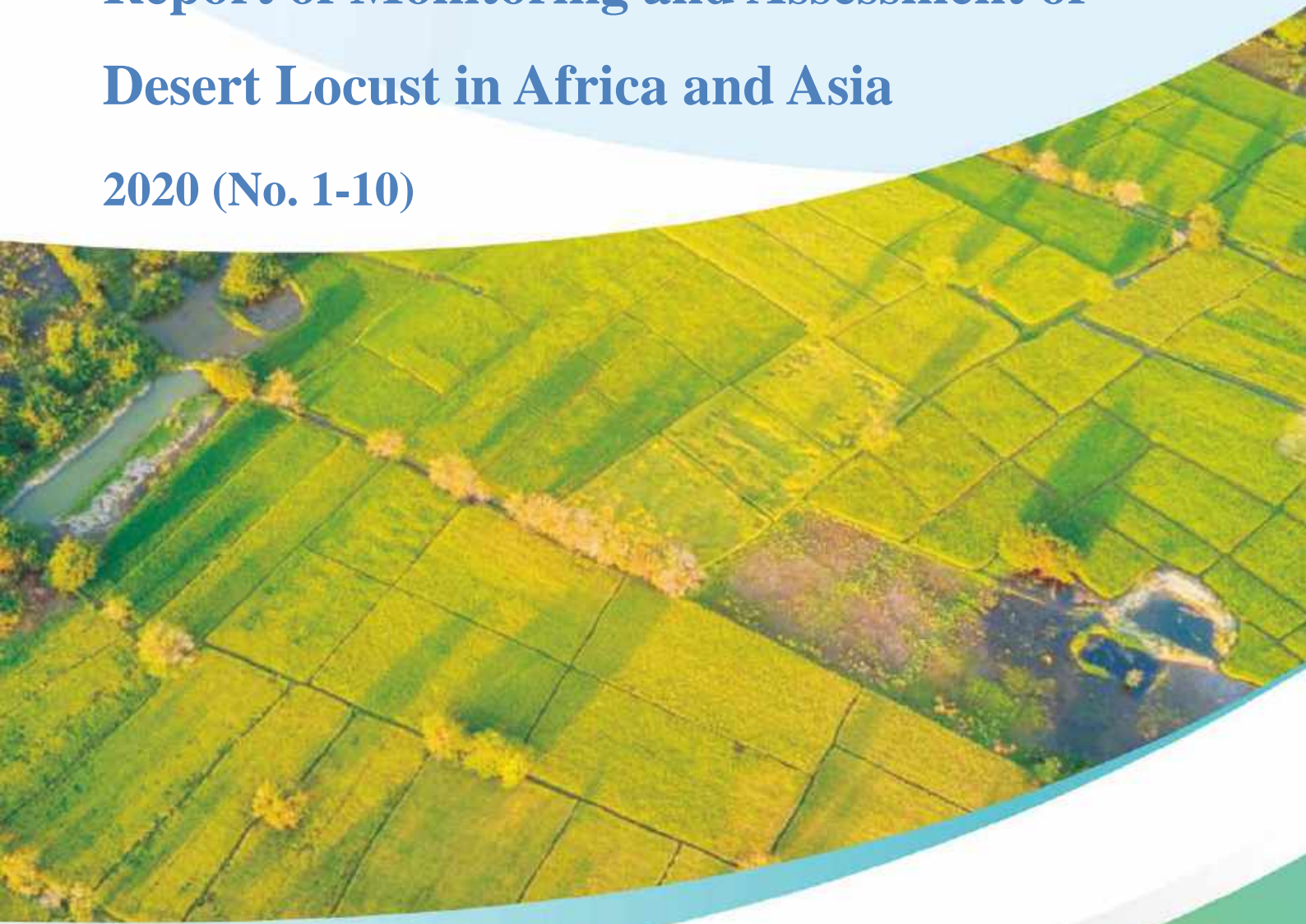




Aerospace Information Research Institute, Chinese Academy of Sciences

Report of Monitoring and Assessment of Desert Locust in Africa and Asia

2020 (No. 1-10)



Contents

| | |
|--|----|
| No. 1 Desert Locust invasion in Africa and Asia (February)..... | 01 |
| No. 2 Assessment of Desert Locust migration and loss in Asia and Africa (Early March)..... | 05 |
| No. 3 Assessment of Desert Locust migration and loss in Kenya and Ethiopia (Late March)..... | 13 |
| No. 4 Desert Locust monitoring and loss assessment in Somalia and Pakistan (Early April)..... | 20 |
| No. 5 Desert Locust monitoring and loss assessment in Yemen and Ethiopia (Mid April)..... | 27 |
| No. 6 Desert Locust monitoring and loss assessment in Pakistan and Somalia (Early May)..... | 35 |
| No. 7 Desert Locust monitoring and loss assessment in Kenya and Ethiopia (Late May)..... | 41 |
| No. 8 Desert Locust monitoring in Asia and Africa and loss assessment in Yemen (June)..... | 47 |
| No. 9 Desert Locust Monitoring and Loss Assessment in Six Asian and African Countries (July)..... | 54 |
| No. 10 Desert Locust Monitoring and Loss Assessment in Three Southwest Asia Countries (August) | 68 |

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National Engineering Research Center for Agro-Ecological Big Data Analysis & Application
Desert Locust monitoring and forecasting

February 2020

Desert Locust invasion in Africa and Asia

Overview

Integrated with multi-source Earth Observation data, e.g. meteorological data, field data, and remote sensing data (such as GF series in China, MODIS and Landsat series in US, Sentinel series in EU), and self-developed models and algorithms for Desert Locust monitoring and forecasting, the research team constructed the 'Vegetation pests and diseases monitoring and forecasting system', which could regularly release thematical maps and reports on Desert Locust.

The Desert Locust has ravaged the Horn of Africa and Southwest Asia, posing serious threats on agricultural production and food security of the inflicted regions. The Food and Agriculture Organization of the United nations (FAO) has issued a worldwide Desert Locust warning, calling for joint efforts from multiple countries in prevention and control of the pest to ensure food security and regional stability. The migration path of the Desert Locust and make a detailed analysis on the possibility of the Desert Locust invasion of China has been

Content

| | |
|---|---|
| Overview | 1 |
| Migration path and prediction of Desert Locust in Africa and Asia | 1 |
| Contact us | 4 |

tracked.

Migration path and prediction of Desert Locust in Africa and Asia

Figure1 shows the migration path of the Desert Locust from Year 2018 to 2020. Due to the influence of Northeast Monsoon and the barrier of Qinghai-Tibetan Plateau, it has a lower probability of the Desert Locust in the Indo-Pakistan border invading China at present. However, if the locust in Pakistan and India cannot be controlled effectively, and even disasters erupt, then when the Southwest Monsoon is extremely strong, it may has a higher probability for the locust moving from India to Myanmar via Bangladesh, and higher risk to invading China's Yunnan and Tibet in May to June 2020, according to the analysis.

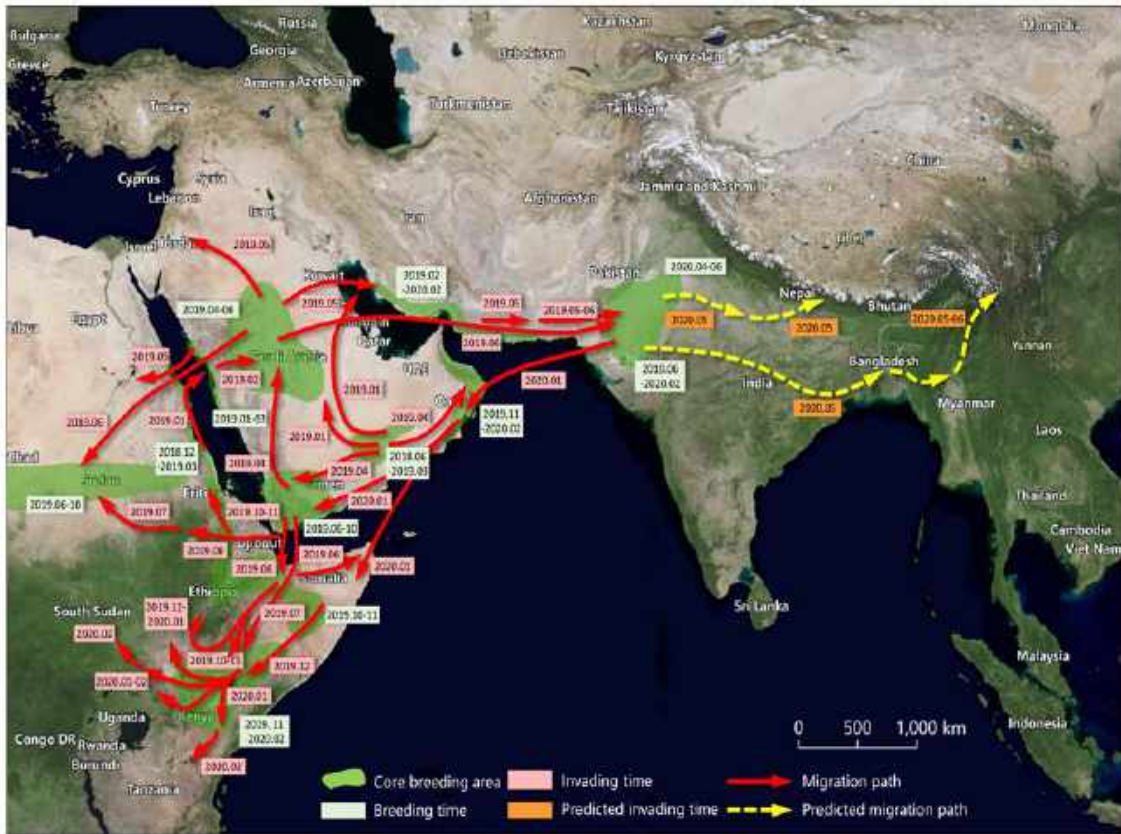


Figure 1 Migration path of Desert Locust (Year 2018 – 2020)

The time series remote sensing monitoring results are shown in Figure 2. From October to December 2019, the locust swarms at the Indo-Pakistan border began to breed in three generations and migrated to spring breeding areas of southern Iran and northern Oman via Baluchistan. From January to February 2020, locust swarms existed in northwest Pakistan, Nara, Tharparkar, and Cholistan. Some of them moved north of Bahawalpur, and some had the trend of migration to southwest Pakistan and southern Iran due to climate impact.

Before May 2020, affected by the Northeast Monsoon, there are three potential migration paths of locusts along the Indo-Pakistan border, which are Indo-Pakistan border—Bahawalpur—Khyber Pakhtunkhwa, Indo-Pakistan border—Quetta and southern

Region, Indo-Pakistan border—southwestern Baluchistan, shown in Figure 3.

At present, a large number of locusts on the Indo-Pakistan border have spawned on the ground and are about to enter the next round of spring breeding. In addition, desert locusts on the southeast coast of Iran continue to breed and invade Pakistan. The scientists warn that, if the desert locusts in Pakistan are not effectively controlled in the adult stage in May 2020, the locust plague will continue to outbreak, which may cause a severe blow to Pakistan’s agricultural production. In addition, although the Indian locust plague has been controlled to a certain extent, affected by the southwest monsoon from May to June, locusts on the Indo-Pakistan border may migrate from Pakistan to India, continue to invade Nepal,

Bangladesh, Myanmar, and may a higher risk to invade Yunnan and Tibet of China.

Considering China's biodiversity, climate and other conditions are conducive to further breeding and migration of locusts, coupled with the local Migratory Locust, one of the main

pests in China, it will bring serious threats to China's food security. The scientists suggested the government to carry out large-scale locust disaster monitoring and early warning, while boosting global cooperation on Desert Locust prevention to help ensure global food security.

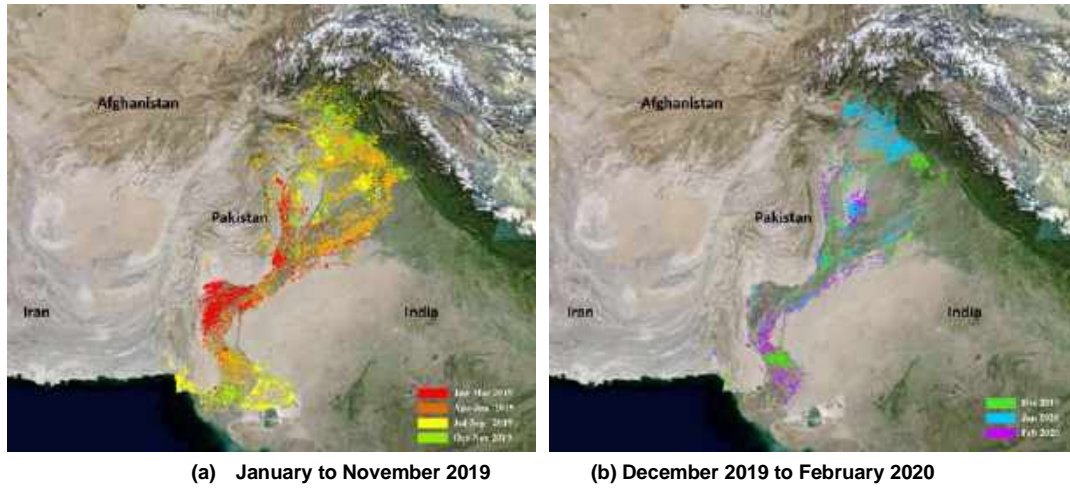


Figure 2 Time series remote sensing monitoring of Desert Locust damaged area in Pakistan from Year 2019 – 2020



Figure 3 Migration path of Desert Locust in Pakistan from Year 2019 – 2020

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Mission statements: As the science and knowledge service, the Sino-UK Crop Pest and Disease Forecasting & Management Joint Laboratory is to support independent evidence for crop monitoring.

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Desert Locust monitoring and forecasting

Early March 2020

Assessment of Desert Locust migration and loss in Asia and Africa

Overview

Integrated with multi-source Earth Observation data, e.g. meteorological data, field data, and remote sensing data (such as GF series in China, MODIS and Landsat series in US, Sentinel series in EU), and self-developed models and algorithms for Desert Locust monitoring and forecasting, the research team constructed the 'Vegetation pests and diseases monitoring and forecasting system', which could regularly release thematical maps and reports on Desert Locust.

Last week, researchers conducted following research on dynamic monitoring of Desert Locust migration and damage in Asian and African countries based on the Digital Earth Science Platform, and forecasting of the possible breeding areas and migration paths from March to June 2020 (Figure1). The result shows that currently the Desert Locusts are mainly located in the winter breeding areas of

Content

| | |
|---|---|
| Overview | 1 |
| Migration path and prediction of Desert Locust in Africa and Asia | 2 |
| Monitoring and assessment of Desert Locust in Pakistan | 3 |
| Monitoring and assessment of Desert Locust in Ethiopia | 4 |
| Contact us | 8 |

the Red Sea and the Gulf of Aden coast and Pakistan, and the winter-spring breeding areas of Ethiopia and Kenya in southern Horn of Africa. These places are seriously ravaged. At present, the Desert Locusts in Pakistan have harmed 1035 thousand hectares of wheat planting area, accounting for 11% of the total national wheat planting area. In Ethiopia, which is mainly engaged in agriculture and pasture, the vegetation damaged area has reached 3753 thousand hectares, seriously affecting the local livelihood. In addition, Desert Locusts in Ethiopia, Kenya, southern

Iran and Pakistan have entered the spring breeding season. Multi-generational breeding of locust will lead to a surge in pest populations over the next three months, which coincides with the growth season or harvest season of crop. Desert Locusts will pose a major threat to the food security of the above-mentioned countries. It is necessary to carry out the monitoring and early warning of the intercontinental Desert Locust plague continuously and dynamically, and organize joint prevention and control in multiple countries, to ensure the safety of agricultural and pasture production and regional stability.

Migration path and prediction of Desert Locust in Africa and Asia

By the end of 2019, the core breeding areas of Desert Locust in East Africa and southwest Asia were mainly located along the Red Sea (eastern Sudan and Eritrea, western Saudi Arabia and Yemen), Indo-Pakistan border, central Sudan and eastern Ethiopia, as well as eastern Oman, southeastern Iran and central Saudi Arabia.

In January 2020, the locust swarms invaded south and central rift valley of Ethiopia and northeast Kenya, and then continued to invade south and northwest Kenya. Meanwhile, the locust swarms along

the Indo-Pakistan border moved to northeast Oman, while the locust swarms in northeast Oman also moved south to south Yemen and north Somalia. In February, the swarms in Kenya moved northwest into southern South Sudan, south into northeastern Tanzania, and west to northeastern Congo through northern Uganda. Locust swarms from Saudi Arabia and western Yemen moved North-East through central Saudi Arabia to Bahrain, Qatar and Kuwait and reached southeastern Iraq by the end of February; Parts of locust swarms in northern Pakistan migrated to the southwest, and parts crossed the border into Afghanistan.

At present, locusts spring breeding are underway in most areas. New spring breeding areas are expected to form in central Saudi Arabia, Iran-Pakistan border, and India-Pakistan border from March to June. Locust swarms in these areas are supposed to move into the summer breeding areas in May or June, such as central Sudan, southern Yemen, northern Ethiopia and Indo-Pakistan border, and the locusts may even migrate eastwards with the Southwest Monsoon, if the adults along Indo-Pakistan border are not controlled effectively in May. In the next three months (March-June 2020), countries will step into the key growing season or harvest season of crop, and if the Desert Locusts continue to

invade, agricultural and pasture production and national livelihoods in Asian and African countries will be seriously threatened. FAO has issued a worldwide Desert Locust warning,

Monitoring and assessment of Desert Locust in Pakistan

In January 2020, the locust in Nara, Tharparkar, Cholistan areas along Indo-Pakistan border continued to breed and migrate northwards to Bahawalpur in southern Punjab. Desert Locust harmed about 256 thousand hectares of vegetation area (including 234 thousand hectares cropland and 22 thousand hectares grassland), mainly distributed in the border areas between Sind and Punjab (Figure2). In February, locust swarms moved northwest to Okara in Punjab, Lucky Marwat in Khyber Pakhtunkhwa and Dera Ismail Khan, damaged 298 thousand hectares of vegetation (including 265 thousand hectares cropland and 33 thousand hectares grassland). Till late February, part of locust swarms from northern Pakistan moved into Khost, Afghanistan. Locusts along the Indio-Pakistan border and the southern coast of Baluchistan will start a second generation of spring breeding from March to June. Part of the locusts are expected to migrate to the Iran/Pakistan boundary in March; locust

calling for high alert for an ongoing locust plague and raising funds globally to help inflicted countries to fight locusts plague and troubleshoot the food crisis.

swarms in southern Iran are expected to move into southwestern Pakistan along with the summer monsoon, and locust swarms along the Indio-Pakistan border may migrate to eastern India in May (Figure3).

At present, most wheat areas of Pakistan are within the booting stage of growth, effectively control of locust must be conducted to protect wheat yield security. Our results showed that by the end of February, the locust had affected 1035 thousand hectares of wheat in Pakistan, accounting for 11% of Pakistan's seeded area, In which, Sind has the damaged area about 234 thousand hectares, accounting for 20% of the province's seeded area; Punjab has the damaged area of about 701 thousand hectares, accounting for 11% of the whole province's seeded area; Baluchistan has the damaged area of about 48 thousand hectares, accounting for 9% of the whole province's seeded area; Khyber Pakhtunkhwa has the damaged area of about 52 thousand hectares, accounting for 17% of the whole province's seeded area. Combined with the recent regional agrometeorological conditions such as the precipitation, temperature, etc., it

is estimated that the wheat yield in the damaged areas of these four provinces will decrease by about 28%, 14%, 24% and 11% respectively, which brings a significant impact on the food security of Pakistan.

Monitoring and assessment of Desert Locust in Ethiopia

In June 2019, mature locust swarms from Yemen invaded northwest Somali in Ethiopia, and sufficient rainfall provided favorable conditions for the breeding of Desert Locusts (Figure4). From July to September, some locust swarms spread to the northeast of Amhara and the central Afar for summer reproduction, endangering about 638 thousand hectares of vegetation in western Somali, Amhara and southern Afar (including 199 thousand hectares cropland, 108 thousand hectares grassland, and 331 thousand hectares shrub). From October to December, the swarms continued breeding, with some of the swarms moving north along Amhara to Tigray, and some of local swarms moving east into the area around Dire Dawa and towards Ogaden in eastern Somali. While part of locust swarms in northern Somalia invaded into Ethiopia across the country border, then migrated southward from the northern Ogaden and invaded southeast

Ethiopia and southern Somalia, reached northeastern Kenya at the end of February. Local pasture and cropland in Ethiopia had been badly damaged with an increased area of about 978 thousand hectares (135 thousand hectares cropland, 81 thousand hectares grassland, and 762 thousand hectares shrub). In January 2020, locusts in Harar and Jijjiga of eastern Somali, Warder, Kebridehar, Gode were constantly hatching and growing, and migrating westwards and southwards to Yabello of southern Oromiya and the edge of the Rift Valley in eastern Southern Nations Nationalities and People Region (SNNPR). An area of 1038 thousand hectares of plant were increased (69 thousand hectares of cropland, 35 thousand hectares grassland, and 934 thousand hectares of shrub). In February, swarms moved into the Rift Valley from the north and the south, larger swarms were formed combined with the local locust breeding. The hazard areas are mainly distributed in Somali, Oromiya and SNNPR with an increased area of about 1099 thousand hectares, (540 thousand hectares cropland, 149 thousand hectares grassland, and 410 thousand hectares shrub) (Figure5). The results showed that since June 2019, Desert Locust has caused the damage of 3753 thousand hectares of vegetation in

Ethiopia with 943 thousand hectares cropland, 373 thousand hectares grassland and 2437 thousand hectares shrub, accounting for 4.7%, 2.5% and 3.9% of the total cropland, grassland and shrub in Ethiopia, respectively. The Rift Valley, known as the Ethiopia's granary, has also been badly devastated. Since 80% of Ethiopia's population are agricultural and pastoral, this locust plague has seriously threatened national livelihood and regional stability.

Comprehensive analysis showed that the locust located in Rift Valley of Oromiya and SNNPR will continue its spring breeding from March to June in 2020 and may migrate to

summer breeding area in northern Amhara, Afar and Jibouti between April and June. At the same time, the locust in eastern Somali will conduct spring breeding from March to June and the swarms are expected to migrate to Indo-Pakistan border in June with the southwest monsoon. Currently, a large number of locusts in Ethiopia have laid eggs on the ground and next generation of spring breeding is about to begin. If the locust couldn't be controlled effectively, the plague will continue, which may bring a heavy blow to the agricultural and pasture production in Ethiopia.

