Food and Agriculture Organization of the United Nations

Good practice fact sheet
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# ELOCUST3:
# AN INNOVATIVE TOOL FOR CROP PEST CONTROL

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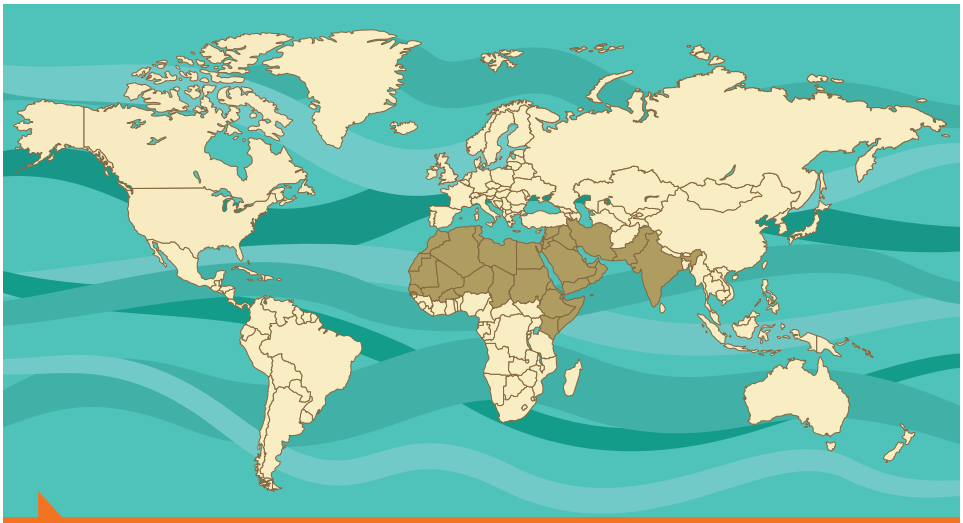
## Objective

This good practice fact sheet aims to share the experience and technology behind eLocust3, a highly effective data recording and transmission system for crop pest monitoring. The document highlights the system's innovative features and the lessons learned from the process of product development. It also sets out to explore how this technology, currently being used with considerable success as a detection and early warning tool for Desert Locusts, could be adapted and replicated to monitor other crops pests, both migratory and sedentary.

## Geographical coverage



Map showing location of desert locust affected countries. (© Fernandez H.Alejandro)

The area includes 19 frontline countries in West and Northwest Africa, East and Northeast Africa, Arabia and Southwest Asia, and other countries that may be invaded in the case of a major outbreak.

## Introduction

The Desert Locust is considered the world's most dangerous migratory pest species. It threatens people's livelihoods, food security, the environment and economic development. A single outbreak can affect as many as 65 of the world's poorest countries, and up to 20 percent of the Earth's land mass.

An innovative technology developed by FAO and partners is helping to improve early warning by enabling rapid detection of locust outbreaks and green vegetation likely to become sites of locust infestations. Released in 2014, eLocust3 is a tried and tested data recording and transmission system, suitable for difficult and remote locations where monitoring is a challenge. The device consists of a robust tablet and custom designed software, which enable field staff to gather data and transfer it in real-time via satellite from the field to their national locust centres, before transmission to the Desert Locust Information Service (DLIS) at FAO Headquarters in Rome. eLocust3 is the latest update to the eLocust series, which has proved effective in early warning and preventive control in locust-affected countries.

Information obtained via eLocust3 is used to assess the current situation, forecast its development and warn locust-affected countries and the international donor community of likely locust invasions and plagues. Designed for use in areas with no Internet connection, the device is suitable for monitoring large expanses of inaccessible territory. A navigation feature enables locust survey and control teams to pinpoint and find their way to areas of green vegetation and potential locust infestations.

This tool, based on new advances in technologies, could be adapted and replicated for other migratory or sedentary crop pests as a way of monitoring pest levels and implementing more timely control, as needed.

