Climate Change and Desert Locust
An overview of analytical tools

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FAO has developed three important tools to help countries face the emerging issues of climate change and their potential effects on Desert Locust. In 2000, FAO developed the RAMSES custom geographic information system (GIS) to allow national locust information officers in nearly two-dozen frontline countries to manage and analyze ecological, weather and locust data, including survey and control data. The system is currently being re-written and upgraded to take advantage of the latest advances in open-source software and spatial database technologies so that it is more powerful yet easier to use. In 2005, FAO developed eLocust2, a handheld device to record field observations during locust survey and control operations and transmit this data via satellite in real time to the respective national locust control centre for further analysis. Nearly 400 devices are in use in locust-affected countries. This data is the foundation of preventive control and is used in FAO's Desert Locust early warning system for assessment, forecasting, planning and alerts. The software and hardware of the system were upgraded in 2014 to allow additional data and photos to be collected and recorded. In 2009, FAO developed the Desert Locust Contingency Planning Assistant (DeLCoPA) to help national locust control programmes to be better prepared for coping more effectively with Desert Locust emergencies. It provides guidance to identify and mitigate constraints, gaps or operational weaknesses. Additional tools are planned to further assist countries in assessing their strengths and vulnerabilities in managing Desert Locust infestations under a variety of climate change scenarios. At the global level, FAO's Desert Locust Information Service integrates these three tools into the SWARMS GIS for managing and analyzing spatial data in order to operate the Desert Locust early warning system.

1. eLocust

eLocust data represents the foundation of FAO's Desert Locust early warning system - the oldest migratory pest monitoring and early warning system in the world. The data are used for assessing the current situation, forecasting its developments and planning an effective response at all levels.

All frontline countries affected by Desert Locust have a centralized national locust control centre (NLCC) within their Plant Protection Department in the Ministry of Agriculture that is responsible for monitoring their territory through regular field surveys and undertaking control operations when required. eLocust2 is the *de facto* system used by national survey and control officers in all locust-affected countries for recording field observations during survey and control operations and transmitting data by satellite in real time to NLCCs and the Desert Locust Information Service (DLIS) at FAO Headquarters. DLIS maintains a global perspective and is responsible for monitoring habitat conditions and locust infestations on a 24/7 basis from West Africa to India. Since 1975, DLIS has been keeping countries informed by issuing monthly bulletins that summarize the current situation and forecasts developments six weeks in advance. The Bulletins are supplemented by updates, alerts and warnings so that affected countries and international donors have time to respond in an effective manner in order to prevent Desert Locust plagues. The latest technologies (email, Internet, social media) are used for this purpose.

The handheld eLocust unit transmits data by Inmarsat to the respective NLCC via the service provider, NOVACOM, in Toulouse, France. The data arrives at the NLCC by email within a

matter of minutes after transmission. eLocust data for the previous 24 hours are collated into a single file that is sent by email to NLCCs in the early hours of every morning. The data are imported into a custom geographic information system (RAMSES) used by each NLCC. At least one nationally designated locust information officer is responsible for managing and analyzing the field data, preparing maps of the locust situation and issuing monthly bulletins. They also export the data from RAMSES and immediately send it by email to FAO DLIS. In Rome, the data are checked and corrected before importing into a custom global GIS (SWARMS) that is used to analyze the field data in combination with satellite imagery indicating rainfall and green vegetation, locust development and trajectory models, and historical records dating from 1930 to assess the current situation and forecast the location timing and scale of locust breeding and migration.

The current eLocust2 system was developed in 2005 by FAO and NOVACOM, the commercial branch of the French Space Agency CNES. This was preceded by an initial proof-of-concept system in 2000. At that time, eLocust2 was a significant advancement because, for the first time in history, decision-makers had access to real time data from some of the remotest areas on Earth thanks to data transmission via satellite. They could also monitor the position and work of the field teams. Furthermore, countries could easily manage large volumes of data associated with increased locust activity without the need to recruit additional staff. Nevertheless, a number of shortcomings became apparent over time such as hardware and software obsolescence, inadequate cables, no battery or GPS, non-expandable memory, a lack of Arabic, mapping, photographic and upgrading capabilities, and limited ability to record all the required data collected during survey and control operations in the field. The objective of the eLocust2 upgrade to eLocust3 was to address and resolve all of these shortcomings.