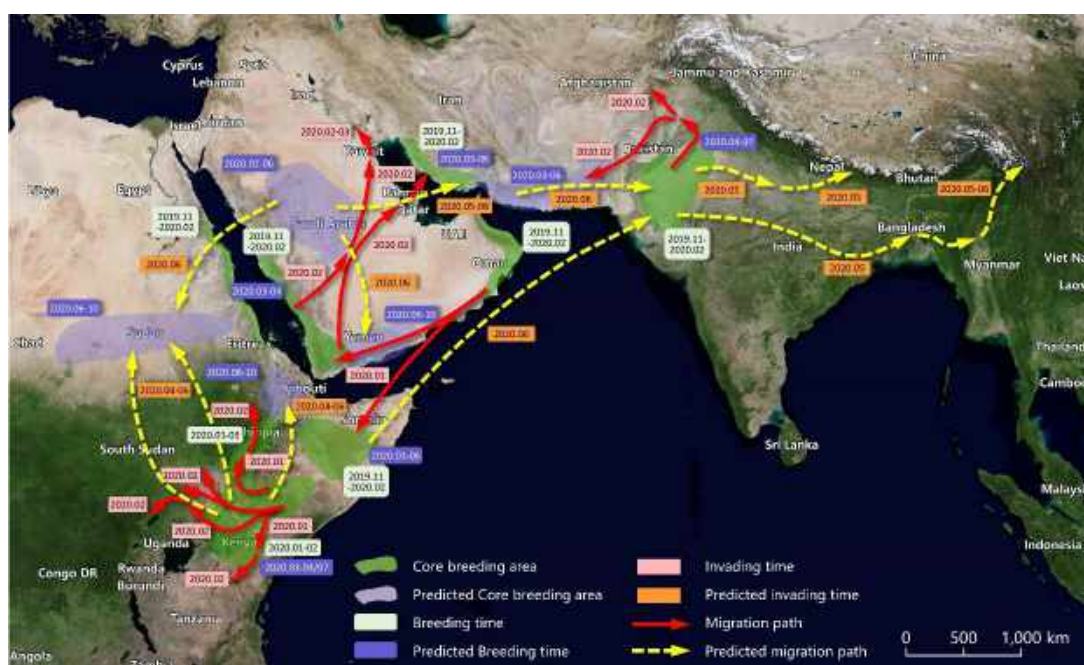


Figure 1 Migration path of Desert Locust in Asia and Africa (January-June 2020)

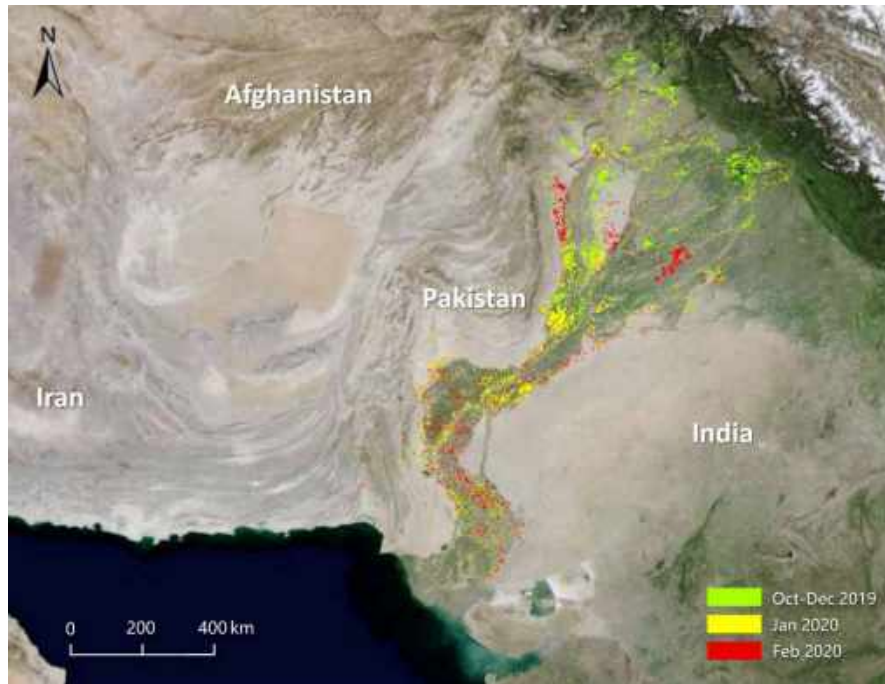


Figure 2 Monitoring of Desert Locust damage in Pakistan (October 2019-February 2020)



Figure 3 Migration path of Desert Locust in Pakistan (January-June 2020)

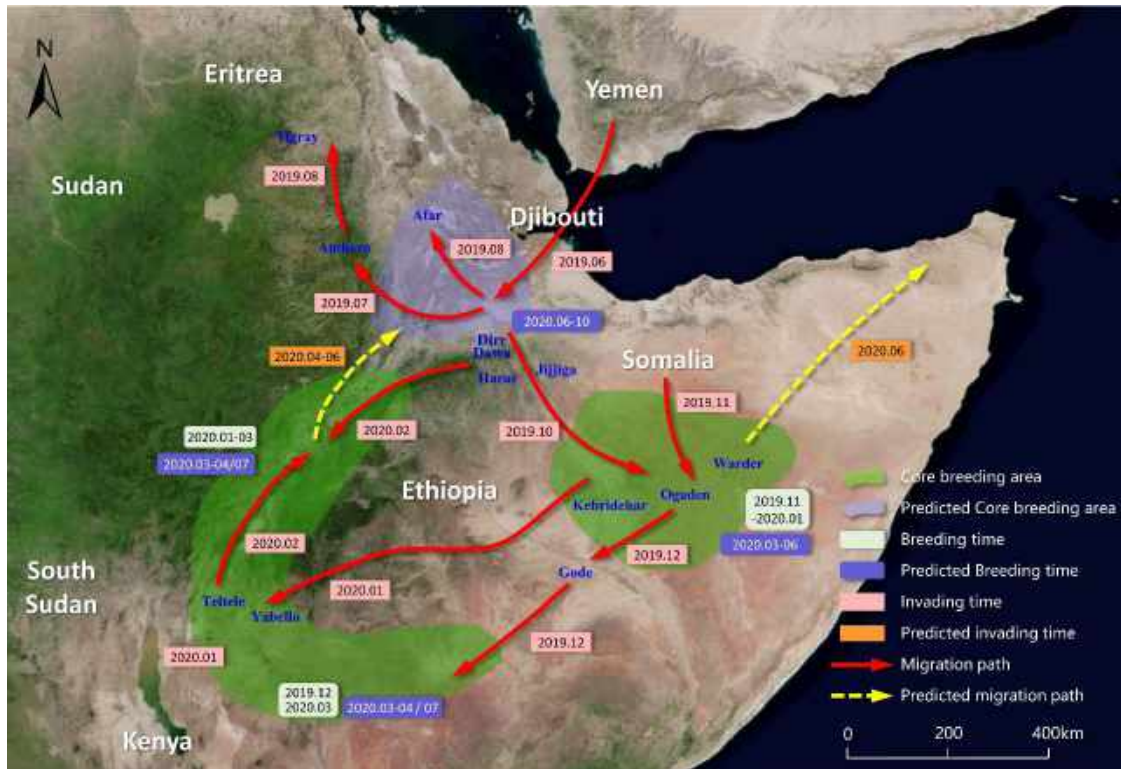


Figure 4 Migration path of Desert Locust in Ethiopia (2019-2020)

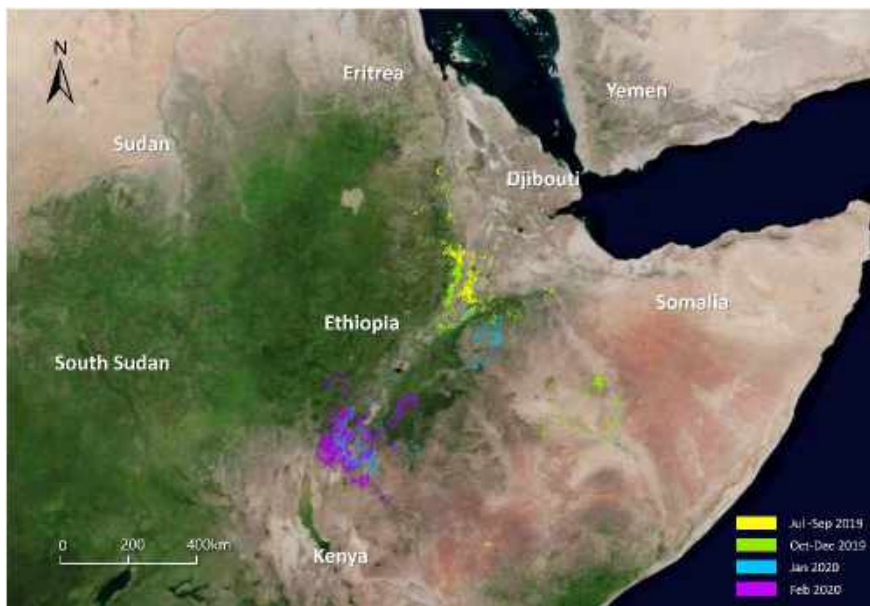


Figure 5 Monitoring of Desert Locust damage in Ethiopia (Year 2019-2020)

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Desert Locust monitoring and forecasting

Late March 2020

Assessment of Desert Locust migration and loss in Kenya and Ethiopia

Overview

Integrated with multi-source Earth Observation data, e.g. meteorological data, field data, and remote sensing data (such as GF series in China, MODIS and Landsat series in US, Sentinel series in EU), and self-developed models and algorithms for Desert Locust monitoring and forecasting, the research team constructed the 'Vegetation pests and diseases monitoring and forecasting system', which could regularly release thematical maps and reports on Desert Locust.

Researchers continued to conduct research on remote sensing dynamic monitoring of Desert Locust in Asian and African countries. This report focuses on the locust plagues in Kenya and Ethiopia. The results showed that, by early to mid-March

Content

| | |
|--|---|
| Overview | 1 |
| Monitoring and assessment of Desert Locust in Kenya | 2 |
| Monitoring and assessment of Desert Locust in Ethiopia | 4 |
| Contact us | 7 |

2020, 21 counties in Kenya had been harmed since desert locusts invaded northeastern Kenya on December 28, 2019. The vegetation damaged area has reached 2745.3 thousand hectares, including 934.1 thousand hectares of cropland, 985.2 thousand hectares of grassland, and 826 thousand hectares of shrub. From February to mid-March 2020, the Desert Locusts in Ethiopia have harmed 2062.3 thousand hectares of local pasture and cropland, including 1094.3 thousand hectares cropland, 291.3 thousand hectares grassland and 676.7 thousand hectares shrub. Desert locust endangered areas are mainly in

Oromiya and Southern Nations Nationalities and People Region (SNNPR) in central Ethiopia. At present, Ethiopia and Kenya have entered the spring breeding season. Multi-generational breeding of locust will lead to a surge in populations over the next three months, which coincides with the planting season or growing season of crops, such as corn. If not properly controlled, Desert Locusts will pose a major threat to the food security of Ethiopia and Kenya. It is necessary to carry out the monitoring and early warning of Desert Locust plague continuously and dynamically, and organize joint prevention and control in multiple countries, to ensure the safe of agricultural and pasture production and regional stability.

Monitoring and assessment of Desert Locust in Kenya

From October to November 2019, east African countries have experienced exceptionally heavy rains attributed to the Indian ocean dipole – a climate phenomenon in which the western part of Indian ocean near the east African coast was warmer than the eastern part. Suitable temperature and sufficient rainfall continued to increase green vegetation, which provided ideal conditions for desert locust breeding. On December 28,

locust swarms in Ogaden in eastern Ethiopia and central Somalia invaded Mandera in northeastern Kenya.

In January 2020, locust swarms in Ethiopia and Somalia were constantly migrating to the northeast of Kenya. The swarms in Mandera spread south to Wajir and Garissa, west along the Ethiopian border (Moyale and Marsabit) and southwest into central areas north of Mt Kenya (Isiolo, Samburu, Meru and most recently Laikipia). And locust swarms moved north of Mt. Kenya westwards to the southern Rift Valley near Kapedo on the border of Baringo and Turkana. As of the 28th, desert locusts had spread to 13 counties in northern, central, and southwestern Kenya. Pastures and cropland had been severely damaged, with an area of approximately 934.1 thousand hectares (220.4 thousand hectares of cropland, 279.9 thousand hectares of grassland, and 433.8 thousand hectares of shrub). In February, the locust swarms in northern and central Kenya continued to mature and lay eggs, and the number of locusts continued to increase. The swarms kept moving south to Kajiado and west to West Pocket in the Rift Valley Province, and reached the Tanzania border and the Uganda border on the 7th and 9th, respectively, and reached Kericho in

southwestern Kenya on the 17th. Meantime, the swarms appeared in the coast of Lake Turkana of northern Kenya. By the end of February, 21 counties in Kenya had been affected by locust plagues, with an additional area of approximately 985.2 thousand hectares (233.3 thousand hectares of cropland, 287 thousand hectares of grassland, and 464.9 thousand hectares of shrub). Aerial and ground locust control operations are ongoing, and FAO estimated that Kenya has treated at least 15 thousand hectares in February. In early to mid-March, locust continued to breed, the number of locusts has been increasing, and the first generation of mature locust populations was forming. The swarms in Marsabit, Turkana, Mandela, Wajir, Isiolo, and Sambu are further concentrated, with an increasing of damaged area about 826 thousand hectares (199.9 thousand hectares of cropland, 252.3 thousand hectares of grassland, and 373.8 thousand hectares of shrub) this month (Figures 1 and 2).

Our results showed that from the end of December 2019 to the early-mid March, Desert Locust has caused the damage of 2745.3 thousand hectares in Kenya with 934.1 thousand hectares of cropland, 985.2 thousand hectares of grassland, and 826 thousand hectares of shrub, accounting for

12.4%, 4.2% and 3.6% of the total cropland, grassland and shrub in Kenya. Among them, Rift Valley Province has the largest damage area of 1325.2 thousand hectares, mainly distributed in Turkana, West Pockets, Samburu, Laikipia, Baringo, Kericho and Cajado. Then is the Eastern Province, with an area of 1163.2 thousand hectares, mainly distributed in Marsabit, Isiolo, Meru, Embu and Kitui. The central province suffered an area of 141.5 thousand hectares, mainly distributed in Nyeri and Kirini. The affected area of Binjai Province is 71.5 thousand hectares, mainly distributed in Tana River County. The affected area of Northeast Province is 14.7 thousand hectares, distributed in Mandela, Wajir and Garissa. The affected area of Nairobi Special Zone is 14.3 thousand hectares. The affected area of Nyanza Province is 12.6 thousand hectares, mainly distributed in Kisumu. Part of the western province is also affected, with an area of 2.3 thousand hectares. Since 70% of Kenya's population are agricultural and pastoral, this locust plague has caused a huge impact on local agriculture and animal husbandry production. It is the worst locust infestation in Kenya in 70 years, which seriously threatens national livelihood and regional stability.

Comprehensive analysis showed that, from March to April 2020, desert locusts in northern and central Kenya will continue to breed in spring. It is expected that the swarms will continue to invade northeastern Uganda westward or migrate northwestward to South Sudan. The swarms have a lower risk of invading Tanzania from Kenya due to the south wind. From April to June, Desert locusts are expected to migrate to summer breeding areas in central Sudan and northern Ethiopia. At present, a large number of locusts in Kenya have laid eggs on the ground and kept hatching. A new round of spring breeding has begun. If the locust couldn't be controlled effectively, the plague will continue, which may hit Kenya's agricultural and livestock production hard.

Monitoring and assessment of Desert Locust in Ethiopia

In February 2020, locusts in Harar (East Harerghe) and Somali (Jijjiga, Warder, Kebridehar, Gode) and southern Oromiya were migrating to the central Rift Valley from south and north, coupled with the continuous breeding and hatching of local locusts, the damage continued to increase. In early to mid-March, with the new generation of locusts in spring, the locust population in the Rift

Valley continued to increase, and the area of damage was further expanded. An area of 928.5 thousand hectares were increased (537.4 thousand hectares of cropland, 47.7 thousand hectares grassland, and 343.4 thousand hectares of shrub), mainly distributed in the south region of Amhara and Afar, and rift valleys of Oromiya and SNNPR (Figure 3).

The results showed that from February to early-mid March 2020, the desert locusts in Ethiopia endangered the area of vegetation in the country by a total of 2062.3 thousand hectares, of which 1094.3 thousand hectares of cropland, 291.3 thousand hectares of grassland, and 676.7 thousand hectares of shrub, respectively, accounted for 5.4%, 2.0% and 1.1% of Ethiopia's cropland, grassland and shrub. Among them, Oromiya has the largest area of damage, with a total of 1506.3 thousand hectares, including 728.4 thousand hectares of cropland, 212.7 thousand hectares of grassland, and 565.2 thousand hectares of shrub. The southern ethnic states are the second most affected, with a total of 499.6 thousand hectares, including 360.3 thousand hectares of cropland, 67.8 thousand hectares of grassland, and 71.5 thousand hectares of shrub. 44.6 thousand hectares of land was affected in Afar, of which 1.5

thousand hectares of cropland, 9.1 thousand hectares of grassland, and 34 thousand hectares of shrub. Amhara's damaged area is 11.8 thousand hectares, of which 4.1 thousand hectares of cropland, 1.7 thousand hectares of grassland, and 6 thousand hectares of scrub. In Ethiopia, 80% population are the agricultural and pastoral population. The locust plague has caused a huge impact on the local agricultural and pastoral production, which seriously threatened the local agricultural and pastoral safety and national livelihood. The domestic disaster situation is severe.

Comprehensive analysis showed that the locusts located in central Ethiopia will continue its spring breeding from March to April in 2020.

At the same time, the swarms in northern Somalia will cross the border and reach Somali in eastern Ethiopia. It is expected that the swarm will migrate to the summer breeding areas of Amhara, Afar and Djibouti between April and June, while the swarms in Somali are expected to migrate with the Indian Ocean southwest monsoon to the Indo-Pakistan border in June. At present, locusts in Ethiopia have begun a new round of spring breeding. The situation of desert locust control is still severe. Continuous monitoring and multi-country joint prevention and control are needed to ensure local agricultural and animal husbandry production and food security.

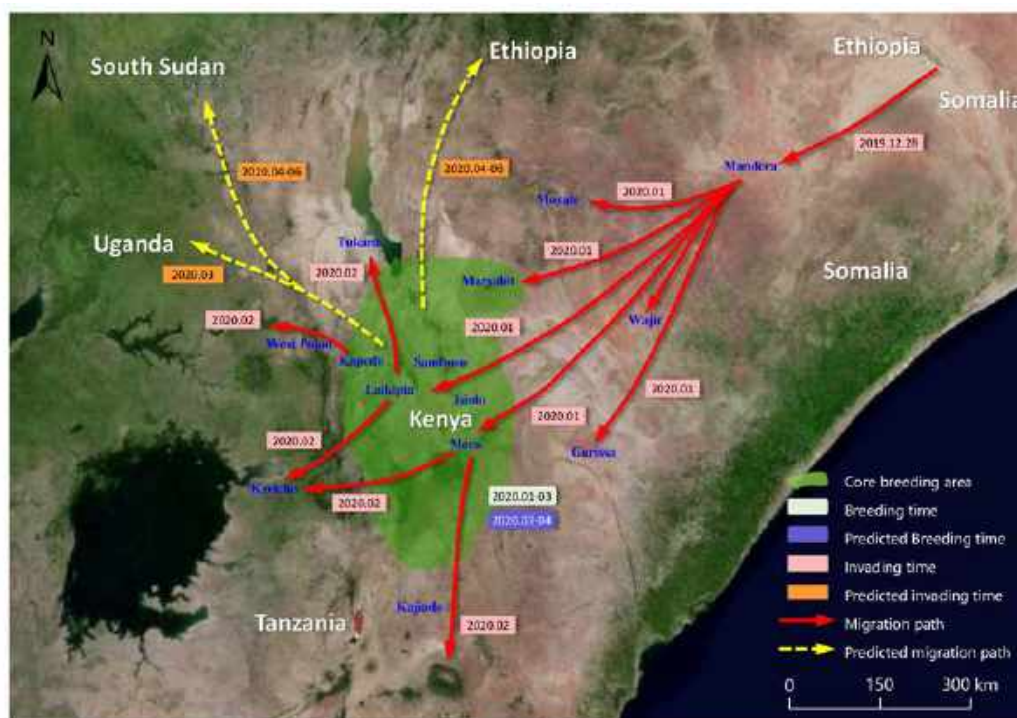


Figure 1 Migration path of Desert Locust in Kenya in 2020

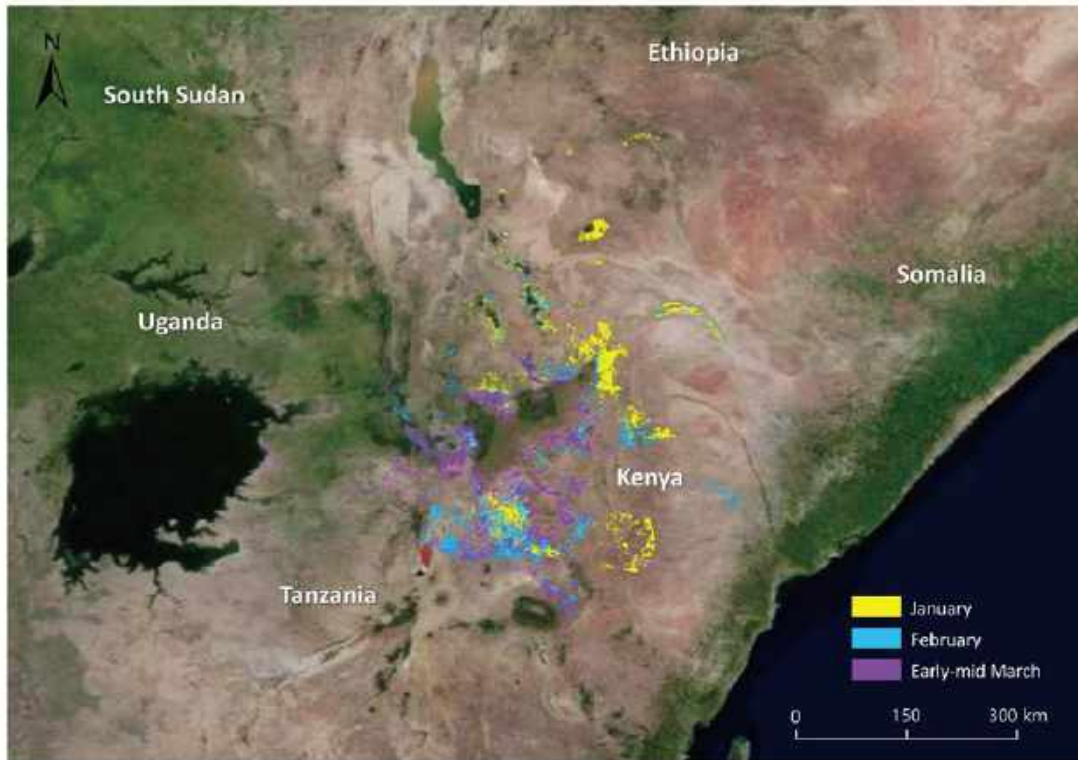


Figure 2 Monitoring of Desert Locust damage in Kenya (January to Early-mid March 2020)

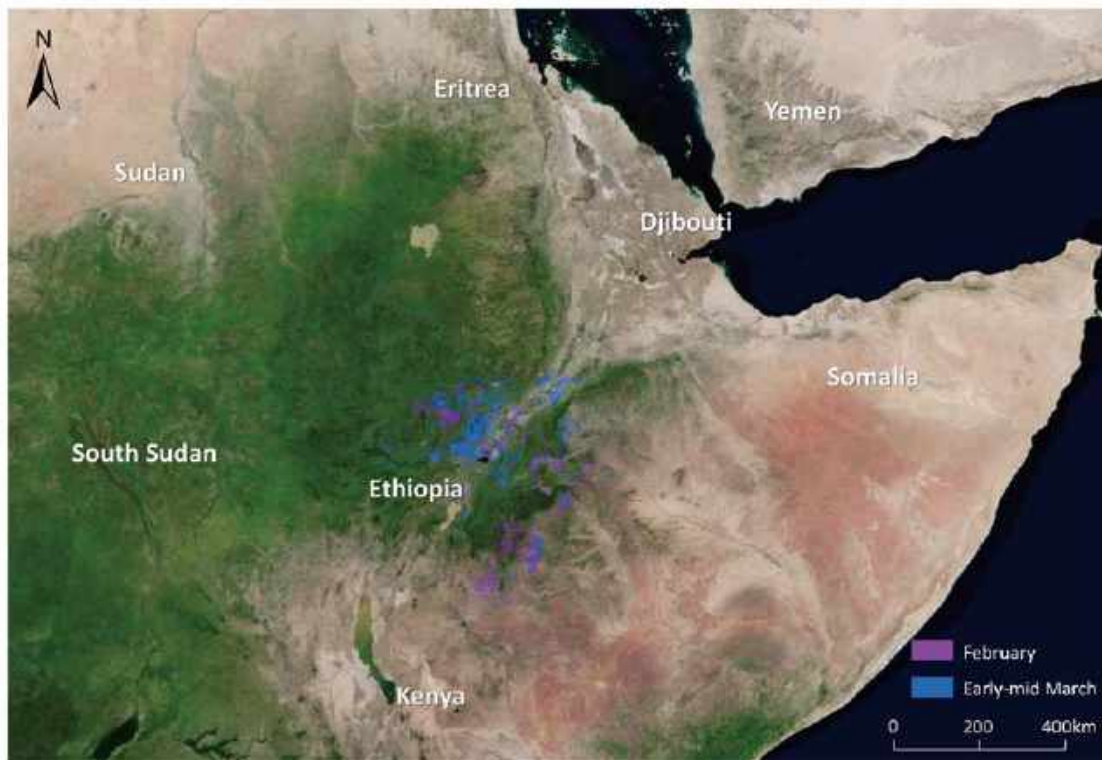


Figure 3 Monitoring of Desert Locust damage in Ethiopia (February to Early-mid March 2020)

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Mission statements: As the science and knowledge service, the Sino-UK Crop Pest and Disease Forecasting & Management Joint Laboratory is to support independent evidence for crop monitoring.