**From eLocust1 to eLocust3** One of the main challenges facing FAO's Desert Locust Information Service (DLIS) has been to collect and send information from remote locations to decision-makers in good time. Up until 1995, DLIS had to manage all data received from frontline countries using paper and pencil. Information from the field was recorded on forms, which were submitted to Rome by telex, fax, and later email, often several weeks later. Rome staff would then plot the data on maps, using coloured pencils and transparent paper. In the mid-1990s, the development of GIS – which enabled users to enter data and see the results on a map – and GPS – which allowed that data to be spatially referenced – opened up new opportunities. In 2000, FAO distributed a hand-held PSION data logger to several locust affected countries. Field staff could enter data into the device and see it on a map. This was eLocust1 and represented a significant step forward. However, users had to physically connect the PSION to a GPS in order to obtain geo-referenced data and those had to be downloaded from a computer, thereby causing long delays in transmission of information to decision-makers.

In 2006, eLocust1 was upgraded to a hand-held unit with the ability to record geo-referenced data and transmit it by satellite via a small antenna that was placed on top of a 4X4 vehicle. This was eLocust2 and made real-time data available for the first time, in both English and French. Overnight, this system revolutionized the early warning and preventive control strategy to manage Desert Locusts, enabling rapid transmission of locust sightings and control results to national decision-makers and FAO forecasters. For the first time, National Locust Control Centre (NLCC) heads could see the real-time position of their teams in the field on a map. The system was used for 8 years.

In 2012, DLIS started developing eLocust3, FAO's latest update of the programme. Based on a robust tablet, which could withstand sun glare, dust and high temperatures, and specially programmed software, the device had a built in GPS and battery, so the operator could move away from the vehicle and still record and transmit data. This version added Arabic to the other two languages. It can record and transmit nearly double the volume of data as its predecessor and has a larger colour screen, so that staff can see satellilte imagery and visualize vegetation. In addition to its primary function as a data recording and transmission device, eLocust3 is a reference, training and navigation tool. The tablet supports a digital reference library of valuable material, including technical information on Desert Locusts, guidelines for conducting field operations, owners' manuals for sprayers and other equipment, photographs of locusts and training videos for use of the device. More flexible than its predecessors, the eLocust3 platform offers many advantages and is expected to be in operation for 10 years.

# Methodological approach

FAO's Desert Locust Information Service (DLIS) has been keeping countries informed with situation assessments and forecasts, supplemented by updates, alerts and warnings to prevent Desert Locust plagues since 1978.

The launch of the eLocust system in 2000 introduced significant changes in operating methods, and in the impacts produced on the ground, harnessing hand-held computer tablets, global positioning systems (GPS), geographic information systems (GIS), email and satellite-based rainfall estimates and greenness maps. This approach increases the timeliness and accuracy of the data transmitted, so that interventions can be organized more rapidly and major crop loss averted.

Valuable data collected, recorded and transmitted by eLocust3 – the latest version of the eLocust system – is the fundamental baseline for all decision-making in locust affected countries. It provides the foundation for early warning, forecasting and a preventive control strategy.

eLocust3 is operating in all 19 frontline countries that are vulnerable to Desert Locust infestations and require regular monitoring. The system continues to be expanded to invasion countries – which are not vulnerable to locust infestations per se, but may be threatened by a cross-border spread of Desert Locusts from another country. This figure varies, but worldwide there may be 20 or more invasion countries.

# How eLocust3 works

The eLocust system is the tool used by national survey and control officers in all locust affected countries for recording field observations during survey and control operations. eLocust3 is based on a hand-held tablet, into which users log details about habitat, vegetetation, soil, rainfall, locusts, control and safety before transmitting the data in real time by satellite to that country's National Locust Control Centre (NLCC). All frontline countries affected by Desert Locusts have a centralized NLCC, responsible for monitoring their territory. Data from each country is collated into a single file and sent by email on a daily basis to the Desert Locust Information Service (DLIS) at FAO Headquarters in Rome.

eLocust 3 kit (© FAO )

DLIS maintains a global perspective and keeps countries regularly informed, providing assessments, forecasts, updates, alerts and warnings to prevent Desert Locust outbreaks from escalating. At FAO Headquarters, the data are checked and corrected before being imported into a custom designed global GIS, called SWARMS. This is used to analyse the field data in combination with satellite imagery, indicating rainfall and green vegetation, locust development and trajectory models, and historical records dating from 1930.

Although data logging and transmission is the primary purpose of eLocust3, the device also provides access to satellite imagery in remote locations. This can help users to navigate in difficult conditions, such as a desert landscape. In addition, the tablet uses remote sensing to display satellite images and locations for changing vegetation. This enables a locust officer to carry out a more targeted survey in a large area, with substantial benefits in terms of time and cost savings and more effective early warning and preventive control.