The hardware of the system was upgraded to the latest commercially available Android OS rugged 10.1 inch handheld tablet, Panasonic ToughPad FZ-A1. The tablet is completely sealed so that dust and water cannot penetrate its components. The display is the best available (late 2012) in terms of readability under bright outdoor conditions common during Desert Locust field operations. The tablet also addresses other shortcomings of the smaller eLocust2 Wescor tablet in that it contains a rechargeable battery, USB connection, external storage (micro SD card), built-in GPS, camera and video, and connection to external monitors or projection equipment (for training) as well as possibility for a SIM card. The tablet is a fully operational handheld computer, which extends its versatility and usefulness, and will provide sufficient flexibility to meet future requirements and needs for at least the next decade.

The tablet uses the Android operating system, which experts claim is the most adaptable system for tablet hardware and allows for greater innovation and expansion. The eLocust3 software has been completely rewritten in Java programming language and expanded to include weather, habitat, locust, control and environmental safety data that could not be recorded previously in eLocust2. The application is available in three languages (English, French, and Arabic); whereas, eLocust2 was only in English and French. The application is linked to two separate applications, Adobe Reader and eLocust3 3D. Adobe Reader is used for accessing a wealth of reference material (FAO Desert Locust Guidelines, Standard Operating Procedures, vegetation and locust ID cards, equipment manuals, etc.) in the three languages that users may need to refer to while in the field during survey and control operations. Locust officers now have access to a multilingual digital library while in the field.

elocust3 3D is a custom open source map application that guides users to specific areas where vegetation may be green. The latest high-resolution (250m) MODIS-derived dynamic greenness map as well as the latest satellite-based rainfall map can be displayed on top of a static background map such as a Landsat image or a road map. The position of the user is indicated on the map and is updated when moving in the field. Multi-touches are used to zoom in/out and title the image similar to Google Earth. The application is revolutionary because it does not require an Internet connection. It is extremely powerful yet very easy to use. eLocust3 3D is an example of adopting the latest cutting edge technology for use in the

developing world. The application was developed for FAO at no cost by Trilogis S.r.L. (Italy) and incorporates NASA's World Wind technology.

The eLocust3 application allows users to take photos at the location of the survey or control operation that are automatically geo-referenced and can be accessible on the Internet. Photos of habitat conditions and locust infestations are a very good method of supplementing field observations and data.

The eLocust3 system addresses another major shortcoming of the eLocust2 system, that is, the number of cables required to connect the hardware devices. This has been achieved by utilizing Bluetooth (BT) technology to connect the tablet to the antenna for data transmission in real time by satellite. Consequently, only one cable is utilized that powers the antenna from the vehicle cigarette lighter plug. This cable includes a BT adaptor. The antenna itself no longer must sit atop the vehicle but can reside discreetly inside on the dashboard.

The eLocust3 system improves the quality and completeness of data recorded and transmitted by the tablet. This is done through a complex set of logic checks and mandatory data fields that must be realised before data can actually be transmitted by satellite.

The eLocust3 system is compatible with the latest generation of INMARSAT telecommunication satellites that were launched last year; whereas, eLocust2 was incompatible. This means that eLocust2 will cease to transmit data after 2014 when the previous generation of satellites are decommissioned. Therefore, it was obligatory to upgrade eLocust2 to eLocust3 in order not to disrupt data flow from the field to national locust centres and FAO. Data transmission has been improved substantially under the latest INMARSAT satellite and, as a result, very little data are lost or corrupted during transmission compared to the previous satellite.