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Desert Locust monitoring and forecasting

Early April 2020

Desert Locust monitoring and loss assessment in Somalia and Pakistan

Overview

Integrated with multi-source Earth Observation data, e.g. meteorological data, field data, and remote sensing data (such as GF series in China, MODIS and Landsat series in US, Sentinel series in EU), and self-developed models and algorithms for Desert Locust monitoring and forecasting, the research team constructed the 'Vegetation pests and diseases monitoring and forecasting system', which could regularly release thematical maps and reports on Desert Locust.

This report focuses on the locust plagues in Somalia and Pakistan. The results showed that, by the end of March 2020, 11 states in Somalia had been harmed since Desert Locusts invaded northern Somalia in June 2019. The vegetation damaged area is 2239.4 thousand hectares, including 9.3 thousand hectares of cropland, 596.7 thousand hectares of grassland and 1633.4 thousand hectares of shrub, accounting for 9.6%, 15.3% and 3.7% of the total cropland, grassland and

Content

| | |
|---|---|
| Overview | 1 |
| Monitoring and assessment of Desert Locust in Somalia | 2 |
| Monitoring and assessment of Desert Locust in Somalia | 5 |
| Contact us | 7 |

shrub in Somalia, respectively. In March 2020, Desert Locust in Pakistan harmed about 449.5 thousand hectares of vegetation area (including 374.1 thousand hectares of cropland and 75.4 thousand hectares of grassland), mainly distributed in Punjab, Khyber-Pakhtunkhwa, Federally Administered Tribal Areas in northern Pakistan and Baluchistan in the southwest. At present, locust spring breeding is underway in Somalia and Pakistan. Considering that April is the best period for Desert Locust control, it's very important for Somalia and Pakistan to focus on locust hatching and conduct monitoring, warning, prevention and control of locusts during this month. April-June is an important growing or harvesting season for wheat and

corn in both countries. If not controlled properly, locusts will bring major threat to agricultural and pasture production national economy and the people's livelihood. It is necessary to continue the monitoring and early warning of intercontinental Desert Locust plague and organize joint prevention and control in multiple countries to ensure the safety of agricultural and pasture production and regional stability.

Monitoring and assessment of Desert Locust in Somalia

In May 2018, the tropical cyclone brought lots of rainfall to northern Somalia. The increasing vegetation provided suitable conditions for locust breeding. In September, Desert Locust began breeding locally in Berbera (northwestern Somalia).

From June to July 2019, mature locust swarms of Yemen moved southward across the Gulf of Aden to northern Somalia. Mature locust swarms appeared along the coast of Bosaso in the northeast and Berbera in the northwest. In early August, a group of swarms on the northwestern coast of Somalia migrated to eastern Ethiopia. At the end of August, swarms appeared on the plateau between Boroma and Burao in the northwest. There were many adults on the east coast of Berbera and swarms continue to breed on the plateau between Hadaaftimo and Iskushuban in the northeast. Till the end of September, locusts had invaded Awdal, Woqooyi Galbeed, Togdheer, Sanaag and Bari in northern Somalia. Grassland and cropland were

severely affected, with a damage area of 494.4 thousand hectares (2.7 thousand hectares of cropland, 38.5 thousand hectares of grassland, and 453.2 thousand hectares of shrub). In mid- to late October, swarms in Ethiopia migrated southeast to Bohotley at the border between Somalia and Ethiopia, as well as Laascaanood in northern Somalia. In November, swarms in eastern Ethiopia continued to multiply and spread to Gaalkacyo in central Somalia. In early December, locusts spreaded to Dhuusa Mareeb and Beled Weyne. At the end of December, locusts in eastern Ethiopia and central Somalia migrated southward through Huddur to Garbaharey. The newly added damaged area was about 940.8 thousand hectares (3.2 thousand hectares of cropland, 307.7 thousand hectares of grassland, and 629.9 thousand hectares of shrub).

In January 2020, swarms in central and southern Somalia continued to migrate south to the middle of Jubbada Dhexe at the border of southern Somalia and northeastern Kenya; they continued to move to northeastern Kenya and began to lay eggs. At the end of January, locusts appear in the Garowe of northeast Somalia. In February, the locusts in Beledwin and Galkayo of central Somalia continued to multiply, and the immature locust population was found in northeast Garowe. In March, locusts continued to breed in northeastern, central and southern Kenya. Till the end of March, damaged area in Somalia had increased by about 804.2 thousand hectares (3.4 thousand hectares of cropland, 250.5 thousand hectares of grassland and 550.3

thousand hectares of shrub), shown in Fig 1 and Fig 2.

Our results showed that by the end of March, the locusts had affected 2239.4 thousand hectares of vegetation area in Somalia, including 9.3 thousand hectares of cropland, 596.7 thousand hectares of grassland and 1633.4 thousand hectares of shrub, accounting for 9.6%, 15.3% and 3.7% of the total cropland, grassland and shrub, respectively. Gedo, a region in southern Somalia on its border with northeastern Kenya, suffered the largest area as 440.1 thousand hectares. There are about 304.2 and 299.2 thousand hectares of damaged area in Togdheer and Woqooyi Galbeed respectively, The damaged area in Mudug and Bakool are about 211.6 thousand hectares and 177.2 thousand hectares. The damaged areas in Sanaag and Sool are about 133.7 thousand hectares and 132.9 thousand hectares. The damaged areas in Bay and Galguduud are about 120.7 thousand hectares and 112.5 thousand hectares. The damaged areas in Awdal and Bari are about 90.3 thousand hectares and 88.1 thousand hectares. The damaged areas in Hiiraan, Shabeellaha Dhexe, Jubbada Dhexe and Nugaal are about

87.7 thousand hectares, 25.7 thousand hectares, 11.9 thousand hectares and 3.6 thousand hectares respectively. The locust plague has devastated pastureland and cropland in Somalia, causing huge losses to local farming and animal husbandry. It was the worst locust disaster in Somalia for the past 25 years, exacerbating the food and nutrition crisis of the local vulnerable groups.

Comprehensive analysis showed that, from April to June 2020, the Desert Locust in northern, central and southern Somalia will continue its spring breeding. It is expected that the swarms will migrate to summer breeding areas in northeastern Ethiopia, Djibouti and the southern coast of Yemen from April to June. At the same time, the locusts in the spring breeding area of the central Somalia are expected to migrate towards the Indo-Pakistan border with the southwest monsoon of the Indian Ocean in June. At present, a large number of locusts in Somalia have laid eggs on the ground and the next generation of spring breeding has already begin. If not controlled effectively, the locust plague will continue, which may bring a heavy blow to the agricultural and pasture production in Somalia.

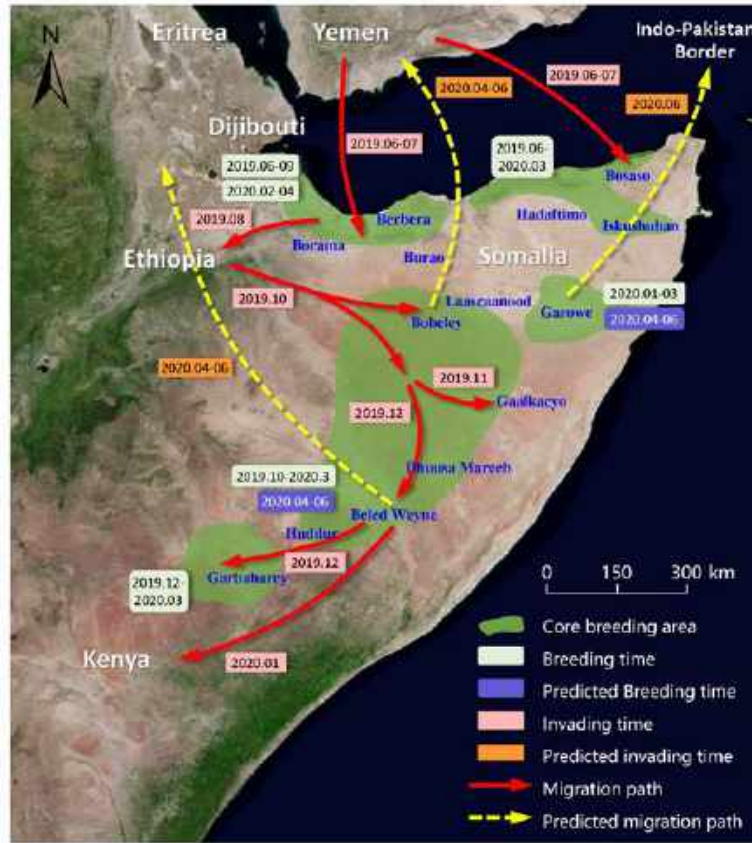


Figure 1 Migration path of Desert Locust in Somalia (2019-2020)

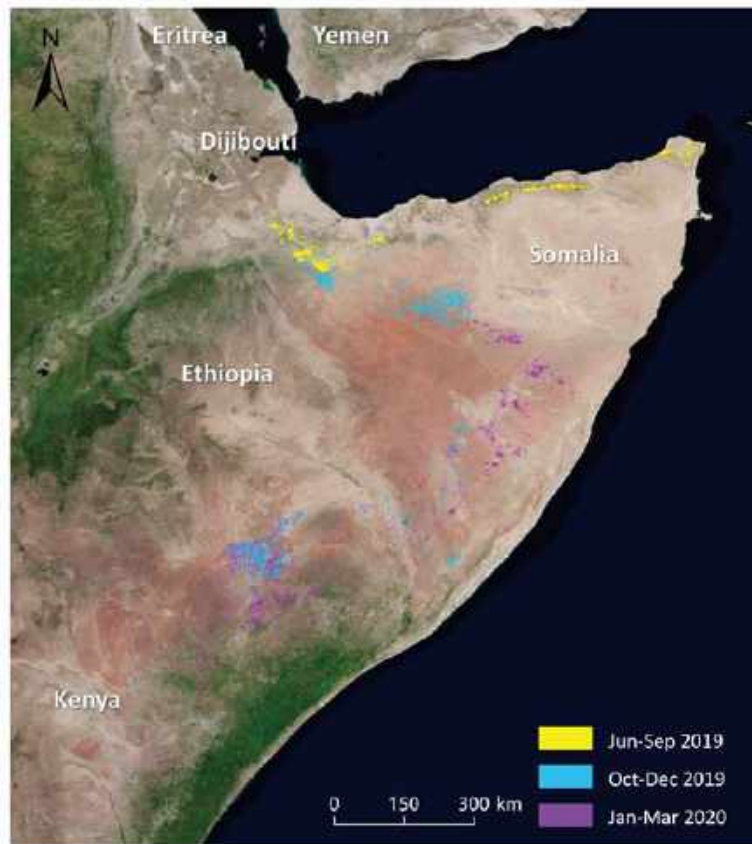


Figure 2 Monitoring of Desert Locust damage in Somalia (June 2019-March 2020)

Monitoring and assessment of Desert Locust in Somalia

From late February to the end of March 2020, the Desert Locusts in Pakistan were mainly distributed in central Punjab, southern Khyber Pakhtunkhwa, central Federally Administered Tribal Areas, and southwestern and Central Balochistan. From February 25th to March 5th, 2020, the China Locust Control Working Group went to Pakistan to conduct a field survey of the Desert Locust plague and provided technical support for locust prevention. China provided 14 sets of locust control equipment and 250 barrels of insecticide to Pakistan on March 9th. The locust plague was under primary control. Our research results showed that in March 2020, the Desert Locusts in Pakistan endangered the area of vegetation in the country by a total of 449.5 thousand hectares, including 374.1 thousand hectares of cropland and 75.4 thousand hectares of grassland. Damaged areas are mainly located in the north central part of Punjab (damaged area of about 354.6 thousand hectares), the southern part of Khyber Pakhtunkhwa (damaged area of about 53.2 thousand hectares), the central part of Federally Administered Tribal Areas (damaged area of about 19.7 thousand hectares) and the central and southwestern of Balochistan (damaged area of about 18.4 thousand hectares). In addition, Sind also had a damage area of 3.6 thousand hectares adjacent to Balochistan (Fig 3).

We used Planet images with higher

spatial resolution of 3m to monitor the Desert Locusts damage in the severely damaged cropland in northern Pakistan (Fig 4). The study areas are located in Punjab. Area 1 is in Chawinda of northeast Punjab, about 80 km south to Lahore and 40 km southwest to Gujranwalawith the Degh Nala River flows through this area. The main vegetation type in Area 1 is cropland with a total area of 52.2 thousand hectares. The monitoring results showed that the cropland was obviously damaged by Desert Locusts in February 2020, with an area of 4.3 thousand hectares, accounting for 8.2% of the total area. Area 2 is in the north-central part of Punjab, about 10 km northeast to Chiniot and 20 km southeast to Faisalabad, with the Genab River flows through the northern edge of Area 2. The main vegetation type is cropland, with a total area of 52.4 thousand hectares. The monitoring results showed that the cropland in Area 2 was obviously damaged by the Desert Locusts in February 2020, with an area of 4.5 thousand hectares, accounting for 8.6% of the total area. The results of our research indicate that Desert Locusts caused great damage to cropland and seriously threaten food security.

At present, locust eggs in Pakistan are gradually hatching, and the best period for locust prevention and control is early to mid-April. Pakistan could carry out targeted Desert Locust egg removal and monitor adults' migration. In Pakistan, 52% land is grassland, and desert grassland with water sources is the key area for Desert Locusts eggs laying. Therefore, it is necessary to focus on monitoring the hatching of Desert Locusts

in desert grassland areas. April-May is the harvest season of wheat and corn in Pakistan. If the Desert Locusts are not effectively

controlled, the locust plague will continue to erupt, which may cause a heavy blow to agricultural production in Pakistan.

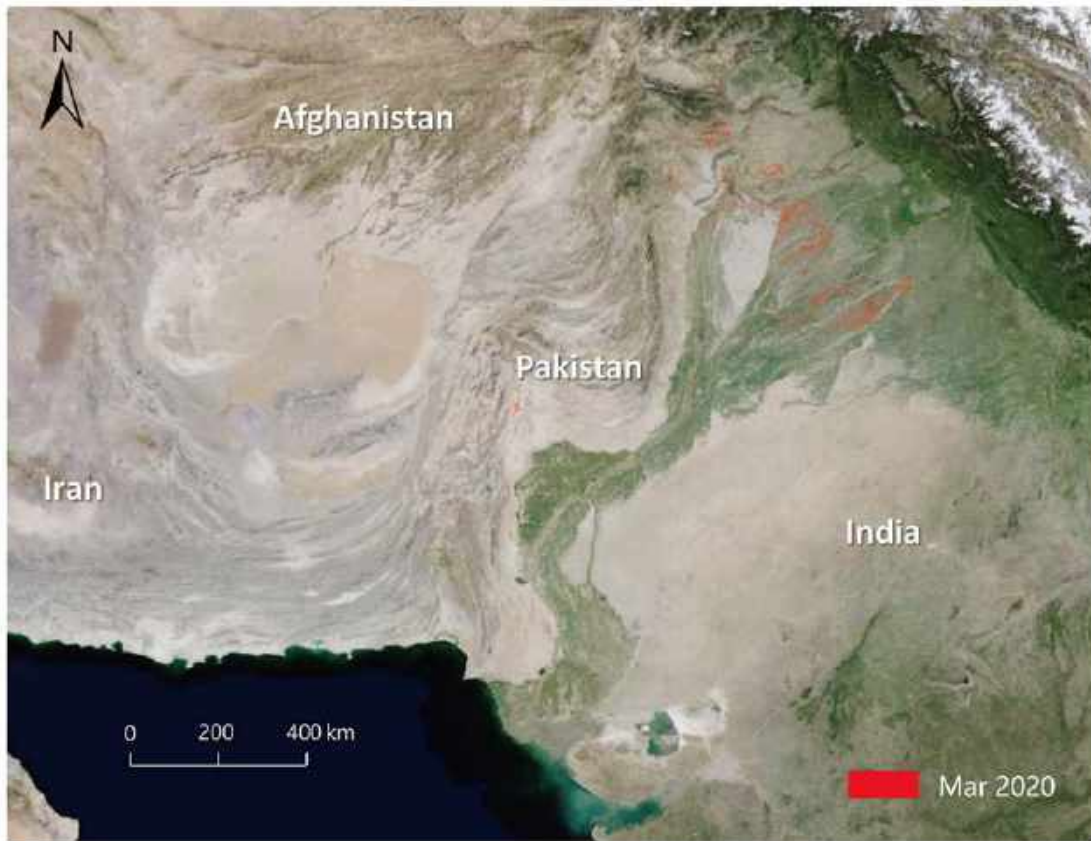


Figure 3 Monitoring of Desert Locust damage in Pakistan (March 2020)

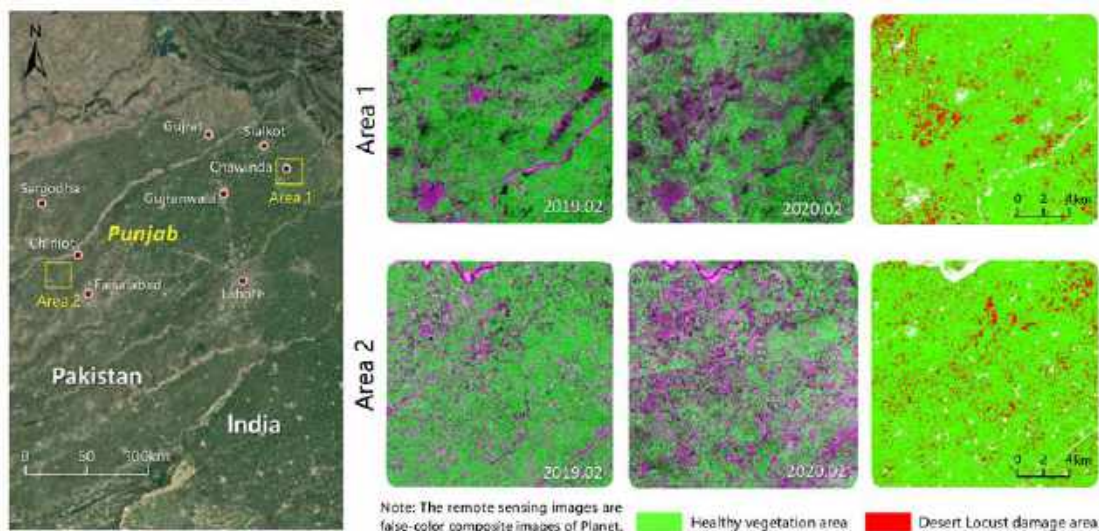


Figure 4 Monitoring of Desert Locust damage in cropland of northern Pakistan based on Planet images

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Desert Locust monitoring and forecasting

Mid April 2020

Desert Locust monitoring and loss assessment in Yemen and Ethiopia

Overview

Integrated with multi-source Earth Observation data, e.g. meteorological data, field data, and remote sensing data (such as GF series in China, MODIS and Landsat series in US, Sentinel series in EU), and self-developed models and algorithms for Desert Locust monitoring and forecasting, the research team constructed the 'Vegetation pests and diseases monitoring and forecasting system', which could regularly release thematical maps and reports on Desert Locust.

This report focuses on the locust plagues in Yemen and Ethiopia. The results showed that, as of mid-April 2020, 20 provinces in Yemen had been harmed since Desert Locust invaded northeastern Yemen in January 2019. The vegetation damaged area is 1535.9 thousand hectares, including 437.3 thousand hectares of cropland, 264.5 thousand hectares of grassland and 834.1 thousand hectares of shrub, accounting for 34.4%, 46.0% and 14.8% of the total cropland,

Content

| | |
|--|---|
| Overview | 1 |
| Monitoring and assessment of Desert Locust in Yemen | 2 |
| Monitoring and assessment of Desert Locust in Ethiopia | 5 |
| Contact us | 8 |

grassland, and shrub in Yemen, respectively. In March to early-mid April 2020, Desert Locust in Ethiopia harmed about 1750.4 thousand hectares of vegetation area (including 393.0 thousand hectares of cropland, 404.7 thousand hectares of grassland, and 952.7 thousand hectares of shrub), mainly distributed in southern SNNPR, northern and central Somalia, and northern and southern Oromiya.

At present, locust spring breeding is underway in Yemen and Ethiopia. April-June is an important planting and growing season for crops in Yemen, and is also an important harvesting season for crops in Ethiopia. If not controlled properly, locusts will bring a major threat to agricultural and pasture production and the national economy and the people's

livelihood. It is necessary to carry out the monitoring and early warning of the intercontinental Desert Locust plague continuously and dynamically, and organize joint prevention and control in multiple countries, to ensure the safety of agricultural and pasture production and regional stability. The specific research results are as follows:

Monitoring and assessment of Desert Locust in Yemen

In May 2018, the tropical cyclone Sagar formed in the Gulf of Aden and the tropical cyclone Mekunu formed in the southern Arabian Peninsula brought lots of rainfall to southern Yemen. In October 2018, the tropical cyclone Luban formed over the Arabian Sea and moved towards the Arabian Peninsula, brought lots of rainfall to eastern Yemen, southern Oman, and southern Saudi Arabia. The two precipitations increased green vegetation in southwestern, southern and eastern Yemen, and the border areas with Oman and Saudi Arabia, providing suitable conditions for Desert Locust reproduction.

In January 2019, Desert Locust appeared in the Rub' Al Khali Desert (Empty Quarter), at the border of southeastern Yemen, Oman, and Saudi Arabia. The second-generation reproduction was completed at the end of the month. Part of the locusts invaded northern Saudi Arabia, western Rub' Al Khali Desert, United Arab Emirates (UAE) and southern Iran. From February to March 2019, the Desert Locust in northeastern Yemen continued to multiply and spread to the planting area of

Wadi Hadramawt. From April to May 2019, the Desert Locust moved westward to Marib and Al Jawf, and continued westward to the northern highlands of Dhamer and Sana'a. Mature locust swarms appeared in Ataq and Shabwah in the south, some locusts began to lay eggs. By the end of May 2019, 9 provinces in eastern and mid-western Yemen had been invaded by Desert Locust. The vegetation damaged area is 131.6 thousand hectares, including 22.4 thousand hectares of cropland, 16.4 thousand hectares of grassland and 92.8 thousand hectares of shrub. From June to July 2019, Desert Locust started summer breeding, Desert Locust in southern Marib continued to lay eggs and hatch. Mature locust swarms appeared in the Suq Abs area in the north of the Red Sea coast, and the Gulf of Aden in the south continued to lay eggs and hatch. The precipitation in July caused Yemen's locusts to multiply for many generations and gradually spread to the southwest of Saudi Arabia along the Red Sea. At the same time, some locust swarms crossed the Gulf of Aden invaded northern Somalia, southern Eritrea, and eastern Ethiopia. From August to September 2019, locust swarms reached the coast of the Red Sea and the Gulf of Aden. Unusually heavy rainfall gave birth to a large number of locust swarms in Yemen, especially in the southern and eastern Marib. From October to December 2019, locusts in the breeding area of the coastal plain of the Red Sea in northern Yemen and the neighboring areas of Saudi Arabia continued to lay eggs, hatch, and start winter breeding. Besides, locusts in the southern coastal were also breeding and

gradually clustered. By the end of December 2019, the newly added vegetation damaged area was 499.4 thousand hectares, including 155.0 thousand hectares of cropland, 136.6 thousand hectares of grassland and 207.8 thousand hectares of shrub.