After extensive testing, the hardware selected for eLocust3 is the Panasonic Toughpad FZ-A1 tablet, with custom designed software supplied by Novacom Services and navigation software delivered by Trilogis Srl.

### The Desert Locust (Schistocerca gregaria)

There are many species of locust, but the Desert Locust is the most dangerous and destructive. Desert Locusts reproduce rapidly, and under particular environmental conditions, such as unusually heavy rains, can change both their appearance and behaviour, transforming from a harmless individual to part of a collective mass of insects that form a swarm.

Desert Locusts are particularly problematic because of the ability of swarms to fly rapidly, crossing continents and seas, destroying a farmer's field and entire livelihood in a single morning.

A single adult can consume roughly its own weight in vegetation (approximately 2 g) per day. Desert Locusts are polyphagous, feeding on leaves, shoots, flowers, fruit, seeds, stems and bark. They eat nearly all plants, both crop and non-crop, including millet, maize, sorghum, barley, rice, pasture grasses, cotton and vegetables. A 1 $km^2$ size swarm contains about 40 million locusts, which will devour the same amount of food in one day as about 35 000 people.

Swarms are often hundreds of square kilometres in size. A swarm the size of Bamako, the capital of Mali, would eat the same amount of food in one day as 8.5 million people – the equivalent of half the entire population of Mali.

During quiet periods – known as recessions – solitary locusts are found in low numbers scattered throughout arid areas of North Africa, the Near East and Southwest Asia. This recession area, of approximately 16 million $km^2$, includes about 25 countries.

The largest Desert Locust outbreak in recent years occurred in West and Northwest Africa, between October 2003 and May 2005, affecting 24 countries. Some 13 million hectares were sprayed with 13 million litres of pesticides and huge amounts of food aid were mobilized. Harvest losses were valued at up to US$2.5 billion, with a disastrous effect on food security. In Mauritania, one of the countries affected, 80 percent of heads of household went into debt because of the locust problem – either crops were eaten, or their agribusinesses were destroyed.

Colour differences between swarming (black and orange) and solitary (green) desert locust ©FAO

## Validation

Locust survey and control officers at national centres and at FAO Rome Headquarters report that data is now transmitted in real time, representing a dramatic improvement on previous delays. National officers also report that they are able to collect approximately 80 percent more data than with eLocust2, including more details on habitat, vegetation species, locust types, control operations and safety precautions during treatment. Data loss during transmission – an inevitable side effect with satellite transmission – is considerably reduced compared with eLocust2.

Testing of both the eLocust3 tablets and software used in them was extensive, conducted by the developers themselves, by FAO technical staff and by beta testers in-country, before the refined and validated final version was released. In the case of eLocust3, nearly 7 months were spent testing the hardware. Software field testing took a further 8.5 months.

# Impact

The development of eLocust3 has succeeded in producing a system that records observations and makes them rapidly available to decision-makers and forecasters. The system now forms the bedrock of the preventive control strategy adopted by affected countries and FAO to reduce the frequency, intensity and duration of devastating Desert Locust plagues.

Impact on crop loss is hard to measure, partly because it is not possible to attribute all crop loss to Desert Locusts. However, evidence strongly suggests that Desert Locust outbreaks have been prevented from escalating into plagues (see Box). eLocust3 has yet to be tested in a major emergency situation, though six significant outbreaks recorded since 2013 were all contained, before they could grow or spread.

Locust survey and control teams use eLocust3 3D software to navigate directly to areas of green vegetation and potential locust infestations. In this way, the vast areas of the desert that need to be checked can be targeted and prioritized.

This eLocust approach offers benefits in efficiencies of cost and timing. More accurately timed and targeted pest application results in the use of smaller quantities of chemicals, and less of an impact on the environment. It also reduces the cost of treatment. Most importantly, effective preventive control avoids serious crop damage, which is the ultimate goal.

The 2003-2005 emergency in West and Northwest Africa cost US$570 million to bring under control. The annual cost of prevention in the emergency area is $3.3 million. So the money spent in 2003-2005 was the equivalent of 170 years of preventive control.