There are a number of very sophisticated technologies that have been incorporated into eLocust3. Many of these technologies were just released and had not been utilized before by FAO or locust-affected countries. Therefore, considerable time was required to identify and to become familiar with these technologies, formulate them into the project, incorporate them into eLocust3, and test and validate each component under real field conditions before the development phase of the project could be concluded. It was not possible to indicate all of the technologies and associated requirements at the beginning of the project prior to the programming phase. Consequently, development and testing took longer than originally anticipated at the onset. A more flexible approach was partially adopted that allowed changes to be made during the development and testing phases in order to minimize further delays. This helped to address additional changes that locust-affected countries requested at the last moment and to resolve new issues that appeared during the testing of the software and hardware. NOVACOM delivered a prototype version to DLIS in month 6, followed by more than a dozen beta versions that were tested over the next eight months in Rome and in several countries under field conditions to obtain feedback from potential users. Although these factors delayed delivery of the final product, it did result in an exceptionally good and fully tested final product that should be more robust and reliable, meet the users' needs better, and have a longer operational life.

Phased development

In early 2012, a Desert Locust outbreak developed in Northwest Africa and spread to West Africa. This was an opportunity to address the shortcomings of eLocust2 and upgrade it. Consequently, it was agree that a portion of the emergency funds from FAO and international donors could be used for this purpose since the associated costs exceeding regular programme funding. By the end of the summer, sufficient funding had been obtained to commence the project.

The development project consisted of five distinct phases – preparatory, hardware, software, deployment and training – and lasted just over two years, from 1 June 2012 to 1 July 2014.

During the preparatory phase (152 days), the various options of upgrading eLocust2 were examined, potential funding sources were identified, different hardware, software and transmission possibilities were explored and, finally, the hardware manufacturer and software developer were selected. Most of the time was spent on examining, exploring and testing various options before making the final decision.

During the hardware phase (193 days), DLIS first evaluated all rugged tablets that were commercially available in late 2012 on their processor, memory, storage, display, size, battery, camera, GPS, communications, and ports. From the initial screening, several tablets were selected that met the minimum requirements and manufacturers provided DLIS with evaluation models[1]. This allowed DLIS to test the hardware under field conditions with users in Sudan, India, and Libya prior to the procurement process (tender, order and delivery). The final selection, a Panasonic ToughPad FZ-A1, was based on its outdoor readability, ruggedness, and brand name. The evaluation and testing portion of the hardware phase lasted nearly two months while it took 168 days to complete the procurement process.

During the software phase (571 days), the developer NOVACOM was contracted (42 days), version 1 (303 days) and version 2 (145 days) of the custom eLocust3 software was coded. NOVACOM was the preferred developer because of their experience with eLocust2, knowledge of the FAO Desert Locust early warning system and, and service provider for data transmission. This experience and familiarity helped to shorten development time and cost. Throughout the development process, DLIS work closely with NOVACOM to identify and refine the data structure and user interface of eLocust3 based on the requirements of the locusts countries and DLIS. The time spent on testing the custom software and NOVASAT Bluetooth antenna cable was equivalent to half the time spent on programming and coding. Once all remaining bugs were resolved, the final version, eLocust3v25, was delivered on 2 June 2014.

During the deployment phase (118 days), the 375 tablets were pre-configured at FAO in DLIS (30 days) prior to distribution to countries by FAO pouch and DHL. Panasonic provided an engineer, equipment and procedures for batch configuration of the units. The units were distributed first to the Master trainers in each country, followed by country quotas prioritized according to countries who will be first using eLocust3 in the summer, followed by those countries who will start using it after the summer. While it took only a few days for the units to reach the countries, it often took up to several weeks or more for the units to be cleared by customs and delivered to the national locust centre.

During the training phase (120 days), DLIS prepared training videos in English, French and Arabic on the various software and hardware aspects of eLocust3. DLIS conducted an inter-regional workshop to train national Master trainers so they can provide training to the end-users, that is, the national locust officers in their country.