In January 2020, Desert Locust in the coastal plains of the Red Sea continued to multiply, new locust swarms continued to form and lay eggs, some locust swarms moved to the eastern highlands, some crossed the Red Sea to Eritrea. At the same time, some locust swarms along the border between India and Pakistan, and south of Oman moved south along the coast, to the southern coast of Yemen. In February 2020, the locust swarms of the coastal plain started the next generation reproduction. Some locust swarms moved northward to Saudi Arabia, and some locust swarms moved to the eastern highlands and inside Yemen. On the 29th, mature locust swarms appeared in Sana'a, and newly reproduced locusts appeared in Aden on the southern coast. In March 2020, the locusts in the Aden area of the southern coast continued to multiply, mature, and form swarms. A large amount of precipitation occurred in central Wadi Hadramawt, continuously forming new locust swarms in the inland and coastal areas at the border between Yemen and Oman. In early April 2020, mature locust swarms appeared along the border with Oman, and in northern Aden. Desert Locust in the eastern plateau were laying eggs. By the end of early-mid April 2020, the newly added vegetation damaged area was 904.9 thousand hectares, including 259.9 thousand hectares

of cropland, 111.5 thousand hectares of grassland and 533.5 thousand hectares of shrub (Fig 1 and 2).

Research results showed that from January 2019 to early-mid April 2020, Desert locusts invaded 20 provinces in Yemen except Suqutra. Desert Locust has caused the damage of 1535.9 thousand hectares in Yemen with 437.3 thousand hectares of cropland, 264.5 thousand hectares of grassland, and 834.1 thousand hectares of shrub, accounting for 34.4%, 46% and 14.8% of the total cropland, grassland, and shrub in Yemen. Most of the vegetation in Yemen is distributed in the western region, so the vegetation damage area in western Yemen is larger. Among them, Al-Hudaydah province on the west coast of the Red Sea has the largest damage area of 341.1 thousand hectares. The second is in the southwestern province of Ta'izz with an area of 293.5 thousand hectares. Next, in the provinces of San'a and Ibb adjacent to the east, the affected areas were 138.9 thousand hectares and 134.4 thousand hectares. The affected area of Ad-Dāli Province is 112.7 thousand hectares; the affected areas of Lahij Province in the southwest and Dhamar in the Midwest are 96.3 and 92.4 thousand hectares, respectively. The affected areas of Hajjah and Amrān in the northwest are 62.7 thousand hectares and 59.2 thousand hectares, respectively. The affected areas of Al-Mahwīt, Sa'dah, and Al-Baydā are 46.2 thousand hectares, 45.8 thousand hectares, and 38.8 thousand hectares, respectively. Although the locusts appeared earlier and had higher density in the

central and eastern provinces, the vegetation coverage in these areas was low and the affected area was relatively smaller. The affected areas of Abyān, Hadramawt, Raimah, Al-Mahrah, Shabwah, Ma'rib, and Al-Jawf Province are 17.8 thousand hectares, 14.6 thousand hectares, 13.3 thousand hectares, 10.6 thousand hectares, 7.7 thousand hectares, 5.6 thousand hectares, and 4.3 thousand hectares, respectively. In addition, although there are locusts invaded in Aden, the affected area is slightly smaller, totaling 48.44 hectares. Yemen is a typical agro-pastoral country with an agricultural population of 75%. The locust plague severely damaged Yemen's pastures and farmland, reduced crop production, and caused huge losses to local agricultural and animal husbandry production.

The comprehensive analysis showed that, from April to June 2020, the Desert Locust along the Red Sea coast, the southwestern coast, and the junction with Oman in the east of Yemen will continue spring breeding and gradually spread inland. It is expected that the swarms will move to central Saudi Arabia from April to May. As the locusts in the Arabian Peninsula breed in spring, it is expected that the swarms will migrate to central Yemen in June for summer breeding. At present, a large number of locusts in Yemen have laid eggs on the ground and kept hatching. A new round of spring breeding has begun. April-June is an important planting and growing season for crops in Yemen. If the locusts couldn't be controlled effectively, the plague will continue, which may hit Yemen's agriculture and livestock production hard.

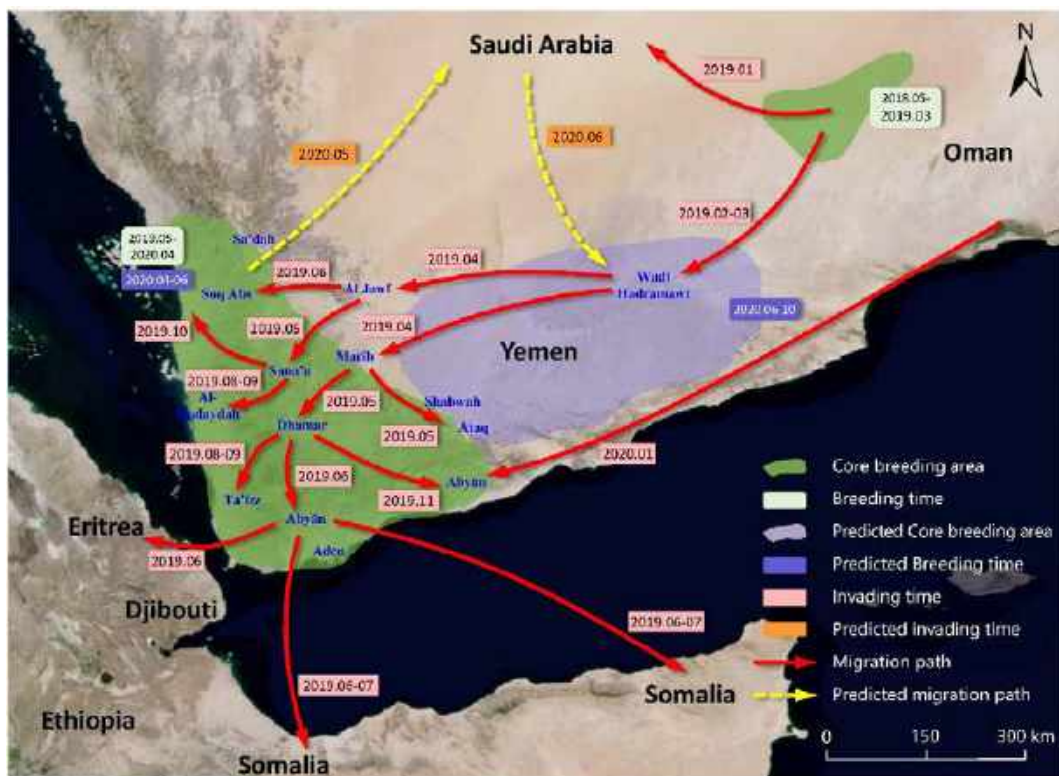


Figure 1 Migration path of Desert Locust in Yemen (2019-2020)

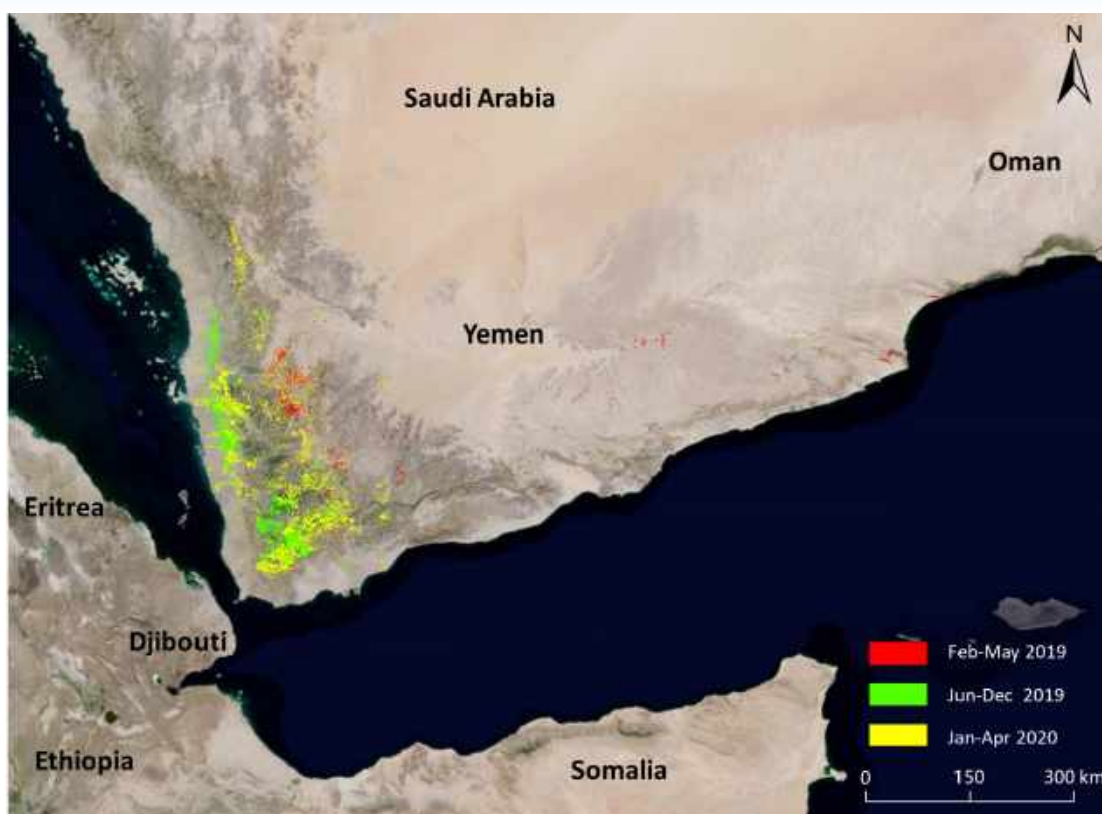


Figure 2 Monitoring of Desert Locust damage in Yemen (February 2019 to Early-mid April 2020)

Monitoring and assessment of Desert Locust in Ethiopia

In March 2020, locusts in southern Amhara and Afar, and rift valleys of northern Oromiya and SNNPR, continued to reproduce in spring. Locusts were maturing and swarming, air and ground control operations were continuing. In late March, Ethiopia experienced extensive precipitation, which promoted the reproduction of locusts. At the end of the month, new locust swarms appeared in Dire Dawa and Jijjiga in western Somali, and locusts continued to mature and lay eggs. By the end of March 2020, the newly added vegetation damaged area in Ethiopia was 1016.3 thousand hectares, including 300.9 thousand hectares of cropland, 271.4 thousand hectares of grassland and 444.0

thousand hectares of shrub. In the early-mid April, the locusts in northern Kenya spread northward, the number of locusts in the SNNPR, and Yabello and Negele regions in southern Oromia increased. In mid-April, locust swarms were reported to appear in the Gode region of southern Somalia, and the locust swarms in the north also continued to multiply and expand, causing further damage to the area. The newly added vegetation damaged area is 734.1 thousand hectares (including 92.1 thousand hectares of cropland, 133.3 thousand hectares of grassland and 508.7 thousand hectares of shrub) (Fig 3).

The result shows that from March to mid-April 2020, the newly added vegetation damaged area in Ethiopia is 1750.4 thousand hectares, including 393.0 thousand hectares of cropland, 404.7 thousand hectares of

grassland and 952.7 thousand hectares of shrub, accounted for 1.6%, 2.3%, and 1.3% of Ethiopia's crop land, grassland, and shrub, respectively. The affected areas are mainly located in central and southern Ethiopia. Among them, Oromiya has the largest area of damage, with a total of 1151.1 thousand hectares. The Somali is the second most affected, with a total of 289.7 thousand hectares. The SNNPR ranks third, with a total of 267.9 thousand hectares. The newly affected areas in Afar and Amhara in the northwest are 38.4 thousand hectares and 3.3 thousand hectares, respectively. 80% of the population in Ethiopia is the agricultural and pastoral population. The locust plague has caused a huge impact on the local agricultural and pastoral production, which seriously threatened the local agricultural and pastoral safety and national livelihood. The domestic disaster situation is severe.

This study used Planet images with a spatial resolution of 3 m to monitor the Desert Locusts damage in severely affected areas in the Rift Valley of eastern Ethiopian (Figure4). Research data is Planet data for February 2019 and February 2020. The study area is located at the junction of Oromiya and Afar, about 24 km southwest to Awash, and about 22 km northeast to Mieso. The vegetation types include grassland, shrub and cropland, with a total area of 37.3 thousand hectares, of which grassland is 6.5 thousand hectares, shrub is 28.6 thousand hectares, and cropland is 2.2 thousand hectares. The monitoring results showed that, the vegetation affected by

Desert Locust was 4.5 thousand hectares, accounting for 12.1% of the total area of the study area. Among them, shrub has the largest area of damage, with a total of 3.6 thousand hectares. Grassland is 0.7 thousand hectares. Cropland is 0.2 thousand hectares, accounting for 12.6%, 10.8%, and 9.1% of the total area of shrub, grassland and cropland in the study area, respectively. The results prove that, Desert locusts can cause large losses to vegetation, and its outbreaks will seriously affect Ethiopia's agricultural production and food security (Figure4).

The comprehensive analysis showed that, from April to May 2020, Desert locust in central Ethiopia will continue spring breeding. At the same time, locust swarms in northern Somalia are also at risk of crossing the border to eastern Somalia. The locust swarm is expected to move to summer breeding areas in northern Amhara, Afar, and Djibouti from April to June. The locust swarm in Somalia is expected to move towards the Indo-Pakistan border with the southwest monsoon of the Indian Ocean. At present, the spring breeding is underway in Ethiopia. With the continuous hatching of locust eggs in May, it is expected that new locust swarms will form from late June to July. April-June is an important harvesting season for crops in Ethiopia. The situation of desert locust control is still severe. Continuous monitoring and multi-country joint prevention and control are needed to ensure local agricultural and animal husbandry production and food security.

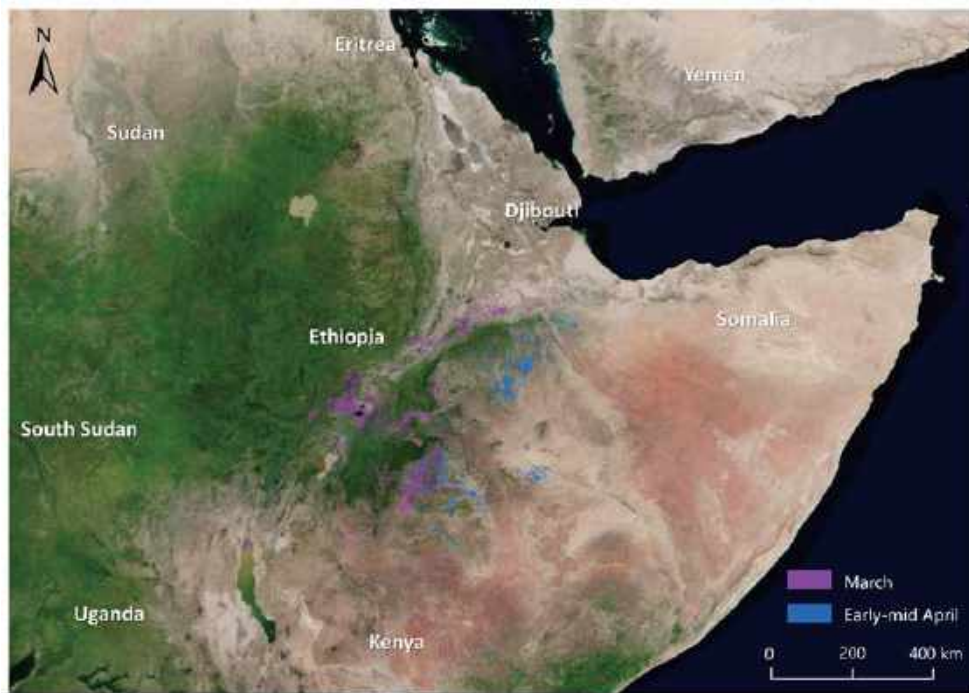


Figure 3 Monitoring of Desert Locust damage in Ethiopia (March to Early-mid April 2020)

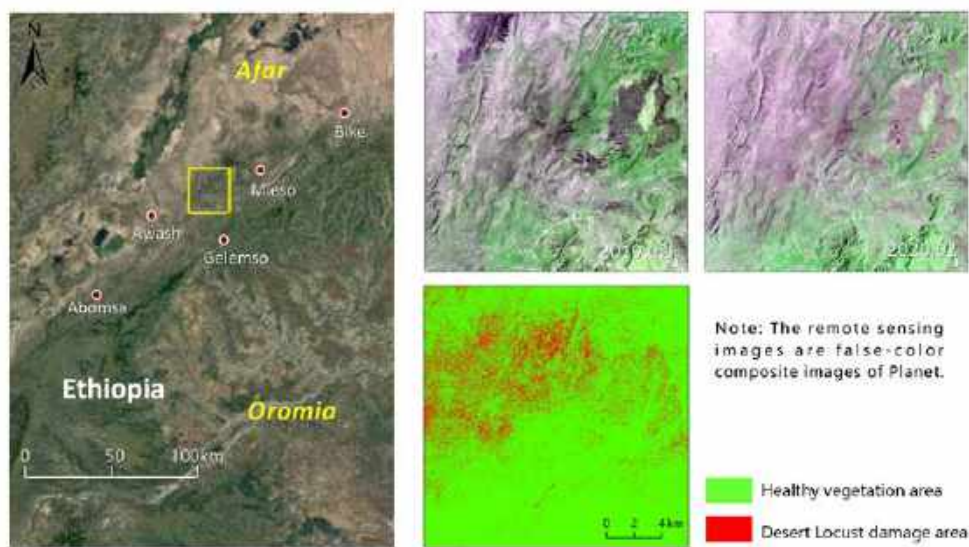


Figure 4 Monitoring of Desert Locust damage in the key damage area of Ethiopia based on Planet images

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Mission statements: As the science and knowledge service, the Sino-UK Crop Pest and Disease Forecasting & Management Joint Laboratory is to support independent evidence for crop monitoring.

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Desert Locust monitoring and forecasting

Early May 2020

Desert Locust monitoring and loss assessment in Pakistan and Somalia

Overview

Integrated with multi-source Earth Observation data, e.g. meteorological data, field data, and remote sensing data (such as GF series in China, MODIS and Landsat series in US, Sentinel series in EU), and self-developed models and algorithms for Desert Locust monitoring and forecasting, the research team constructed the 'Vegetation pests and diseases monitoring and forecasting system', which could regularly release thematical maps and reports on Desert Locust.

This report focuses on the damage monitoring of the Desert Locust in Pakistan and Somalia. The result showed that by the end of April 2020, Desert Locust in Pakistan harmed about 431.9 thousand hectares of vegetation area (including 233.0 thousand hectares cropland and 198.9 thousand hectares grassland), mainly distributed in North-central Punjab, northern Baluchistan, southern Khyber-Pakhtunkhwa, central Federally Administered Tribal Areas and

Content

| | |
|--|---|
| Overview | 1 |
| Monitoring and assessment of Desert Locust in Pakistan | 2 |
| Monitoring and assessment of Desert Locust in Somalia | 3 |
| Contact us | 6 |

Western Sind in Pakistan. Desert Locust in Somalia harmed about 392.1 thousand hectares of vegetation area in April (including 1.4 thousand hectares cropland, 136.4 thousand hectares grassland and 254.3 thousand hectares shrub), mainly distributed in Jubbada Hoose, Gedo, Bakool and Bay states in southern Somalia, Awdal, Woqooyi Galbeed and Gogdheer states in the northwest and Mudug state in the Middle. At present, locusts in Somalia and Pakistan are constantly breeding and spreading. The period from May to July coincides with the important growing season or harvesting season of wheat, corn and other crops in the two countries. If not properly controlled, locusts will bring major threats to agricultural

and pasture production and national economy and people's livelihood. It is necessary to continue the monitoring and early warning of the intercontinental Desert Locust plague, and organize joint prevention and control in multiple countries, ensuring the safety of agricultural and pasture production, as well as regional stability.

Monitoring and assessment of Desert Locust in Pakistan

In early April 2020, the Desert Locusts in Pakistan, mostly immature swarms, were mainly located in the southwest of Baluchistan province. In the early-mid April, the locust hoppers appeared at the border of Sind and Punjab, the central and northern Punjab and the southern Khyber-Pakhtunkhwa. The locusts developed into mature swarms in the southwest Baluchistan. In late April, Desert Locusts continued multiplying, with mature locusts appearing in Punjab, Federally Administered Tribal Areas and central and southern Sind. Locusts began spreading across the Indo-Pakistan border into India. Our results showed that by the end of April 2020, the Desert Locusts had affected 431.9 thousand hectares of vegetation area in Pakistan, including 233.0 thousand hectares cropland and 198.9 thousand hectares grassland. Damaged areas are mainly located

in the northern and central Punjab (damaged area is about 252.9 thousand hectares), the northern Baluchistan (damaged area is about 77.6 thousand hectares), the northern Federally Administered Tribal Areas (damaged area is about 52.8 thousand hectares) and the southern Khyber-Pakhtunkhwa (damaged area is about 40.0 thousand hectares). In addition, Sind was also damaged by a small area of locusts, about 8.6 thousand hectares (Figure 1).

The comprehensive analysis showed that, in May 2020, locusts in Pakistan will continue to breeding, and locusts in spring breeding areas in southwestern Baluchistan, central Punjab, southern Iran and northern Oman will move to summer breeding areas in Indo-Pakistan border and gradually spread into western India. Swarms of summer breeding areas in Somalia in the horn of Africa are expected to migrate towards the Indo-Pakistan border across the Arabian Sea during June and July. At present, a large number of locusts in Pakistan have matured and begun laying eggs. May to July is the growing season or harvesting season of wheat, corn and rice in Pakistan. If the locusts couldn't not be controlled effectively, the locust plague will continue, which may bring a heavy blow to the agricultural and pasture production in Pakistan.