### A question of scale

Locust plagues do not develop overnight, but generally build up over a period of about one year. There are various phases of locust infestation. The first stage is an outbreak, which might cover the size of a small town. If this is not controlled, it can turn into an upsurge as locusts could infest the entire country and spilling over the borders. If this phase is not controlled, and environmental conditions remain favourable, it may become a plague, which could affect an entire continent. Preventive control is the key to avoiding a plague situation. Prevention relies entirely on early detection and warning, so that the next step can be halted before it has a chance to escalate.

There is evidence to suggest that early detection rates are higher, and that in most cases, these outbreaks can be controlled, probably due to improved monitoring as a result of eLocust3. Figures are difficult to come by, but in 2013 there were 4 outbreaks – in Eritrea, northern Somalia, Sudan and Yemen – and all were detected and controlled. If that had happened several decades ago, it is unlikely there would have been the same outcome. In 2014, there were 2 outbreaks – in Saudia Arabia and Sudan. Both were controlled before they could spread further, but had they done so, it would have meant huge losses.

# Success factors

- The Desert Locust early warning system has evolved greatly over time, going through many different stages and constantly improving. It is important for the system to be flexible and able to respond to changes and requests from end users and decision-makers. It is critical to have buy-in from the countries and the three FAO regional Desert Locust commissions, which must be involved from the beginning.
- The system should be thoroughly tested at different levels, especially by potential users in locust affected countries. This is to ensure that the device will perform as required, in the particular circumstances where it will be used. Effective testing is a long process. Given that the hardware must work in difficult conditions, such as sandstorms and temperatures up to 50 degrees C, the final choice may not be the least expensive. Without sufficient testing, the product will lose credibility and in-country staff will not use it.
- Devices must be user-friendly and ready for use by field staff. Before the launch of eLocust3, the FAO DLIS office in Rome spent six months configuring each tablet, so users would be able to start operating it immediately. This is important both for the user experience and for standardization, making it easier to provide technical support and troubleshooting when the need arises.
- It is important to teach users how to operate the device correctly, so training is essential. For eLocust3, the three FAO regional Desert Locust commissions organized workshops to train master trainers – the locust information officer for each country – in use and maintenance. Each master trainer then trained staff in their own country. Updated training is provided to each officer on an annual basis.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- Training videos can be far more effective than written user manuals. Visual instructions are easier to follow and avoid the need for extensive translation into different languages. The eLocust3 videos rely almost entirely on images, with no narration and use of only a few words when necessary.
- It is important to have enough units available to distribute if needed quickly. The FAO DLIS office has an emergency stock of units ready to be sent out to countries if an outbreak erupts. Using a courier service, these can be sent and mobilized within 48 hours.
- It is recommended that all custom applications and GIS have open standard, open source software, so that everything is adaptable and transferable. With any software development, it is important that FAO remains the owner of the source code so that it can be easily updated in the future. This should be clearly stipulated in the contract.

# Constraints

- A significant challenge is how to maintain well-trained users during calm and dry periods when there is little locust activity and few surveys are undertaken. Continuous refresher training is required, so that locust officers do not forget how to use eLocust3. Care must be taken to store and maintain the equipment properly during the off-season.
- When contracting outside companies, it is a good idea to ask if the same team will oversee the entire project. This ensures continuity and commitment. In eLocust3's case, one of the software developing teams changed and it proved difficult to pick up and establish the same relationship with the new one.
- Given that the Desert Locust preventive control strategy is implemented across a large geographical area, it is crucial that all countries involved contribute with data collection and transmission. Failure of all locust affected countries to provide continuous collaboration will compromise the effectiveness of the system to provide meaningful, accurate and timely early warning.
- The specific configuration and distribution of the eLocust3 units to so many different countries created difficulties. This time-consuming operation involved air shipments, custom clearances and confirmation that each national locust control centre had received all its allotted units safely. Cumbersome internal FAO administrative procedures concerning inventory and property transfer posed a further challenge.
- With the switch to data transmission via satellite, countries now had to pay for the data transfer service. This required a paradigm shift on the part of some national decision-makers, although evidence suggests that the service is highly cost-effective and saves substantial sums in avoiding crop losses and large-scale pesticide applications.

# Lessons learned

New technologies offer tremendous advantages, but they must be used and adopted by countries in an effective and coordinated manner.

