, spread prediction and reporting and mapping are possible integrated in one process as demonstrated by the digital system CropShield. The actual value of their use is unknown and should be assessed by pilot projects, experience with outbreaks in the past and cost–benefit analyses. With the insect's biology and movement across borders, it is not realistic to remove all swarms. More realistic objective for Pakistan is early detection of an outbreak of a highly contagious disease, forecasting the location of the outbreak and allocating the resources efficiently and benefiting from every outbreak. All of this is possible with the help of technology at each of these steps, but only if there is trained staff, appropriate equipment, capable institutions, farmer participation and cooperation with neighbouring countries.

Declaration of AI Use

During the preparation of this manuscript, the author used Claude (Anthropic) to rephrase and edit the text for language and readability, to restructure the paper, and to prepare figures from the reported data. The author reviewed and edited all content and takes full responsibility for the accuracy and integrity of the work.

References

CropShield Project Report. (2026). *CropShield: AI-powered locust early warning and control system* [Unpublished project report].

Food and Agriculture Organization of the United Nations. (n.d.-a). *Desert locust situation in Pakistan*. FAO in Pakistan. https://www.fao.org/pakistan/resources/in-depth/desert-locust-situation-in-pakistan/en/

Food and Agriculture Organization of the United Nations. (n.d.-b). *The desert locust upsurge in Southwest Asia has been stopped!* FAO in Pakistan. https://www.fao.org/pakistan/resources/in-depth/the-desert-locust-upsurge-in-southwest-asia-has-been-stopped/en/

Government of Pakistan, Ministry of Finance. (2020). *Pakistan economic survey 2019–20*. https://finance.gov.pk/survey/chapter_20/PES_2019_20.pdf

Sultana, R., Kumar, S., Samejo, A. A., Soomro, S., & Lecoq, M. (2021). The 2019–2020 upsurge of the desert locust and its impact in Pakistan. *Journal of Orthoptera Research, 30*(2), 145–154. https://doi.org/10.3897/jor.30.65971

World Bank. (2020a, July 31). *Pakistan: Locust Emergency and Food Security Project*. https://www.worldbank.org/en/news/loans-credits/2020/07/30/pakistan-locust-emergency-and-food-security-project

World Bank. (2020b, July 31). *Pakistan invests $400 million to manage the locust outbreak and respond to school disruptions due to COVID-19* [Press release]. https://www.worldbank.org/en/news/press-release/2020/07/30/pakistan-invests-400-million-to-manage-the-locust-outbreak-and-respond-to-school-disruptions-due-to-covid-19

World Bank. (2020c). *Pakistan: Locust Emergency and Food Security Project (P174314): Project appraisal document*. https://documents1.worldbank.org/curated/en/142741596592886338/pdf/Pakistan-Locust-Emergency-and-Food-Security-Project.pdf