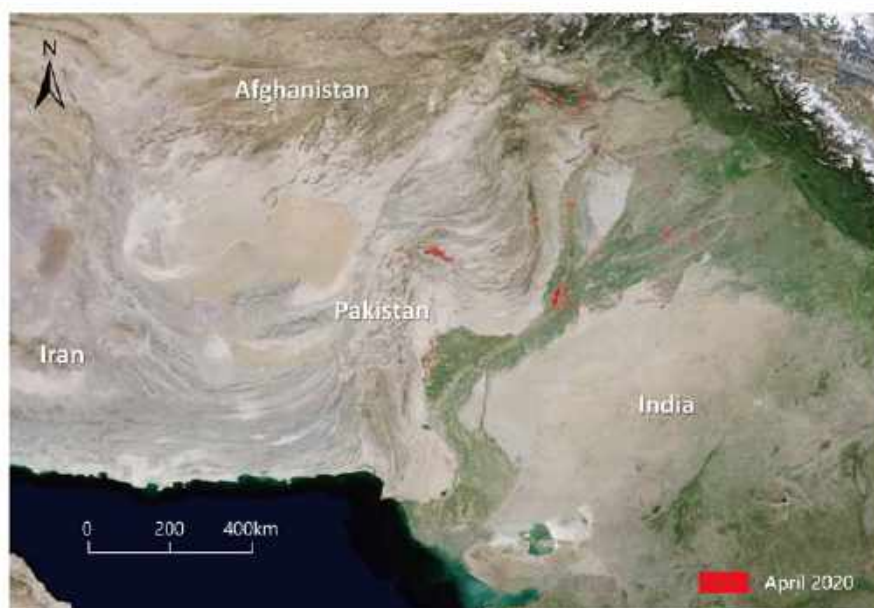


Figure1 Monitoring of Desert Locust damage in Pakistan (April 2020)

Monitoring and assessment of Desert Locust in Somalia

In late March 2020, abundant rainfall provided suitable conditions for locusts breeding in Somalia. In early April, the number of locusts in Somalia continued breeding and forming swarms. Locusts mainly located in Awdal, Woqooyi Galbeed in the northwest, Nugaal, Galguduud, Musug in the middle and Bay in the south of Somalia. In early-mid April, the locusts in Somalia continued laying eggs and hatching. The number of locusts and damage area kept increasing. At the end of April, swarms of locusts started appearing in Sanaag with a tendency of spreading to Bari. Our results showed that by the end of April 2020, the locusts had affected 392.1 thousand hectares of vegetation area in Somalia, including 1.4 thousand hectares cropland, 136.4 thousand hectares grassland and 254.3 thousand hectares shrub. Damaged areas are

mainly located in the western Jubbada Hoose (damaged area is about 140.1 thousand hectares), the northern Bay (damaged area is about 80.4 thousand hectares), the western and southern Bakool (damaged area is about 66.0 thousand hectares), the northern Gedo (damaged area is about 39.0 thousand hectares), the southern Woqooyi Galbeed (damaged area is about 29.2 thousand hectares), the western Mudug (damaged area is about 12.9 thousand hectares), the western and southern Togdheer (damaged area is about 9.8 thousand hectares), the southern Awdal (damaged area is about 4.7 thousand hectares), the central Hiiraan (damaged area is about 3.3 thousand hectares), the central and western Sool (damaged area is about 2.6 thousand hectares), the western Galguduud (damaged area is about 2.1 thousand hectares) and the southern Nugaal (damaged area is about 1.2 thousand hectares). In addition, the southern Sanaag and western Jubbada Dhexe were also damaged by a

small area of locusts, about 0.8 thousand hectares (Figure 2).

In this study, Planet data with a spatial resolution of 3 m in February 2019 and February 2020 were also used to monitor the Desert Locusts damage in the heavily affected vegetation areas in the northern Somalia. The study area is located in the northern Bay, about 17 km to the northwest of Goof Gaduud, and about 16 km to the southeast of Baidoa. The vegetation types are mainly shrub and grassland with a little area of cropland, and the total area is 17.2 thousand hectares. The monitoring results showed that the affected area of vegetation in the study area was 2.2 thousand hectares, accounting for 12.5% of the total area of the study area. Among them, the shrubs affected the most area at 1.3 thousand hectares, and the grassland damaged area was 0.9 thousand hectares, accounting for 9.8% and 20.8% of the total area of shrubs and grasslands in the study

area, respectively. The results show that desert locusts can cause great loss to vegetation, and its outbreaks will seriously affect the agricultural and pastoral production and food security in Somalia (Figure 3).

The comprehensive analysis showed that, in May 2020, locusts in Somalia will continue to hatch. Locusts from eastern and southern Ethiopia and southern Yemen are expected to migrate to northern and central Somalia from May to June. As the locusts continue to mature and spawn, new swarms are expected to form in Somalia from late June to July and migrate to the Indo-Pakistan border along with the southwest monsoon. May to July is the key growing season and harvesting season of corn and other crops in Somalia. The situation of desert locust control and prevention is still severe, which requires continuous monitoring and multinational joint prevention and control to ensure local agricultural and animal husbandry production and food security.

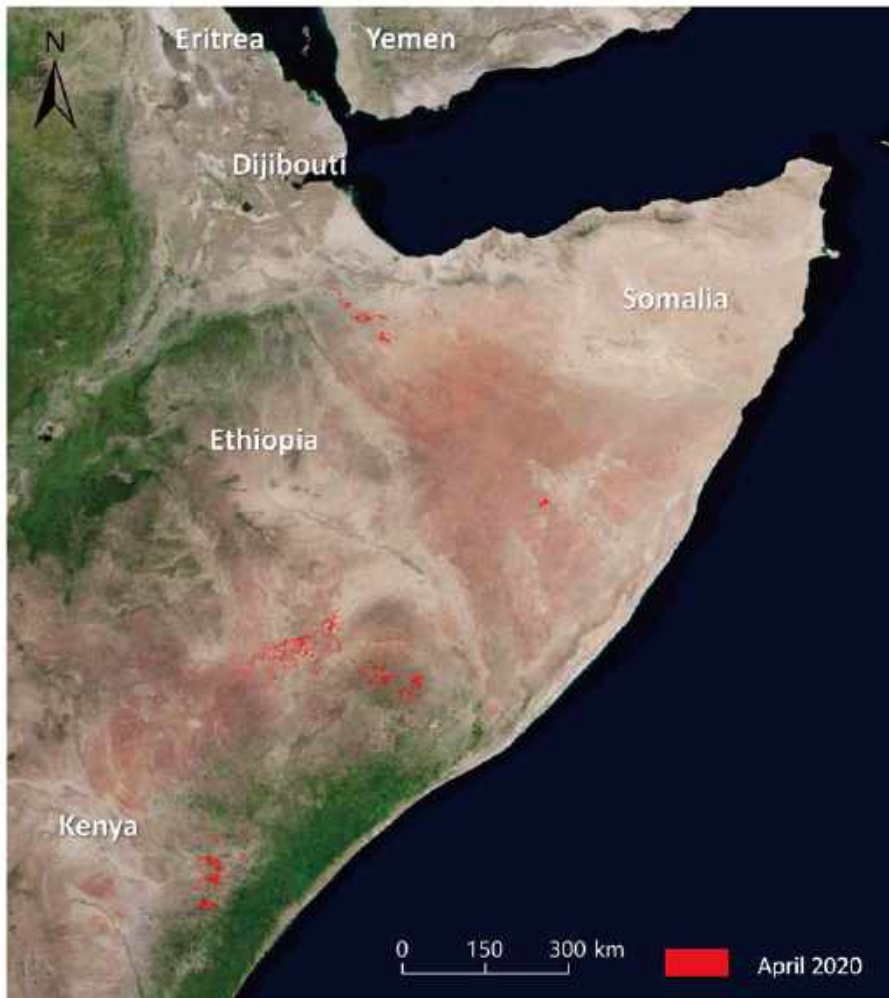


Figure 2 Monitoring of Desert Locust damage in Somalia (April 2020)

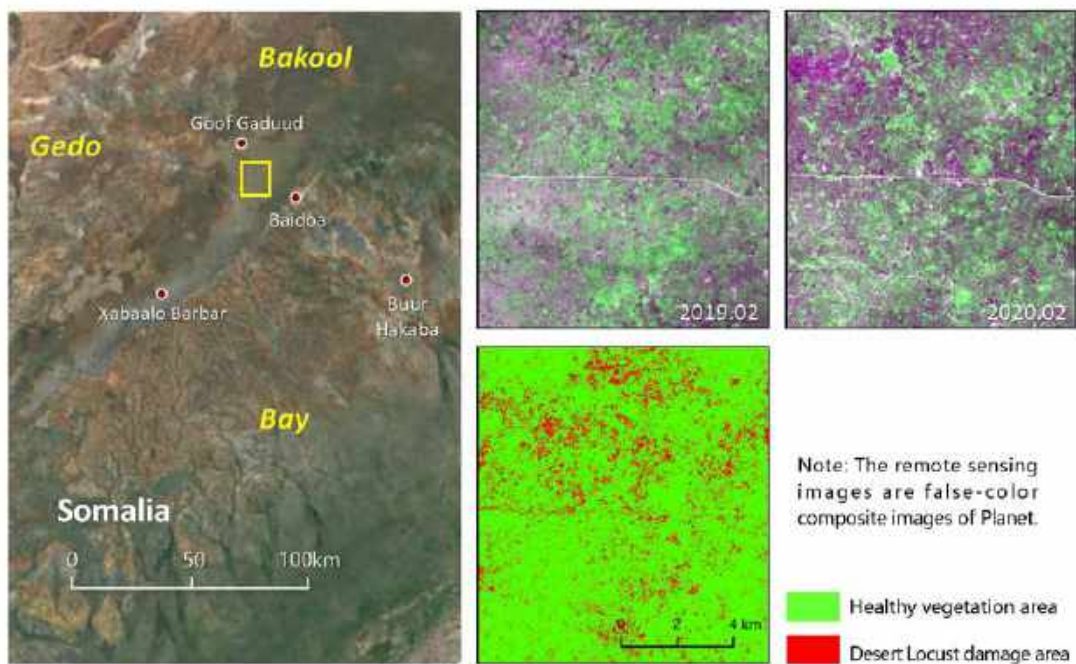


Figure 3 Monitoring of Desert locust damage in key areas of Somalia based on Planet images

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Desert Locust monitoring and forecasting

Late May 2020

Desert Locust monitoring and loss assessment in Kenya and Ethiopia

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Content

| | |
|--|---|
| Overview | 1 |
| Monitoring and assessment of Desert Locust in Kenya | 2 |
| Monitoring and assessment of Desert Locust in Ethiopia | 4 |
| Contact us | 6 |

Nyanza Provinces were less affected. Desert Locust in Ethiopia harmed about 1654.1 thousand hectares of vegetation area from April to mid-May (including 497.0 thousand hectares of cropland, 453.9 thousand hectares of grassland and 703.2 thousand hectares of shrub), mainly distributed in central Afar, western and southern Somalian, eastern Oromia, southern Interracial and eastern Amhara. At present, locusts in Kenya and Ethiopia are constantly breeding and spreading. The period from May to July coincides with the important growing season or harvesting season of wheat, corn, barley, millet, sorghum in these two countries. If not properly controlled, locusts will bring major threats to agricultural and pasture production,

national economy and people's livelihood. It is necessary to continue the monitoring and early warning of the intercontinental Desert Locust plague, and organize joint prevention and control in multiple countries, ensuring the safety of agricultural and pasture production, as well as regional stability.

Monitoring and assessment of Desert Locust in Kenya

In March 2020, the Desert Locusts, mostly mature swarms in the south and immature swarms in the north, were mainly located in northern and central Kenya, including Turkana, Samburu, Baringo, Laikipia, Marsabit, Isiolo, Meru, Nyeri and Nairobi in Rift Valley Province, Garissa in Eastern Province. Our results showed that by the end of March 2020, the Desert Locusts had affected 1077.4 thousand hectares of vegetation area in Kenya, including 385.9 thousand hectares of cropland, 437.2 thousand hectares of grassland and 254.3 thousand hectares of shrub. At the early April, the swarms are getting larger due to precipitation at the end of March, and spread westward migration. Immature swarms began to appear in West Pokot of western Kenya, while in Kericho, in the south, mature swarms developed and began to spawn. From Mid to late March, swarms expand and hatch expanding swarms. And at the end of March, swarms moved west into Uganda. By the end of April 2020, the Desert Locusts had affected 1119.5 thousand hectares of vegetation area in Kenya, including 82.5 thousand hectares of

cropland, 497.4 thousand hectares of grassland and 539.6 thousand hectares of shrub. In early May, mature and immature swarms in northern Kenya continued to mature, spawn and migrate to the north, and reach the northern Marsabit. In mid-May, immature swarms appeared in the northwest of Kenya and some migrated to Kapoeta in the southeast of South Sudan on the 14th and entered Moroto in the northeast of Uganda on the 20th. 1162.3 thousand hectares (including 396.2 thousand hectares of cropland, 459.2 thousand hectares of grassland and 306.9 thousand hectares of shrub) were newly damaged this month (Fig 1).

The result showed that from March to mid-May 2020, Desert Locust in Kenya harmed about 3359.2 thousand hectares of vegetation area (including 864.6 thousand hectares of cropland, 1393.8 thousand hectares of grassland and 1100.8 thousand hectares of shrub), accounting for 16.4%, 7.1% and 3.1% of the total cropland, grassland and shrub, respectively. Among them, Rift Valley Province had the largest affected area of 1787.5 thousand hectares. And the Eastern province followed, with a damaged area of 1255.4 thousand hectares. The affected area in Central Province was 220.6 thousand hectares. The affected area in Coast Province was 53.2 thousand hectares. The Northeast Province, Nairobi Distract, Western Province and Nyanza Province were affected less seriously, at 15.0 thousand hectares, 12.7 thousand hectares, 9.4 thousand hectares and 5.4 thousand hectares,

respectively.

In this study, Planet data with a spatial resolution of 3 m in March 2019 and March 2020 were also used to monitor the Desert Locusts damage in the heavily affected vegetation areas in the Western Province of Kenya. The study area is located in Shianda of Kakamega, northeast side of Lake Victoria, and to the west next to Mumias and Butele. The vegetation types are mainly cropland, grassland and forest, and the total area is 43.2 thousand hectares. The monitoring results showed that the affected area of vegetation in the study area was 5.4 thousand hectares, accounting for 12.5% of the total area of the study area. Among them, the cropland was affected the most seriously at 3.9 thousand hectares, the damaged grassland area was 1.3 thousand hectares, and the affected area of forest was 0.2 thousand hectares, accounting for 12.8%, 12.1% and 10.0% of the total area of croplands, grasslands and forests in the study area, respectively. The results

show that desert locusts can cause great loss to vegetation, and its outbreaks will seriously affect the agricultural and pastoral production and food security in Kenya.

The comprehensive analysis showed that, from May to June 2020. Swarms in the north-west will continue to spread west to northeastern Uganda, northwest to southern South Sudan and northeast to Ethiopia. Between June and July, the swarms are expected to migrate southwest to central Sudan for summer breeding. At present, a large number of locusts in Kenya have matured and begun laying eggs. May to July is the growing season or harvesting season of barley, corn and sorghum in Kenya. It is also growing season for wheat and harvesting and growing season for millet. If the locusts could not be controlled effectively, the locust plague will continue, which may bring a heavy blow to the agricultural and pasture production in Kenya.

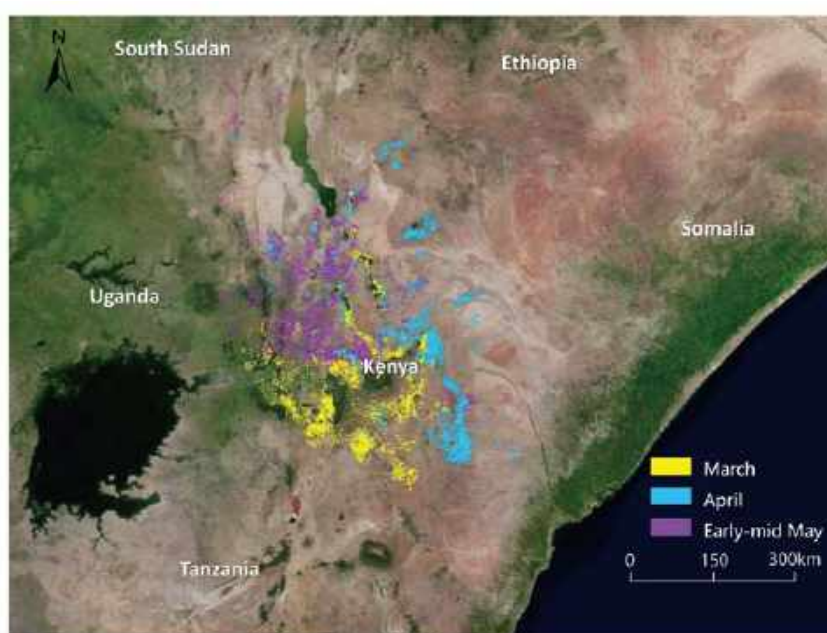


Figure 1 Monitoring of Desert Locust damage in Kenya (March - Early-mid May 2020)

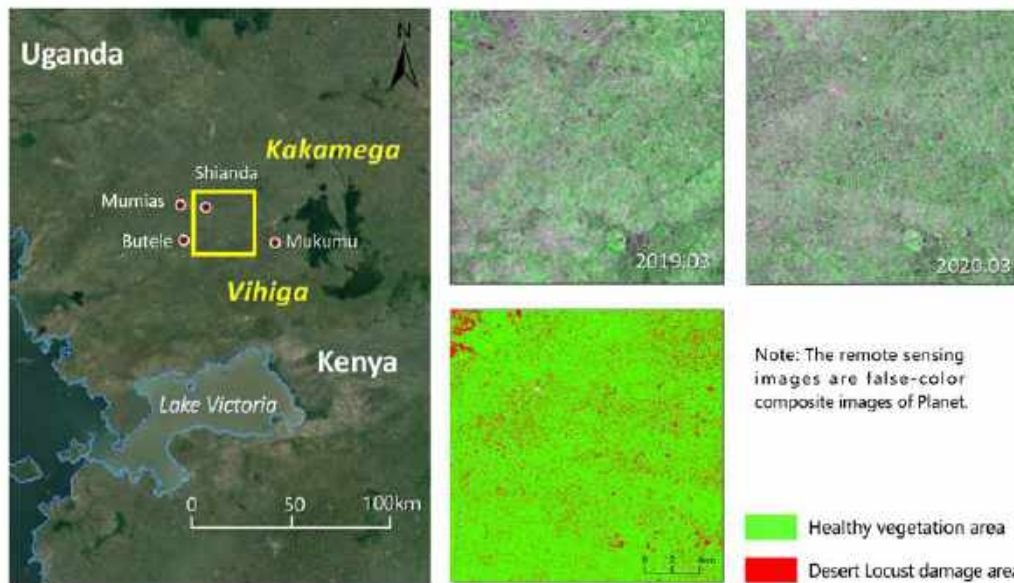


Figure 2 Monitoring of Desert locust damage in key areas of Kenya based on Planet images

Monitoring and assessment of Desert Locust in Ethiopia

In late March 2020, abundant rainfall provided suitable conditions for locusts breeding in Ethiopia. In early April, locusts in northern Kenya spread northward. Locusts are increasing in SNNPR, Konso, Yabello, Negele, Arero in southern Oromiya. In mid-late April, new swarms appeared and multiplied in central Oromia, Gode in southern Somali and DireDawa and Jijjiga in the north Somali. 894.3 thousand hectares (including 167.6 thousand hectares of cropland, 153.2 thousand hectares of grassland and 573.5 thousand hectares of shrub) were newly damaged this month. In early-mid May, locusts in south spread to Afar in northwestern Ethiopia, Somali and Ogaden in eastern Ethiopia. With the control operations, the number of swarms in south is decreasing. Locusts in the border of DE Radhwa area and Somali are maturing, and the affected is

further expanded to 759.8 thousand hectares (including 329.4 thousand hectares of cropland, 300.7 thousand hectares of grassland and 129.7 thousand hectares of shrub).

The result showed that from April to mid-May 2020, Desert Locust in Ethiopia harmed about 1654.1 thousand hectares of vegetation area (including 497.0 thousand hectares of cropland, 453.9 thousand hectares of grassland and 703.2 thousand hectares of shrub), accounting for 2.1%, 2.6% and 1.0% of the total cropland, grassland and shrub, respectively. The harmed areas are mainly in the north and south of Ethiopia. Among them, Oromiya state had the largest harmed area of 842.2 thousand hectares. Southern states of all ethnic groups (SNNPR) were the second most harmed, with 306.1 thousand hectares. Somalia ranked the third with 238.5 thousand hectares of newly harmed areas. 214.8 thousand hectares have been harmed in the Afar state. The newly

affected areas in Tigray and Amhara were 29.8 thousand hectares and 22.7 thousand hectares, respectively (Figure3).

The comprehensive analysis showed that, from late-May to June 2020, Swarms in Ethiopia will continue to breed. Swarms in SNNRR and Oromiya will continue to migrate to Amhara, Tigray and eastern Somali in Northwest Somalia. Swarms in western Somalia will spread westward to Afar and Tigray. Meanwhile, swarms in northern Kenya will migrate to southern and southeastern Ethiopia. From late-June to July, swarms are

expected to migrate westward to central Sudan and eastern Sahara, and migrate northeast to the Indo-Pakistan border for summer breeding. At present, large numbers of locusts are maturing in Ethiopia. May to July is the growing season for corn, millet and sorghum in Ethiopia. The situation of desert locust control and prevention is still imperious, which requires continuous monitoring and multinational joint prevention and control to ensure local agricultural, animal husbandry production and food security.

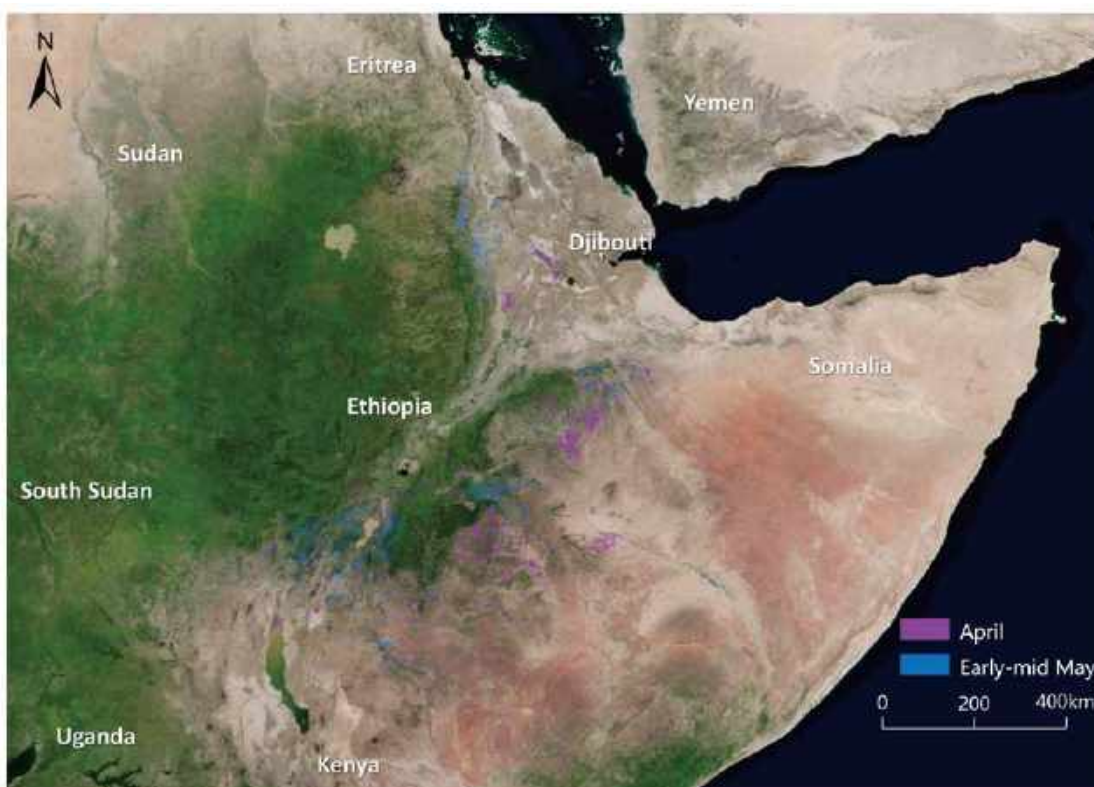


Figure 3 Monitoring of Desert Locust damage in Ethiopia (April - Early-mid May 2020)

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Mission statements: As the science and knowledge service, the Sino-UK Crop Pest and Disease Forecasting & Management Joint Laboratory is to support independent evidence for crop monitoring.

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Desert Locust monitoring and forecasting

Early June 2020

Desert Locust monitoring in Asia and Africa and loss assessment in Yemen

Overview

Integrated with multi-source Earth Observation data, e.g. meteorological data, field data, and remote sensing data (such as GF series in China, MODIS and Landsat series in US, Sentinel series in EU), and self-developed models and algorithms for Desert Locust monitoring and forecasting, the research team constructed the 'Vegetation pests and diseases monitoring and forecasting system', which could regularly release thematical maps and reports on Desert Locust.