The benefits of these technologies come at a price, and it is important to work out from the outset how the cost will be met on a regular and sustainable basis. User countries pay for eLocust3 as part of their annual membership contributions to one of three FAO regional Desert Locust commissions.

Software programming contractual arrangements should be flexible. Experience shows that delays and unexpected challenges are inevitable, so finite, timebound contracts are unlikely to work.

Many companies will offer help and support free of charge to non-profit initiatives such as crop pest management – if you only ask. In the case of eLocust3, all companies involved provided some free or discounted services. The navigation application for eLocust3 was developed and supplied free of charge by Italian software company Trilogis Srl., using technology provided by NASA, also at no cost. Panasonic, which supplied the hardware, offered some of its services without payment.

It is advisable to select a well-known, reputable company as a supplier, such as Panasonic in the case of the tablet, so as to ensure future hardware repair or replacement. If the company is smaller or only recently established, it may be out of business in a short amount of time and not there when it is needed.

For eLocust2, FAO worked with a sole partner, Novacom Services, which delivered both the hardware and the software. This has advantages, since the entire contract could be outsourced and managed with one partner. But it also resulted in eLocust2 being a very closed system. There is an inherent risk with a monopolistic turn-key approach, given that a system such as eLocust needs to be able to grow and adapt to changing technologies and user needs. With eLocust3, FAO worked with two main partners for the hardware and software supply. These partners also had to work together. It is important to consider such collaboration as a partnership that is continuous during the lifetime of a project and beyond.

# Sustainability

It is critical to provide training, and update it on a regular basis. The training-of-trainers approach is probably the most effective, but it is essential to ensure that master trainers are trained properly in the beginning, and then on a regular basis through refresher workshops. The cost is covered by the countries through the FAO regional Desert Locust commissions, which is more sustainable than relying on donors, who may withdraw funding at a later stage. Even countries that were initially reluctant to pay for eLocust3 and training have seen that the outlay is a good investment.


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Ideally, the end users of the project should fall within the framework of a recognized institute. In this case, users were staff of the national locust control centres in plant protection departments within the Ministry of Agriculture of each locust affected country. This approach encourages accountability within the national system and by FAO at national, regional and international levels, and helps to sustain good practices.

The sustainability of the project is ensured also by the affected countries' ownership of the hardware and the data.

The hardware was procured under FAO emergency funds and the asset ownership was subsequently transferred to the national locust control centres within the Ministry of Agriculture of each affected countries.
The software is owned by FAO (Desert Locust Information Service, AGPMM), while the data is "owned" by the locust affected countries, which are ready to share them among each other.

Moreover, the countries are responsible for maintaining the hardware and software in good condition. A national locust information officer have been trained in each country to troubleshoot and solve problems in situ. In case of technical problems with the use of software and hardware cannot be solved in situ, FAO DLIS provides the necessary technical support. If there are hardware problems associated with the tablet or the antenna and cable, Panasonic and Novacom will be informed by FAO DLIS and they will provide a solution or repair the equipment under warranty.

# Stakeholders and partners

## Beneficiary countries

All countries affected by the Desert Locust, including 19 frontline countries and at least 20 invasion countries – though this number may vary – are partners in the project, and specifically their Ministry of Agriculture.

## Regional Commissions

There are three FAO regional Desert Locust commissions, which are administered by FAO with secretariats in Algiers, Cairo and Rome:

- Commission for Controlling the Desert Locust in the Western Region (CLCPRO) – covering Northwest and West Africa
- Commission for Controlling the Desert Locust in the Central Region (CRC) – covering the Red Sea and Arabian countries
- Commission for Controlling the Desert Locust in South-West Asia (SWAC) – covering Southwest Asia

Every country at risk is a member of a commission and pays an annual contribution to fund the secretariat and associated activities. The cost of eLocust3 monthly subscriptions, de/activation fees and data transmission are paid by each Commission's Trust Fund within the framework of a five-year FAO Headquarters contract with

Novacom Services. The requests for activation and deactivation of individual eLocust3 units and payment of monthly invoices is managed by FAO Headquarters. This simplifies administration of the system, as countries are not involved directly.

## Desert Locust Control Committee (DLCC)

In addition, FAO is advised on Desert Locust management, training and information issues by the Desert Locust Control Committee (DLCC), composed of affected countries, donors and other agencies. The DLCC oversees the work of the Commissions and Locust Group, based at FAO Headquarters in Rome.