Benefits to member countries

The eLocust system represents a major benefit to all member countries, regardless if they are locust frontline or invasion countries. The system allows data collection, recording and transmission from the field to analysts, forecasters, and decision makers in real time. This is critical when managing a migratory pest such as the Desert Locust that can increase nearly 20-fold every three months and migrate 100-150 km per day and quickly cross continents and oceans. The eLocust system will be used mainly in frontline countries but can be dispatched rapidly to other countries during invasion periods and emergencies.

[1] Processor: 1GHz, memory RAM: 1 GB; storage: 16GB flash; Keyboard: on screen; OS: Android 4.x; Display: 10 inch, multi-touch input, outdoor readable; Weight: 1.0kg or less; Size: 28x2x22cm or less; IP index: IP65; Temp: +60C; Battery: 3.7Ah rechargeable Li-ion; Battery life: 9 hours or more; Camera: 5MP (with video); GPS: built-in; Compass: built-in; Communications: WIFI (b/g/n), Bluetooth (2.1), GSM; Ports (for satellite connectivity): USB, Serial RS232 (optional); Charging: vehicle, AC.

The upgrade to eLocust3 represents yet another milestone. It extends the system's utility by incorporating the three main languages used by locust-affected countries. It improves the quality of the data recorded and its reliable transmission. Photos and videos can be taken to accompany the data and field observations. Additional applications are integrated in eLocust3 to extend its functionality such as guiding survey teams to green vegetation in the field and accessing important references while in the field.

Data recorded and transmitted by eLocust3 are the basis for early warning and preventive control, the strategies adopted by countries and FAO to manage Desert Locust and reduce the frequency, intensity and duration of upsurges and plagues. The eLocust3 upgrade will certainly lead to improved survey and control operations and early warning, thus protecting agriculture, livelihoods and food security.

Distribution and Training

Before eLocust3 could be distributed to locust-affected countries, each unit was pre-configured by AGPMM/DLIS at FAO Headquarters.

DLIS developed self-training materials such as videos, presentations, slideshows and fact sheets distributed through social media (YouTube, Slideshare, Facebook). The training material was translated into French and Arabic.

eLocust3 training was a two-step process. In the first step, three FAO trainers trained 17 national locust information officers as Master Trainers in English, French and Arabic at an inter-regional workshop in May 2014 (Agadir, Morocco). The training concentrated on the use of the tablet, applications and peripheral devices, general hardware and software maintenance, care and troubleshooting in resolving problems as well as how to train users. During the summer, the national Master Trainers will train national survey and control officers in their respective countries who will be using eLocust3. In this way, eLocust3 will be operational in all locust-affected countries in summer of 2014.

Sustainability

All efforts are made to sustain the routine operation, maintenance and training of eLocust3. The trust funds of the FAO regional locust commissions in the western (CLCPRO), central (CRC) and South-West Asia (SWAC) regions cover the data transmission costs as well as minor support costs. Additional financial mechanisms will be identified to cover any additional costs associated with future updates of eLocust3 to extend its functionality as well as support and further development to the custom national geographic information system, RAMSES, used in each country to manage eLocust3 data.

FAO DLIS would like to ensure further sustainability of the global early warning system by migrating all custom applications and GIS to open standard, open-source and to take full advantage of NASA’s World Wind technology. So far, a few initial steps have been taken. Work is under way to redesign RAMSES GIS, shifting it from ESRI ArcView and Microsoft Access to Open Jump and PostGIS. The eLocust3D application uses NASA World Wind. Further efforts are required to migrate SWARMS GIS from ArcGIS to open source and to integrate all of the various systems into a single open standard, open source LocustGIS4D for use at the national, regional and global level that would benefit all stakeholders. For this to become a reality, extra-budgetary funds will need to be identified for 2015-2017.