This report focuses on forecast of possible breeding areas and migration paths from June to July 2020 and the locust plagues in Yemen. The results showed that, the desert locusts are mainly distributed in the spring breeding areas of Indo-Pakistan border, the west of Pakistan, the coastal and inland areas of the Arabian Peninsula, southern Ethiopia and most of Kenya at the moment, and has begun to move to central Sudan, Indo-Pakistan border and the countries of

Content

| | |
|---|---|
| Overview | 1 |
| Migration path and prediction of Desert locust in Africa and Asia | 2 |
| Monitoring and assessment of Desert Locust in Yemen | 3 |
| Contact us | 7 |

West Africa to start Summer breeding. From April to May 2020, Desert Locust in Yemen harmed about 529.3 thousand hectares of vegetation area (including 85.4 thousand hectares of cropland, 27.8 thousand hectares of grassland, and 416.1 thousand hectares of shrub), accounting for 8.5%, 4.8% and 7.4% of the total cropland, grassland, and shrub, respectively.

At present, locusts in Asia and Africa are multi-generation breeding. The period from June to July coincides with the important crops sowing season, growing season or harvesting season in Asian and African countries. If not properly controlled, locusts will bring a major threat to agricultural and pasture production. It is necessary to continue the monitoring and early warning of the

intercontinental Desert Locust plague, and organize joint prevention and control in multiple countries, ensuring the safety of agricultural and pasture production, as well as regional stability.

Migration path and prediction of Desert locust in Africa and Asia

In February 2020, the desert locusts in east Africa and southwest Asia were mainly distributed on the Indo-Pakistan border, in the west of Pakistan, coastal and inland areas of the Arabian Peninsula (coastal and inland areas of eastern and western Saudi Arabia, southeastern Kuwait, eastern Oman, western and southern Yemen), southern Ethiopia and most of Kenya. In addition, there were small groups of locusts in northeastern Afghanistan, southern Iran, northeastern Sudan, eastern Eritrea, northwestern Somalia, southern South Sudan, northeastern Uganda and northern Tanzania.

In early March 2020, locust swarms in Kuwait continued to spread to southeastern Iraq, while locust swarms along eastern coast of Saudi Arabia moved to the western coast of the United Arab Emirates. At the same time, locust swarms in southern Ethiopian began to move northward. In mid-March, immature locusts were found along Red Sea coast in southeastern Egypt. At the end of March, immature locusts appeared on the east coast of Djibouti. In April, large amounts of precipitation occurred in East Africa, and locusts continued to breed in spring and mature into groups. The locust in Ethiopia and

Somalia continued moving north, while the locust in the northern Arabian Peninsula spread to central Iraq, and the density of locusts along Iran/Pakistan border continued to increase. In May, locust eggs continued to incubate and breed. In the middle and late of that month, locust swarms began to migrate from spring breeding areas such as Kenya, Ethiopia and western Pakistan to summer breeding areas such as central Sudan, southwestern Saudi Arabia and Indo-Pakistan border. At the end of the month, locust swarms moved eastward from the Indo-Pakistan border to northern India (Figure 1).

At present, locust breeding is underway in most areas. It is expected that in early June, locust swarms in eastern and northern Saudi Arabia will move to summer breeding areas, such as southern Yemen and central Sudan, and locust swarms in eastern Oman will continue to migrate to eastern Yemen. From mid-late June to July, locusts in spring breeding areas such as Kenya, Ethiopia and Somalia will move to central Sudan and Indo-Pakistan border for summer breeding. Meanwhile, locusts in southern Iran will move to western Pakistan, and locusts in northern India will continue to breed and spread eastwards. The period from June to July coincides with the important harvesting season in Pakistan and India, the sowing season, growing season and the harvesting season in the Horn of Africa countries. If the locust plague continues, agricultural and pasture production, national economy and people's livelihood will be seriously threatened.

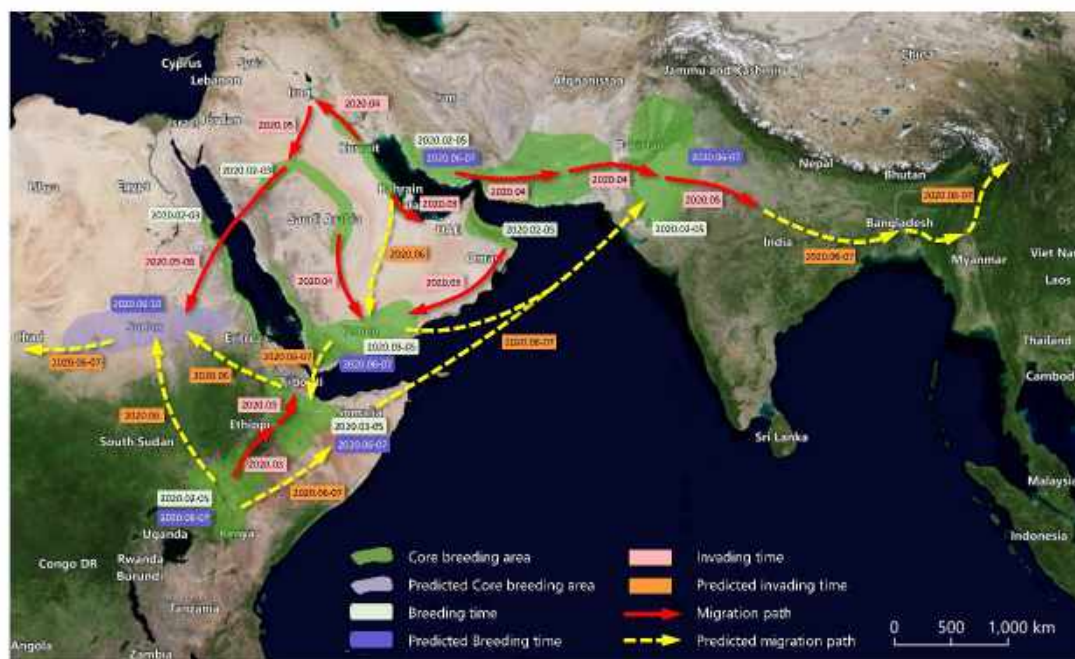


Figure 1 Migration path of Desert Locust in Asia and Africa (March-July 2020).

Monitoring and assessment of Desert Locust in Yemen

In April 2020, in the western of Hajjah province, most of Al-Hudaydah province, the eastern of Ta'izz province, the southern of Ad-Dāli province, the western of Lahij province and Abyān, central Hadramawt and central Al-Mahrah, locusts continued their spring breeding. In late April, inland rainstorms and flooding promoted locust breeding. The results showed that by the end of April, locust in Yemen harmed about 287.3 thousand hectares of vegetation area, including 39.0 thousand hectares of cropland, 13.9 thousand hectares of grassland, and 234.4 thousand hectares of shrub. In early May, locusts in the

southern coast, the edge of Ramlat Sabatyn and the plateau area north of Wadi Hadhramaut continued to mature and lay eggs. In mid-May, locusts in Saudi Arabia and Oman moved to Yemen from the north and east respectively. In late May, the number of locusts in southern Yemen continued to increase, and the damaged area further expanded. By the end of May, locusts in Yemen harmed about 242.0 thousand hectares of vegetation area, including 46.4 thousand hectares of cropland, 13.9 thousand hectares of grassland, and 181.7 thousand hectares of shrub (Fig 2).

The results showed that from April to May 2020, Desert Locust in Yemen harmed about 529.3 thousand hectares of vegetation area

(including 85.4 thousand hectares of cropland, 27.8 thousand hectares of grassland, and 416.1 thousand hectares of shrub), accounting for 8.5%, 4.8% and 7.4% of the total cropland, grassland, and shrub, respectively. The harmed areas are mainly located in western and southern coastal areas of Yemen. Among them, the southwestern province of Ta'izz has the largest damage area of 106.9 thousand hectares, followed by the Al-Hudaydah province along the west coast of Red Sea with an area of 97.3 thousand hectares. The affected areas were 78.2 thousand hectares and 74.7 thousand hectares in Ad-Dāli and Lahij. The affected areas of Ibb in the Midwest and Abyān in the southern coast are 45.7 and 44.9 thousand hectares. The affected area of Dhamar is 37.6 thousand hectares. The affected area of Al-Baydā is 20.4 thousand hectares. In middle east of Hadramawt province, the affected area is 10.2 thousand hectares. The affected areas in other provinces are relatively small. The affected area of Al-Mahrah is 4.5 thousand hectares. The affected area of Shabwah is 2.4 thousand hectares. The affected area of Hajjah is 2.3 thousand hectares. The affected area of Ma'rib is 2.2 thousand hectares. The affected areas of Al-Mahwīt, San'a, Aden and Raimah are 1.0 thousand hectares, 0.5

thousand hectares, 0.3 thousand hectares and 0.2 thousand hectares, respectively. Yemen is a typical agro-pastoral country where 75% of its population are engaged in agriculture. The locust plague has caused a huge impact on local agricultural and pastoral production, which seriously threatened the local agricultural and pastoral safety and national livelihood. The domestic disaster situation is severe.

In this study, Planet data with a spatial resolution of 3m in August 2018 and August 2019 were also used to monitor the Desert Locusts damage in heavily affected vegetation areas in central Al-Hudaydah Province of Yemen (Figure3). The study area is located in the junction of Raimah and Al-Hudaydah, about 15 km to the northwest of Al Mansuriyah, and about 13 km to the southeast of Nafhan. The vegetation types are mainly grassland, shrub and cropland, with a total area of 12.5 thousand hectares (6.2 thousand hectares of grassland, 2.4 thousand hectares of shrub and 3.9 thousand hectares of cropland.) The monitoring results showed that, the affected area of vegetation in the study area was 1.6 thousand hectares, accounting for 12.8% of the total area of the study area. Among them, the grassland were affected the most severely with 0.8 thousand hectares, while the

affected cropland is 0.4 thousand hectares and shrub 0.4 thousand hectares, accounting for 12.9%, 10.3%, and 16.7% of the total area of grassland, cropland and shrub in the study area, respectively. The results show that desert locusts can cause great loss to vegetation, and its outbreaks will seriously affect the agricultural and pastoral production and food security in Yemen.

The comprehensive analysis showed that, in June 2020, locusts in Yemen will continue their spring breeding. The locust swarms in eastern Saudi Arabia and northeastern Oman will continue to migrate north and east of

Yemen, while the locust swarms in southwest Yemen will migrate to the southwest cross the Gulf of Aden to Djibouti, northwestern Somalia and northeastern Ethiopia. It is estimated that from late June to July, the locust swarms will move northeast to Indo-Pakistan border for summer breeding. At present, the desert locusts in Yemen continue to breed, mature and begin to lay eggs. June is the important growing season of crops in Yemen. If the locusts couldn't be controlled effectively, the locust plague will continue, which may bring a heavy blow to the agricultural and pasture production in Yemen.

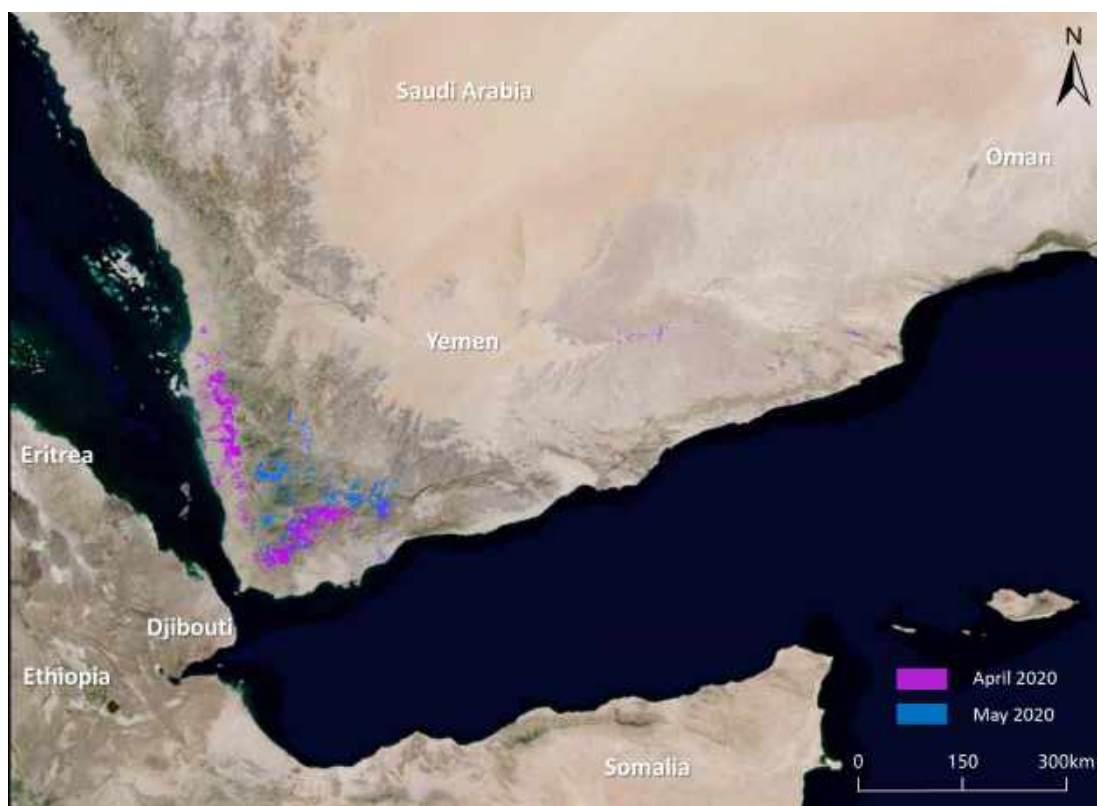


Figure 2 Monitoring of Desert Locust damage in Yemen (April to May 2020)

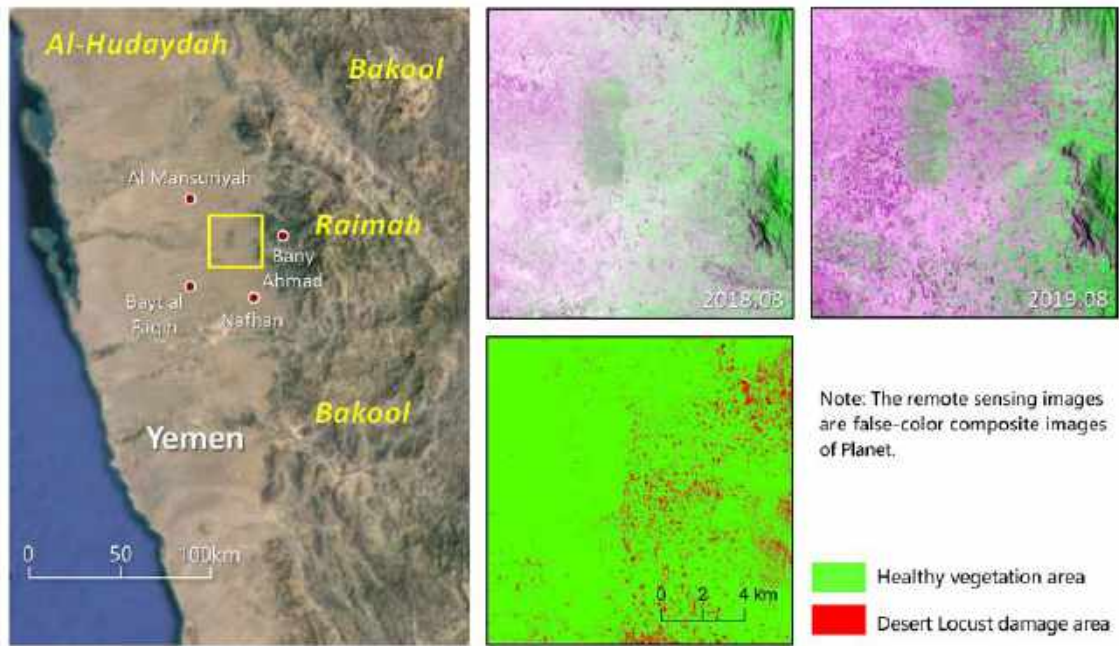


Figure 3 Monitoring of Desert Locust damage in the key damage area of Yemen based on Planet images

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Desert Locust monitoring and forecasting

July 2020

Desert Locust Monitoring and Loss Assessment in Six Asian and African Countries

Overview

Integrated with multi-source Earth Observation data, e.g. meteorological data, field data, and remote sensing data (such as GF series in China, MODIS and Landsat series in US, Sentinel series in EU), and self-developed models and algorithms for Desert Locust monitoring and forecasting, the research team constructed the 'Vegetation pests and diseases monitoring and forecasting system', which could regularly release thematical maps and reports on Desert Locust.

This report updates the assessment of Desert Locust plague in six key Asian and African countries, and forecasts the possible breeding areas and migration paths from July to August 2020 in India, Ethiopia, and Kenya. The results showed that the Desert Locusts are mainly distributed in India, Pakistan,

Content

| | |
|---|----|
| Overview | 1 |
| Migration path and prediction of Desert locust in India | 2 |
| Monitoring and assessment of Desert Locust in Pakistan | 5 |
| Monitoring and assessment of Desert Locust in Ethiopia | 6 |
| Monitoring and assessment of Desert Locust in Kenya | 8 |
| Monitoring and assessment of Desert Locust in Somalia | 10 |
| Monitoring and assessment of Desert Locust in Yemen | 12 |
| Contact us | 14 |

Ethiopia, Kenya, Yemen, and Somalia, severely endangering the agriculture and animal husbandry of these countries. By the end of June 2020, Desert Locusts caused great losses of the vegetation areas, with harmed areas about 1058.3 thousand hectares in India, 792.9 thousand hectares in Pakistan, 1137.5 thousand hectares in

Ethiopia, 936.8 thousand hectares in Kenya, 780.0 thousand hectares in Somalia, and about 763.5 thousand hectares of vegetation area in Yemen.

At present, locusts in Asia and Africa are experiencing multi-generation breeding. The period from July to August coincides with the important crops sowing season, growing season, or harvesting season in Asian and African countries. If not properly controlled, locusts will bring a major threat to agricultural and pasture production. It is necessary to continue the monitoring and early warning of the intercontinental Desert Locust plague, and organize joint prevention and control in multiple countries, ensuring the safety of agricultural and pasture production and protecting regional stability.

Migration path and prediction of Desert locust in India

In July-September 2018, rainfall on the Indo-Pakistan border created a suitable ecological environment for the breeding of Desert Locusts. Scattered Desert Locusts began to appear in the west of Rajasthan, India. In June 2019, local locusts in western Rajasthan began summer breeding, spawning, hatching, and forming early locust swarms. At the same time, locusts in Pakistan

and southern Iran continued to move towards the Indo-Pakistan border; From July to August, Rajasthan locusts continued to develop and reproduce, gradually spreading to the surrounding area, and the number of locusts further increased; In September, the second generation of Desert Locusts began to breed, and India implemented ground control of locusts in Rajasthan; In October, as climatic conditions became drier than before, some locusts began to move from India to spring breeding areas in southwestern Pakistan and southeastern Iran; From November to December, the third generation of locusts on the Indo-Pakistan border began to multiply, and the number of locusts gradually increased. Some locust groups moved across the Arabian Sea to the south of Oman.

In January 2020, although there were still locust groups in the territory, the number of locust groups had gradually declined due to control operations and migration to southern Iran, eastern Oman, and southern Yemen. From February to April, the number of locusts decreased due to the impact of control operations and migration; In May, the spring breeding locusts in western Pakistan began to move towards the Indo-Pakistan border. The locust swarms in western Rajasthan continued to gather and expand, and

continued to move to the central regions such as Madhya Pradesh and Maharashtra with the westerly wind brought by the cyclone Amphan in the Bay of Bengal; In June, the locusts on the Iran/Pakistan border continued to migrate to the Indo-Pakistan border for summer breeding, while the locusts in the middle began to migrate to northern India with strong south winds and arrived on the 26th in Bhairahawa, southern Nepal, bordering Uttar Pradesh, then spread in the central lowlands of Nepal. Some locust swarms reached Butwal and Kathmandu at the foot of the Himalayas on the 27th and 30th respectively (Figure1).

The results showed that, by the end of June 2020, Desert Locust in India harmed about 1058.3 thousand hectares of vegetation area, including 450.9 thousand hectares of cropland, 320.6 thousand hectares of grassland and 286.8 thousand hectares of shrub, accounting for 0.2%, 0.7% and 1.6% of the total cropland, grassland, and shrub in India, respectively. The harmed areas are mainly located in southern Rajasthan (with

630.7 thousand hectares of affected area), northern Gujarat (with 207.6 thousand hectares of affected area), central Madhya Pradesh (with 176.6 thousand hectares of affected area), Punjab (with 23.6 thousand hectares of affected area), as well as northern Maharashtra (with 10.1 thousand hectares of affected area), while Uttar Pradesh and Haryana have small affected areas (Figure2).

The comprehensive analysis showed that, In July 2020, locusts in India will continue to hatch. Due to the southerly wind, they may continue to move northward to Nepal and pose a potential threat to Tibet, China. In mid-to-late July, locusts in northern India are expected to return to western India before the onset of the summer monsoon; From July to August, locusts in southern Iran will continue to migrate to western India for summer breeding. July to August is the important growing season of corn, rice, and other crops in India. If the locusts couldn't be controlled effectively, the locust plague will continue, which may bring a heavy blow to the agricultural and pasture production in India.