## FAO's locust and other migratory pest groups

FAO's Locust and Transboundary Plant Pest and Diseases Group (AGPMM), based at FAO Headquarters, monitors Desert Locust activity through its Desert Locust Information Service (DLIS). This publishes monthly bulletins and six-week forecasts, supplemented by alerts, warnings and updates, based on survey and control data supplied by affected countries using eLocust3.

## Partners

**Panasonic:** supplies the tablets to collect data in the field.
**Novacom Services (France):** developed and supplies the software for eLocust3 and it also provides on-going data transimission services.
**Trilogis Srl. (Italy):** developed eLocust3 3D, a custom open source map application that guides users to specific areas where vegetation might be green.
**NASA:** NASA's World Wind Technology was used by Trilogis Srl. to develop eLocust3 3D.

## Donors

Belgium, France, United Kingdom and United States of America.

## Technical specifications

For eLocust3, the system hardware was upgraded to the latest commercially available Android OS rugged 10.1 inch handheld tablet, the Panasonic ToughPad FZ-A1. This tablet addressed the shortcomings of the eLocust2 tablet. It is sealed against water and sand, its colour display is readable in bright outdoor light, and it contains a rechargeable battery, USB connection, removable and expandable storage, built-in GPS, camera and video, connection to external monitors, as well as the possibility of inserting a SIM card. The tablet is a fully operational handheld computer that provides sufficient flexibility to meet future requirements and needs for at least the next decade.

The application is linked to two separate applications, Adobe Reader and eLocust3 3D. Adobe Reader is used for accessing a wealth of reference material that users may need to refer to while they are in the field for surveys and control operations. eLocust3 3D is a custom open source map application that guides users to specific areas where vegetation may be green. The application does not require an Internet connection.

eLocust3 is available in three languages: English, French and Arabic.

# Conclusion

The eLocust system is a good example of how the latest technology can be adapted for practical use in developing countries in the continuing fight against world hunger and food insecurity. eLocust3 represents a revolution in Desert Locust early warning and prevention, giving decision-makers and forecasters access to real-time information from the field. The valuable data collected, recorded and transmitted by eLocust3 is the fundamental baseline for all decision-making in locust affected countries. It provides the foundation for early warning, forecasting and preventive control strategy, allowing intervention to be undertaken in a more efficient and timely matter. There is good scope for adapting and expanding eLocust3 to other pests – either migratory or sedentary – to monitor pest levels and implement rapid control as needed.

The eLocust model is an example of taking the latest technical advances and adopting them for operational use in different countries with a wide variety of multicultural users of different backgrounds, expertise and knowledge. It is important that any system is simple and intuitive to use, that its purpose is clear and straightforward and that it is made available in local languages. The system should also be robust and easy to maintain in local conditions. This requires intense and regular collaboration with users, developers and vendors from the outset of the project and constant support and follow-up once it becomes operational.

# References and resources

### eLocust3 related websites

- FAO Locust Watch - www.fao.org/ag/locusts
- Desert Locust Information Service - www.fao.org/ag/locusts/en/info/info/index.html
- FAO Food Chain Crisis (EMPRES) - www.fao.org/food-chain-crisis/home/en
- Commission de lutte contre le Criquet pèlerin dans la région occidentale (CLCPRO) - www.clcpro-empres.org/
- Commission for Controlling the Desert Locust in the Central Region (CRC) - www.crc-empres.org/
- Commission for Controlling the Desert Locust in Southwest Asia (SWAC) - www.fao.org/ag/locusts/swac/swac-home/en
- Novacom Services - http://geoflex.novacom-services.com/flex-gen/NovacomGeneric.html
- Trilogis (eLocust3 3D) - www.trilogis.it/?s=elocust3
- NASA World Wind - worldwind.arc.nasa.gov/
- Panasonic - www.panasonicforbusiness.com/2014/12/rugged-toughpad-tablets-aid-in-u-n-s-innovative-locust-watch-project/
- Training videos for eLocust3 - www.youtube.com/playlist?list=PLjxRk5CAwvG_0iFxjZ5C2fLByF3jhvHOx
- Masters training workshop on eLocust3 - www.fao.org/ag/locusts/en/publicat/meeting/topic/2100/2175/documents_2176.html

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