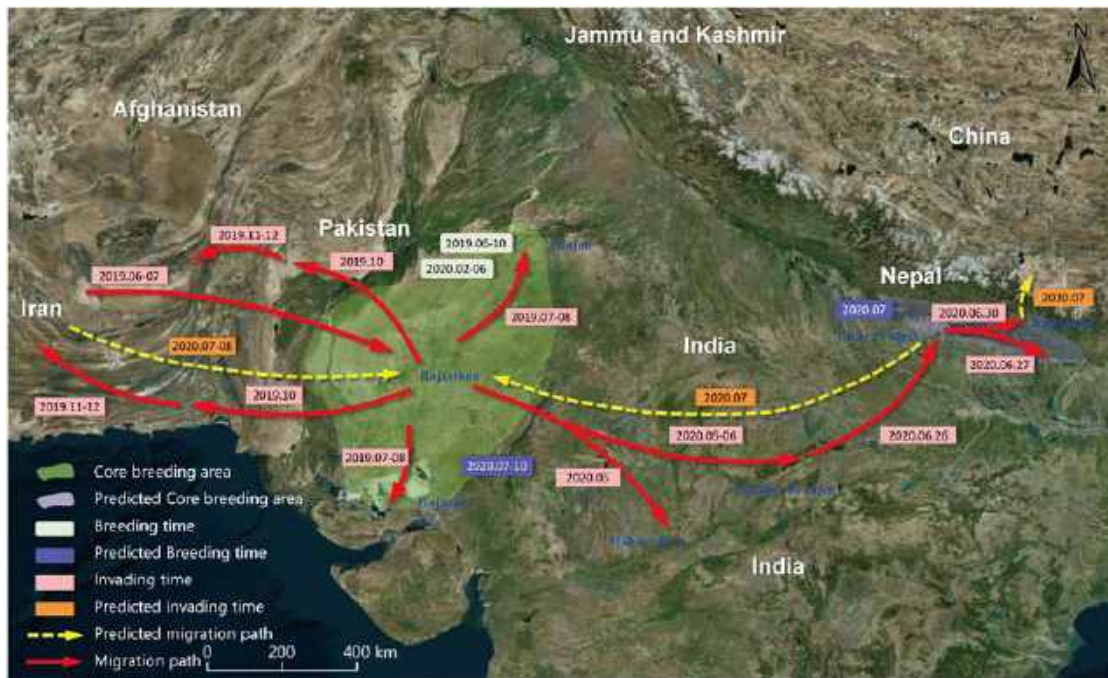


Figure 1 The breeding area, migration path of Desert Locust in India (June 2019-August 2020)

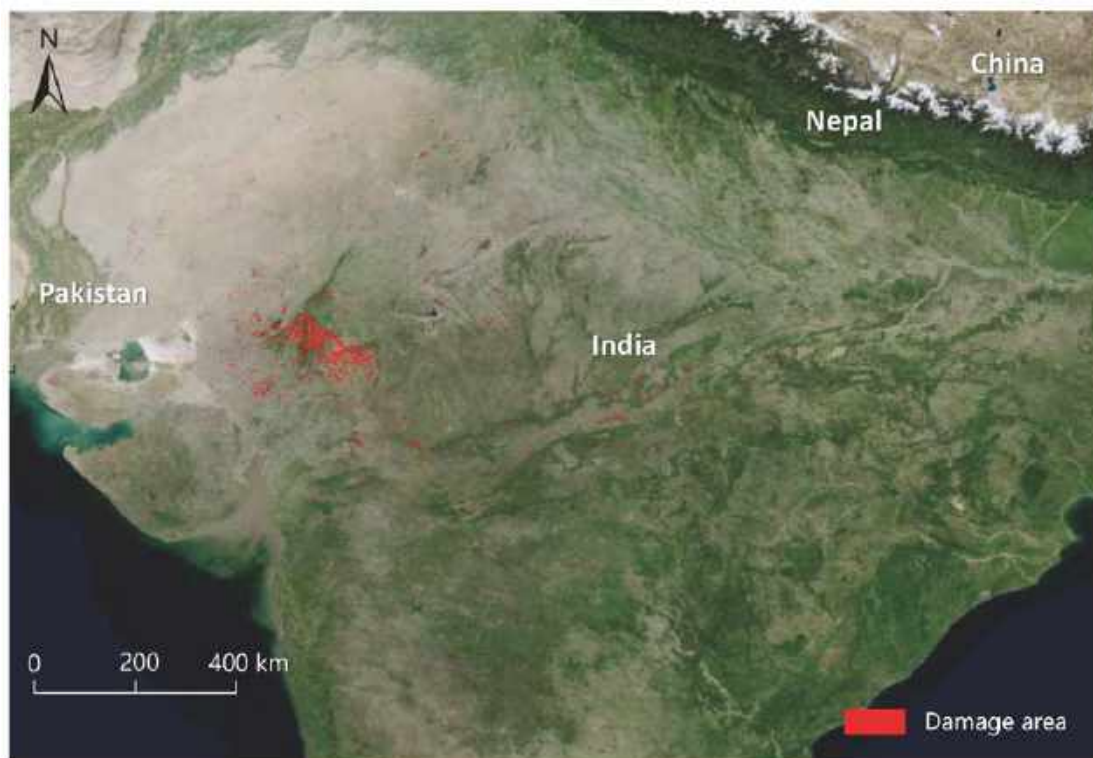


Figure 2 Monitoring of Desert Locust damage in India (July 2020)

Monitoring and assessment of Desert Locust in Pakistan

In May 2020, the Desert Locusts in western Pakistan continued their spring breeding and began to move eastward to the summer breeding area on the Indo-Pakistan border. At the same time, locusts in northern Pakistan continued to multiply and colonize. In June, the spring breeding locust swarms in Pakistan continued to move towards the Indo-Pakistan border and gradually spread into India.

The results showed that, by the end of June 2020, Desert Locust in Pakistan harmed about 792.9 thousand hectares of vegetation area, including 455.2 thousand hectares of cropland and 337.7 thousand hectares of grassland, accounting for 1.8% and 3.5% of the total cropland and grassland in Pakistan respectively. Among them, Sindh Province has the largest damaged area of 433.4 thousand hectares; followed by Punjab, with damaged area of 238.6 thousand hectares; while Baluchistan Province (32.3 thousand

hectares), Federally Administered Tribal Areas (31.7 thousand hectares), and Khyber Pakhtunkhwa Province (56.9 thousand hectares) have less affected areas (Figure3).

The comprehensive analysis showed that, In July 2020, the locust swarms breeding in spring in southern Iran, southwestern Pakistan, and northern Somalia will continue to migrate to the summer breeding area along the Indo-Pakistan border. In August, due to the end of the spring breeding, the number of locusts in southwestern Pakistan will decrease. Desert locusts along the Indo-Pakistan border will hatch and breed in July. It is expected that the first generation of summer locust swarms will form in August. July to August is the important growing season of crops in Pakistan. If the locusts couldn't be controlled effectively, the locust plague will continue, which may bring a heavy blow to the agricultural and pasture production in Pakistan.

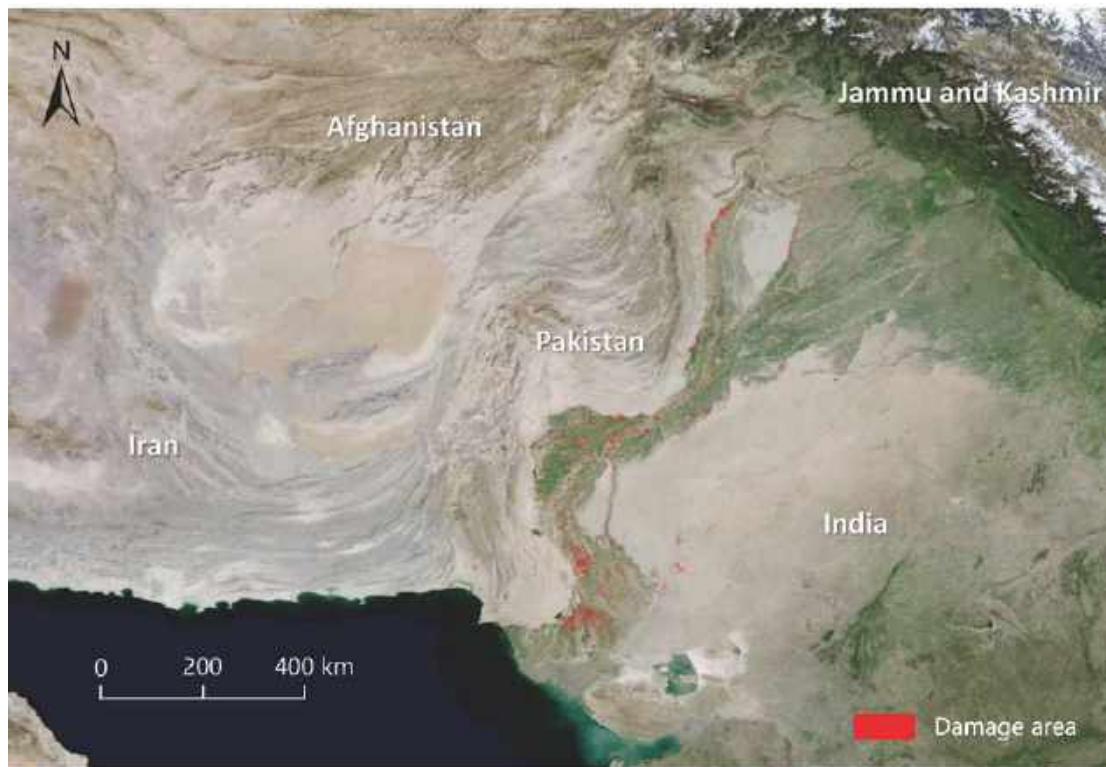


Figure 3 Monitoring of Desert Locust damage in Pakistan (July 2020)

Monitoring and assessment of Desert Locust in Ethiopia

From late May to early June 2020, the Desert Locusts in Ethiopia mainly distributed in Somali, eastern Oromiya, Southern Afar, and northeastern Amhara. In middle June, the locusts swarm in northern Ethiopia migrated to Amhara, Tigray, Afar and Somali in eastern Ethiopia; meanwhile, locust swarm in southern Yemen spread to Afar. In late June, the number of locusts in Ethiopia continued to increase due to local breeding and locust supply from Yemen, the locust population continued to grow in size (Figure4).

The results showed that by the end of

June, Desert Locust in Ethiopia harmed about 1137.5 thousand hectares of vegetation area (including 304.8 thousand hectares of cropland, 364.5 thousand hectares of grassland, and 468.2 thousand hectares of shrub), accounting for 1.3%, 2.1% and 0.6% of the total cropland, grassland, and shrub, respectively. The harmed areas are mainly located in eastern Oromiya with an area of 250.7 thousand hectares, southern nations, southern tribes and southern with an area of 243.8 thousand hectares, northwestern Somali with an area of 277.1 thousand hectares, eastern and northern Tigray with an area of 195.6 thousand hectares, eastern Afar with an area of 132.0 thousand hectares. The

affected areas in Amhara and Gambela are relatively small (Figure5).

The comprehensive analysis showed that, in July 2020, the Desert Locusts in Ethiopia will continue to breed and spread. It is estimated that the locust swarm will move westward to central Sudan and northeastward to the Indo-Pakistan border for summer

breeding in July-August, and may spread to Somalia halfway. The period from July to August is an important growing season for Ethiopian crops. If the Desert Locusts are not effectively controlled, the locust plague will continue, which may cause a heavy blow to the agricultural and animal husbandry production in Ethiopia.

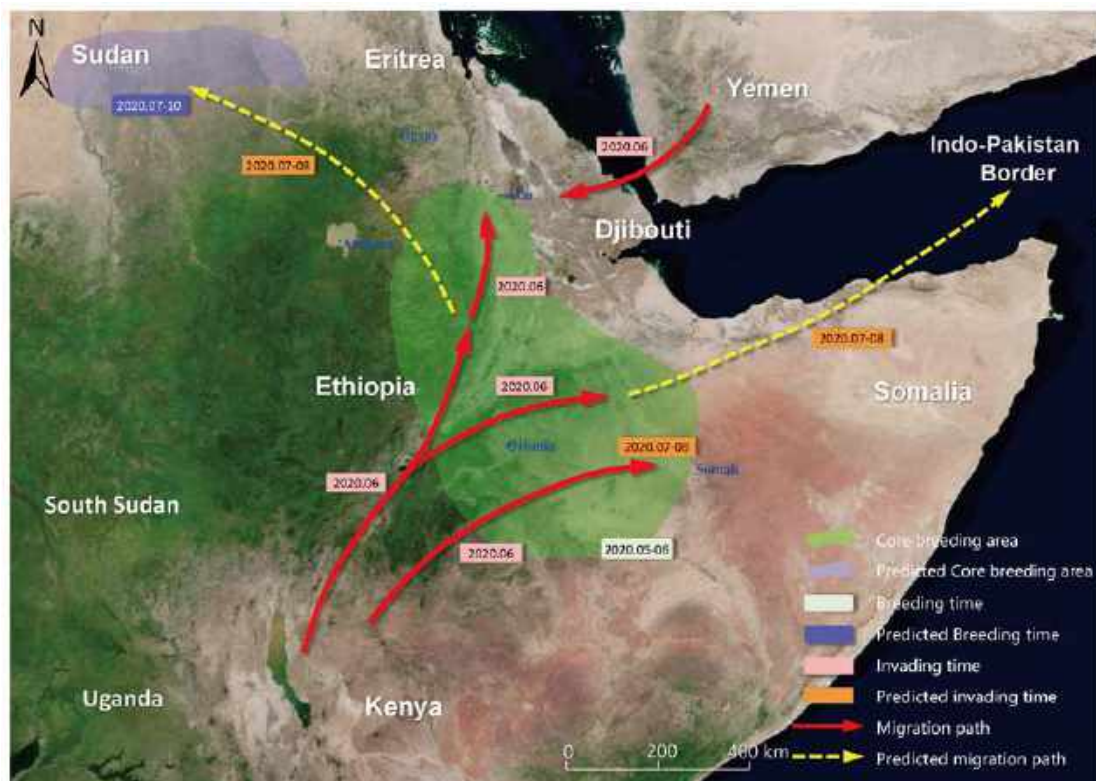


Figure 4 The breeding area, migration path of Desert Locust in Ethiopia (June-Aug 2020)

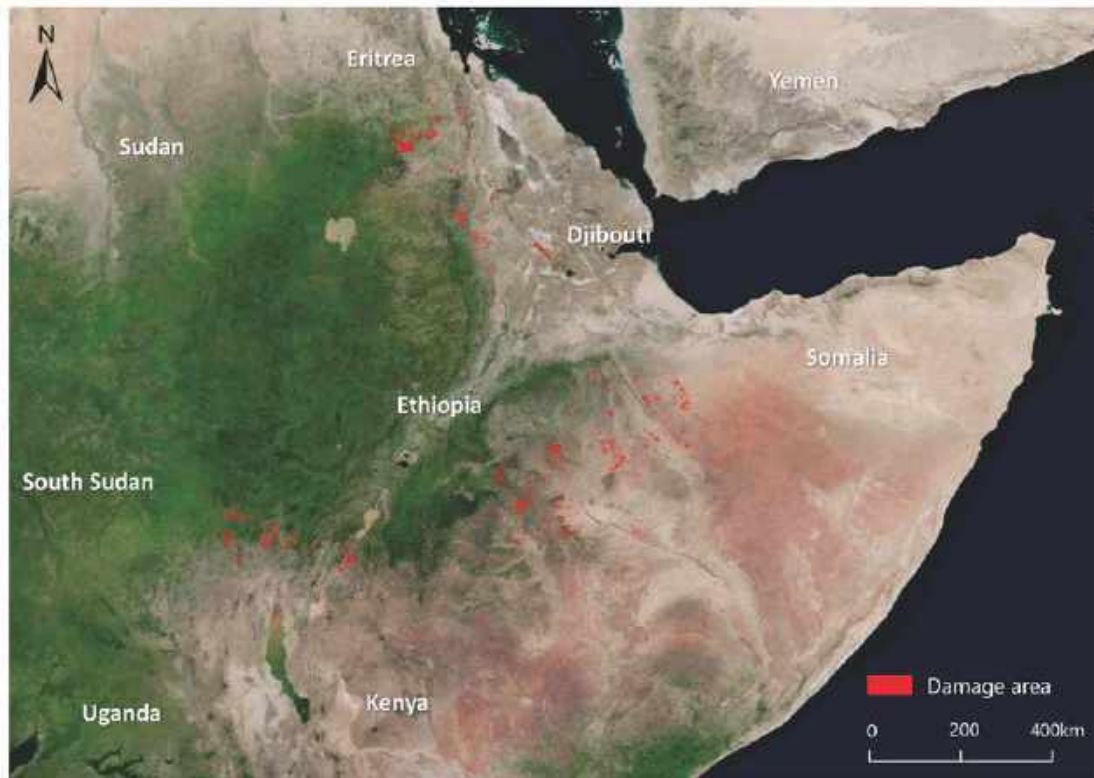


Figure 5 Monitoring of Desert Locust damage in Ethiopia (June 2020)

Monitoring and assessment of Desert Locust in Kenya

In late May 2020, Desert Locusts in Kenya continued the spring breeding; in early June, the locusts were mainly distributed in the Rift Valley Province and northern of the Eastern Province of Kenya, mostly mature locusts; in mid-June, some locusts migrated northwestward to the summer breeding area in southern Sudan through South Sudan and northeast Uganda, and some locust swarms migrated northward and northeastward to the northeast and northwest Ethiopia; in late June, locusts continued to breed and formed more

swarms, and kept to migrate to the Northwest (Figure6).

The monitoring results showed that by the end of June 2020, the vegetation area harmed by locust in Kenya had reached 936.8 thousand hectares, including 86.7 thousand hectares of cropland, 492.8 thousand hectares of grassland and 357.3 thousand hectares of shrubs, accounting for 1.7%, 2.5%, and 1.0% of the total cropland, grassland, and shrub in Kenya, respectively. The damaged areas were mainly located in the central and northern part of Rift Valley Province (with 504.1 thousand hectares of affected area), the central part of northeast

province (with 262.0 thousand hectares of affected area), and the northwest and east part of eastern province (with 170.8 thousand hectares of affected area) (Figure7).

The comprehensive analysis shows that Desert Locusts in Kenya will continue to breed in July 2020. It is expected that locusts will continue to migrate to the northwest to central Sudan for summer breeding from July

to August. It coincides with the important growing season of crops in Kenya, which makes the control of Desert Locust in urgency. It is necessary to carry out continuous monitoring and joint prevention and control among countries to ensure local agricultural and animal husbandry production and food security.

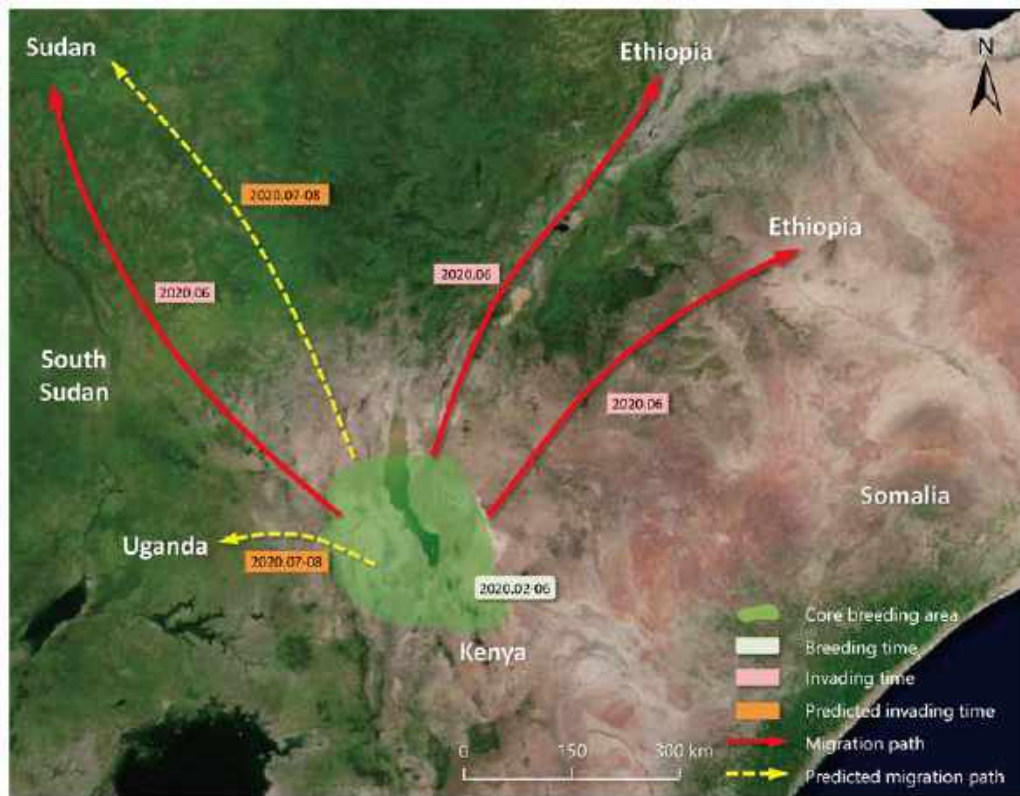


Figure 6 The breeding area, migration path of Desert Locust in Kenya (June-August 2020)

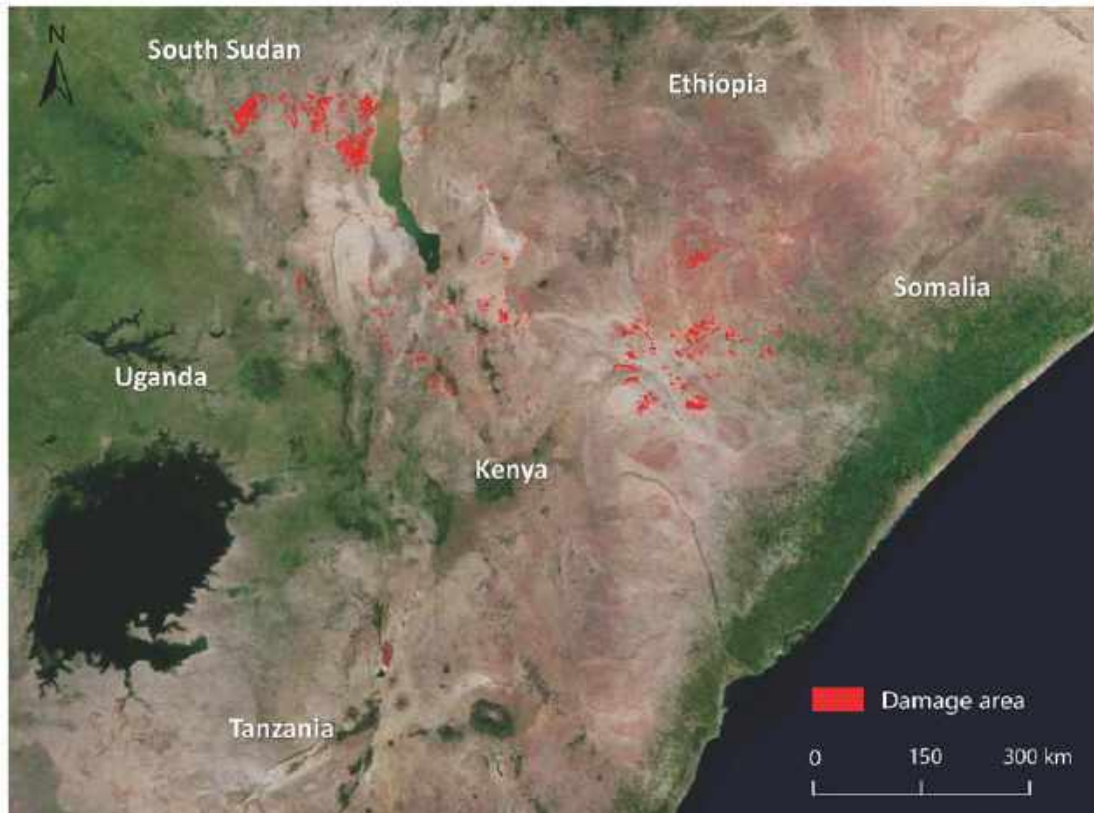


Figure 7 Monitoring of Desert Locust damage in Kenya (June 2020)

Monitoring and assessment of Desert Locust in Somalia

From May to June 2020, the Desert Locusts in Somalia continued their spring breeding locally. The locusts continued to incubate to form new locust colonies, which are mainly located in the northwestern, northern coastal and central Somalia and the border with Ethiopia. The result shows that Desert Locust in Somalia harmed about 780 thousand hectares of vegetation area by the end of June (including 1.6 thousand hectares of cropland, 154.7 thousand hectares of grassland and 623.7 thousand hectares of

shrub), accounting for 1.6%, 4.0% and 1.4% of the total cropland, grassland, and shrub in Somalia, respectively. The harmed area are mainly distributed in west Mudug with an area of 218.3 thousand hectares, east Togdheer with an area of 143.9 thousand hectares, northwest Woqooyi galbeed with an area of 140.9 thousand hectares, south Sool with an area of 113.6 thousand hectares, south Awdal with an area of 79.6 thousand hectares, north Galguduud with an area of 45.2 thousand hectares, north Bari with an area of 20.8 thousand hectares, and south Nugaal with an area of 11.4 thousand hectares. In addition, part of Sanaag and Hiiraan was slightly

harmful by Desert Locust for 5.6 and 0.7 thousand hectares, respectively.

The comprehensive analysis showed that, in July 2020, the Desert Locusts in Somalia will continue to breed. It is estimated that from July to August, the Desert Locusts in southwestern Yemen will move across the Gulf of Aden to northwestern Somalia, and the locusts in eastern Ethiopia will spread to central Somalia. Meanwhile, the locusts in

Somalia will migrate along with the southwest monsoon towards the summer breeding district located on the Indo-Pakistan border. The period from July to August coincides with the important growing or harvesting season in Somalia. If not effectively controlled, the locust plague will continue to erupt, which may cause a heavy blow to agricultural and animal husbandry production in Somalia.

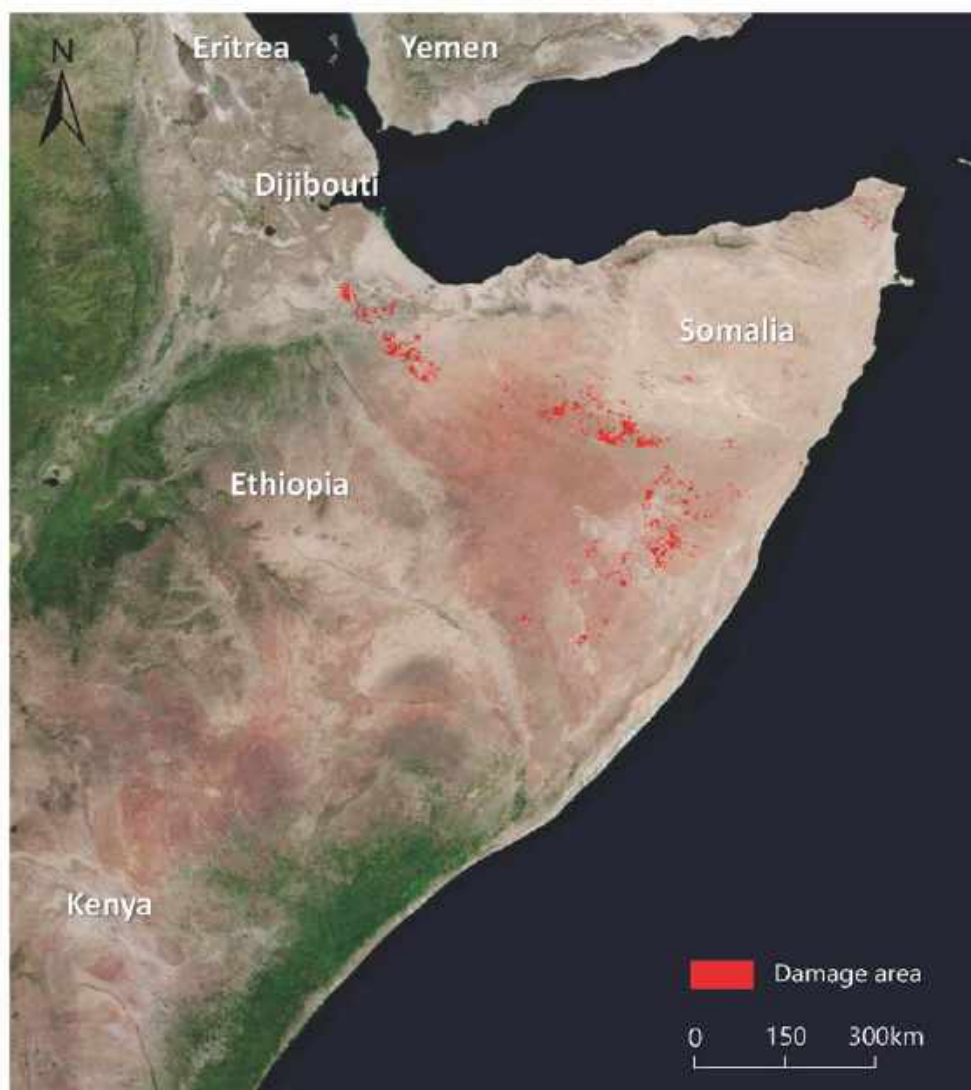


Figure 8 Monitoring of Desert Locust damage in Somalia (2020 June)

Monitoring and assessment of Desert Locust in Yemen

In early May 2020, the Desert Locusts of Yemen were scattered on the southern coast and the central region. Subsequently, the locusts continued to multiply and spread, and formed multiple mature locust colonies by the end of May. There were also locust colonies on the west coast of Yemen. The locusts continued spring breeding locally in June, continuing to incubate to form new locust groups. The locust groups on the west and southwest coasts continue to expand. Some locust groups move southward to northeastern Ethiopia. At the end of June, locusts along the Red Sea continued to breed and form new locust swarms.

The results showed that by the end of June, Desert Locust in Yemen harmed about 763.5 thousand hectares of vegetation area (including 143.8 thousand hectares of cropland, 47.9 thousand hectares of grassland, and 571.8 thousand hectares of shrub), accounting for 14.3%, 8.3% and 10.1% of the total cropland, grassland, and shrub, respectively. The harmed areas are mainly located in eastern Ta'izz with an area of 215.5 thousand hectares, western Amran with an area of 101.7 thousand hectares,

northwestern Lahij with an area of 81.7 thousand hectares, middle and southern Dhamār with an area of 74.2 thousand hectares, middle and western Ibb with an area of 62.5 thousand hectares, most of Ad-Dāli with an area of 59.0 thousand hectares, eastern Al-Mahwīt with an area of 30.3 thousand hectares, eastern Hajjah with an area of 26.3 thousand hectares, southern Hadramawt with an area of 24.3 thousand hectares, southern Al-Baydāwith an area of 23.3 thousand hectares, western San'āwith an area of 23.0 thousand hectares, western Abyān with an area of 17.5 thousand hectares, and southern Al-Mahrah with an area of 10.3 thousand hectares. The affected areas in middle Ma'rib, western Al-Jawf, southern Shabwah, southern Raimah, eastern Adan, and Al-Hudaydah are relatively small, with affected area of 4.5, 3.6, 2.6, 2.5, 0.4, and 0.3 thousand hectares, respectively (Figure9).

The comprehensive analysis showed that, in July 2020, locusts in Yemen will continue to breed. The locust swarms in southwest Yemen will move across the Gulf of Aden to northwestern Somalia and northeastern Ethiopia. The period from July to August is the important growing or harvesting season of crops in Yemen. If not effectively controlled, the locust plague will continue to erupt, which

may cause a heavy blow to agricultural and animal husbandry production in Yemen.

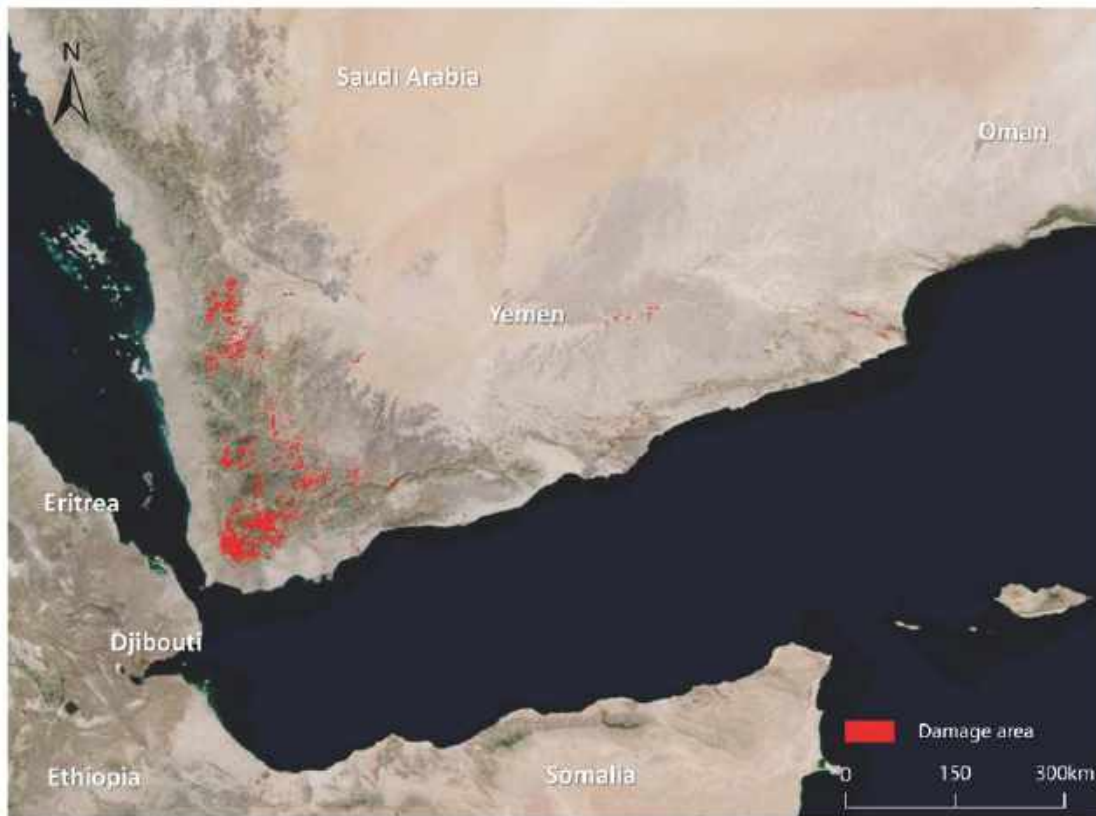


Figure 9 Monitoring of Desert Locust damage in Yemen (2020 June)

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Mission statements: As the science and knowledge service, the Sino-UK Crop Pest and Disease Forecasting & Management Joint Laboratory is to support independent evidence for crop monitoring.

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Desert Locust monitoring and forecasting

Early August 2020

Desert Locust Monitoring and Loss Assessment in Three Southwest Asia Countries

Overview

Integrated with multi-source Earth Observation data, e.g. meteorological data, field data, and remote sensing data (such as GF series in China, MODIS and Landsat series in US, Sentinel series in EU), and self-developed models and algorithms for Desert Locust monitoring and forecasting, the research team constructed the 'Vegetation pests and diseases monitoring and forecasting system', which could regularly release thematical maps and reports on Desert Locust.

This report focuses on the dynamic update of Desert Locust monitoring and loss assessment in Pakistan, India, and Nepal. The results showed that, in July 2020, Desert Locust in Pakistan newly harmed about 628.3 thousand hectares of vegetation area, Desert Locust in India newly harmed about 957.7

Content

| | |
|--|---|
| Overview | 1 |
| Monitoring and assessment of Desert Locust in Pakistan | 2 |
| Monitoring and assessment of Desert Locust in India | 3 |
| Monitoring and assessment of Desert Locust in Nepal | 5 |
| Contact us | 8 |

thousand hectares of vegetation area. Since Desert Locust invaded Nepal on June 26, 2020, it has harmed about 70.1 thousand hectares of vegetation in the territory. At present, locusts in the summer breeding area on the Indo-Pakistan border continue multi-generation breeding. It is expected that the first generation of summer locust swarms will be formed in mid-August and the second generation of locust swarms will be formed in September. The density of locusts in Nepal is relatively low and is not expected to cause major damage. The period from August to

September coincides with the important crops growing season or harvesting season in Pakistan and India. If not properly controlled, locusts will bring a major threat to agricultural and pasture production. It is necessary to continue the monitoring and early warning of the intercontinental Desert Locust plague, and organize joint prevention and control in multiple countries, ensuring the safety of agricultural and pasture production, as well as regional stability.

Monitoring and assessment of Desert Locust in Pakistan

In July 2020, desert locusts in southwestern Pakistan continued to migrate to the summer breeding area on the Indo-Pakistan border. There were still a small number of locust swarms in the southwest Pakistan, and the desert locusts on the Indo-Pakistan border hatched and reproduced in large numbers. Meanwhile, locusts in Somalia moved to the Indo-Pakistan border for summer breeding. The number of locusts continues to increase, and the size of locust swarms continues to grow.

The results showed that, by the end of July 2020, Desert Locust in Pakistan newly

harmed about 628.3 thousand hectares of vegetation area, including 340.5 thousand hectares of cropland, 287.8 thousand hectares of grassland, accounting for 1.3% and 3.0% of the total cropland, grassland in Pakistan, respectively. Among them, Sindh Province has the largest damaged area of 442.4 thousand hectares; followed by Punjab, with damaged area of 143.1 thousand hectares; while Baluchistan Province has the least affected areas, with damaged area of 42.8 thousand hectares (Figure 1).

The comprehensive analysis showed that, in August 2020, the number of locusts in southwestern Pakistan will decrease, and locust swarms in Nepal and northern India returning to the Indo-Pakistan border will continue hatching and breeding. The number of locusts on the Indo-Pakistan border will increase. It is expected that the first generation of summer locust swarms will form in mid-August, and the second generation of summer locust swarms will form in September. August to September is the important growing season or harvesting season of crops in Pakistan. If the locusts couldn't be controlled effectively, the locust plague will continue, which may bring a heavy blow to the agricultural production in Pakistan.

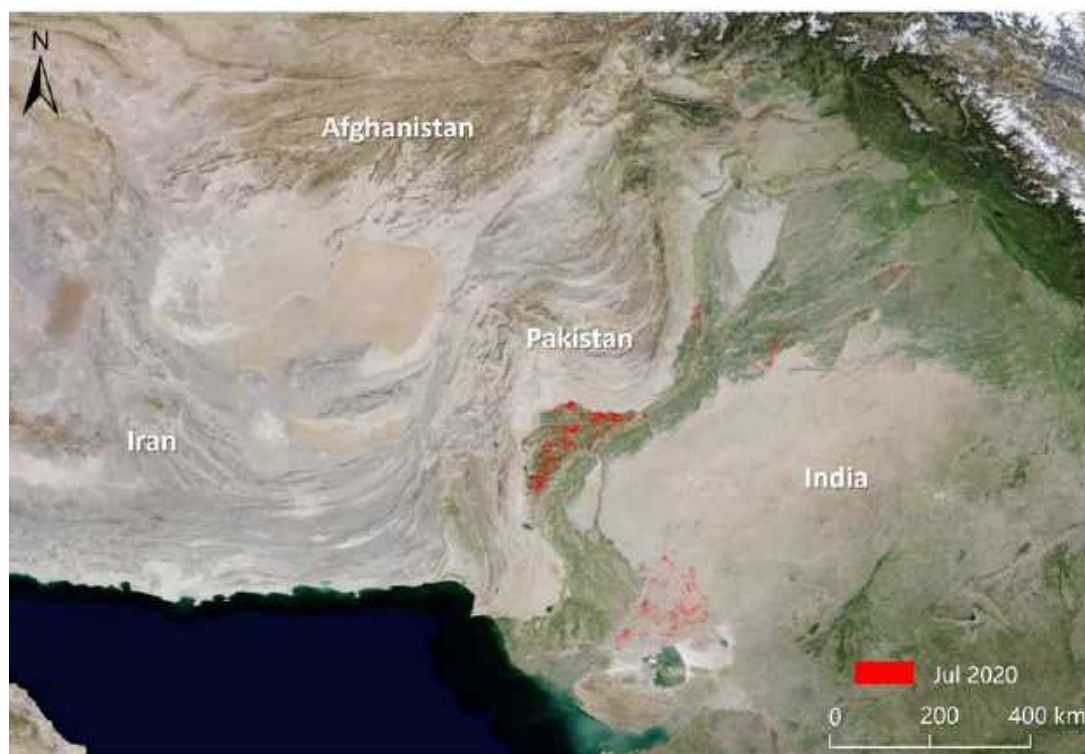


Figure 1 Monitoring of Desert Locust damage in Pakistan (July 2020)

Monitoring and assessment of Desert Locust in India

In July 2020, the Desert locusts that migrated from southwestern Pakistan to western India continued to hatch and their populations continued to increase. The locusts continued summer breeding and continued to extend eastward to the northern states of India. A small number of locust swarms migrated to southern Nepal. In mid-to-late July, locust swarms in Nepal and northern India returned to western India.

The results showed that, by the end of July 2020, Desert Locust in India newly harmed about 957.7 thousand hectares of

vegetation area, including 510.7 thousand hectares of cropland, 246.5 thousand hectares of grassland, and 200.5 thousand hectares of shrubland, accounting for 0.3%, 0.5%, and 1.1% of the total cropland, grassland, and shrubland in India, respectively. Among them, Rajasthan has the largest damaged area of 643.9 thousand hectares; followed by Haryana, with damaged area of 120.6 thousand hectares; while Madhya Pradesh, Uttar Pradesh, and Gujarat have less affected areas, with damaged area of 92.0, 75.1, 26.1 thousand hectares, respectively (Figure 2).

In this study, Planet data with a spatial resolution of 3 m in July 2019 and July 2020

were also used to monitor the Desert Locusts damage in heavily affected vegetation areas in central Rajasthan, India (Figure 3). The study area is located in the central region of Rajasthan, about 73 km to the west of Jodhpur and about 59 km to the southeast of Bealva. The vegetation types include grassland, shrubland, and cropland, with a total area of 29.0 thousand hectares, including cropland 12.8 thousand hectares, 14.6 thousand hectares of grassland, and 1.6 thousand hectares of shrubland. The monitoring results showed that, the affected area of vegetation in the study area was 3.6 thousand hectares, accounting for 12.4% of the total area of the study area. Among them, the grassland was affected the most severely with 1.6 thousand hectares, while the affected cropland is 1.5 thousand hectares and shrubland is 0.5 thousand hectares, accounting for 11.0%, 11.7%, and 31.3% of

the total area of grassland, cropland and shrubland in the study area, respectively. The results show that Desert locusts can cause great loss to vegetation, and its outbreaks will seriously affect the agricultural production and food security in India.

The comprehensive analysis showed that, in August 2020, locust swarms in western India will continue hatching and breeding, and the number of locusts will increase. It is expected that the first and second generations of summer locust swarms will be formed in mid-August and t September, respectively. August to September is the important planting season, growing season, or harvesting season of crops in India. If the locusts couldn't be controlled effectively, the locust plague will continue, which may bring a heavy blow to the agricultural production in India.

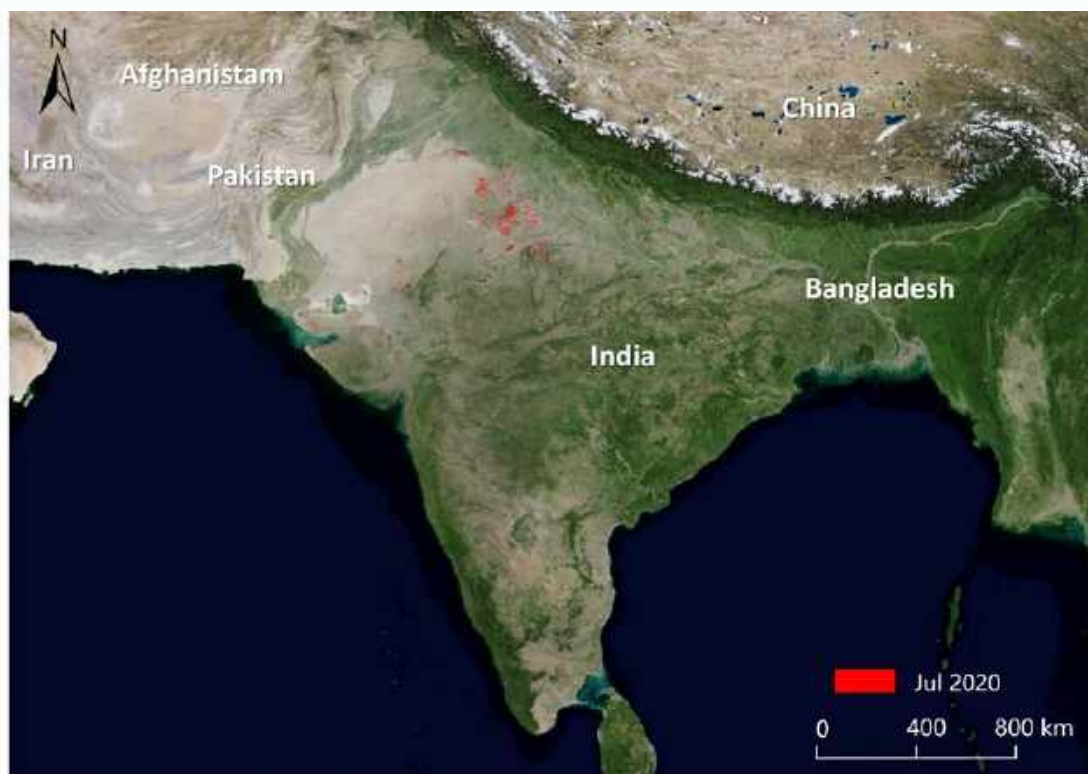


Figure 2 Monitoring of Desert Locust damage in India (July 2020)

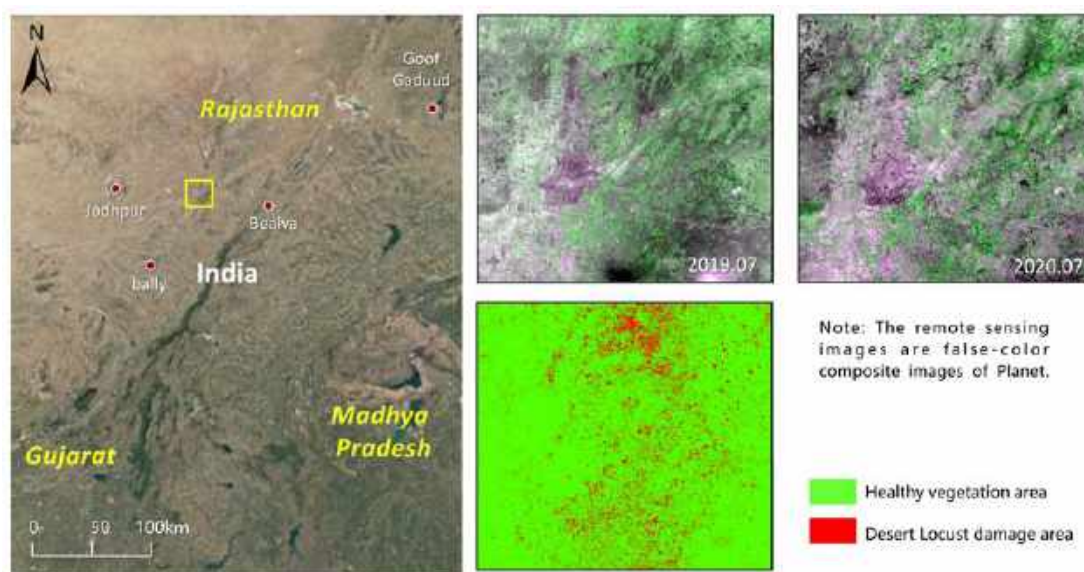


Figure 3 Monitoring of Desert Locust damage in the key damage area of India based on Planet images

Monitoring and assessment of Desert Locust in Nepal

In late June 2020, Desert locusts around the Indo-Pakistan border migrated to northern

India with strong southerly winds and reached the territory of Bhairahawa in southern Nepal on the border with Uttar Pradesh in India on the 26th, and spread in the central lowlands of Nepal. Some locust swarms reached Butwal

and Kathmandu at the foot of the Himalayas on the 27th and 30th respectively. In early July, affected by the southerly wind, locusts on the border between India and Pakistan continued to migrate to Nepal and reached the central plains of Nepal. In mid-to-late July, the locust swarms in Nepal returned to the Indo-Pakistan border.

Monitoring results showed that, by the end of July 2020, Desert Locust in Nepal harmed about 70.1 thousand hectares of vegetation area, including 59.0 thousand hectares of cropland, 7.1 thousand hectares of grassland, and 4.0 thousand hectares of shrubland, accounting for 1.5%, 0.5%, and 0.3% of the total cropland, grassland, and shrubland in Nepal, respectively. Among them, Lumbini District has the largest damaged area

of 23.3 thousand hectares; followed by Narayani District, with damaged area of 19.4 thousand hectares; the third is Rabuti District with damaged area of 13.8 thousand hectares; while Janakpur, Bagmati and Perry have less affected areas, with damaged area of 10.9, 1.4, 1.3 thousand hectares, respectively (Figure 4).

The comprehensive analysis showed that, in August 2020, due to the increasing population in the summer breeding area on the Indo-Pakistan border, a small number of locust swarms will migrate to southern Nepal, which is not expected to cause major damage. However, continuous monitoring is still needed to prevent desert locusts from invading Tibet and other regions of China with the south wind.



Figure 4 Monitoring of Desert Locust damage in Nepal (July 2020)

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Mission statements: As the science and knowledge service, the Sino-UK Crop Pest and Disease Forecasting & Management Joint Laboratory is to support independent evidence for crop monitoring.

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