Publicity

The eLocust3 3D application was featured on an Italian news broadcast, LA7, in January 2014. The eLocust3 system was highlighted as a segment in the prime-time science programme SuperQuark (http://www.superquark.rai.it) on Italian TV (14 August 2014). Panasonic has prepared a business case for eLocust3. National Geographic magazine has

indicated interest in featuring FAO's Desert Locust early warning system including eLocust3 in an upcoming article. eLocust3 3D was a co-winner of the 2014 World Wind Europa Challenge (http://eurochallenge.como.polimi.it/) sponsored by NASA.

2. RAMSES

Forecasting is based on knowledge of the current state and how that state is likely to change in the future. National locust information officers need to know where the locusts are, what they are doing and the types and sizes of the populations. Armed with this information, an understanding of locust biology and behaviour, and knowledge of past events, locust information officers can predict forthcoming events to support decisions on the deployment of resources, such as, insecticide stocks and control teams. The development of locust populations and their movements are closely dependent on environmental factors, so access to information on vegetation and soil conditions, as well as weather and climate data is also important.

Continuity in assessment from one population to the next and from one period of time to the next is crucial. It is also important to be aware of what is happening in neighbouring countries.

Access to information is therefore critical for all locust operations at the national level, and the basis of successful locust operations is information.

The data must be collected, catalogued, filed and presented in a form that complements a locust officer's own knowledge and experience.

The data used come from a variety of sources and include:

- Survey reports from field teams;
- Supplementary local information from officials, NGOs, farmers, nomads, etc;
- Weather data from the local meteorological office;
- Satellite-derived rainfall and vegetation maps;
- FAO Desert Locust Bulletins and Updates;
- Frequency maps of Desert Locust incidence;
- Case Studies of past events; and
- Locust life cycle development models.

Traditionally, locust and associated environmental data have been presented in map form. Geographical information systems (GIS) based on computers are modern powerful tools for storing, transforming and displaying the same sorts of data.

Initial development

In the late 1990s, FAO developed a custom geographic information system (GIS) called RAMSES (Reconnaissance And Monitoring System of the Environment of Schistocerca) to allow national locust information officers to manage, query, display, analyze, and map field and other data.3 RAMSES consists of ArcView 3.x for GIS functionality and MS Access as the database. The eLocust2Mapper export file is imported into RAMSES, where it can be over-laid on remote sensing products such as rainfall estimates (RFE) and MODIS imagery and derived-products such as dynamic greenness maps, and other background reference layers.

National locust information officers in nearly two-dozen frontline countries use the RAMSES GIS to manage and analyze ecological, weather and locust data, including survey and control results in order to assess the current locust situation and determine the need for survey and control operations. Most of the data entered into RAMSES comes from eLocust. Each country exports RAMSES data and sends it to FAO's Desert Locust Information Service (DLIS) in Rome to be imported into the SWARMS GIS used for global monitoring and

forecasting. RAMSES has been updated regularly since it became operational in 2000. The current version is RAMSESv3.

The results of the data summary and analysis are presented in national locust bulletins that are issued every week, 10 days, fortnight, or month, depending on the country and the locust situation. The bulletins are distributed to concerned parties within the locust-affected country, such as national ministries and research institutes, embassies, donors, UN agencies, NGOs, and other relevant individuals and groups. The bulletins are also sent by e-mail to neighboring countries, regional locust organizations, and commissions such as the desert locust Control Organization for Eastern Africa (DLCO-EA), FAO Commissions for Controlling the Desert Locust in the Western Region (CLCPRO), Central Region (CRC), and South-West Asia (SWAC), and to the FAO DLIS. In addition, RAMSES export files containing the corrected survey and control data are sent to the FAO DLIS within five days of the end of the survey or control operation.

Upgrading

There are numerous shortcomings of RAMSESv3. It relies on obsolete commercial GIS software (ArcView) that is no longer supported by the vendor. It uses a database (MS Access) that has reached its technical limitations to manage data. RAMSES has been updated so many times in an ad-hoc manner that every country now has a different database version and format so countries cannot exchange data easily. RAMSESv3 is cumbersome to operate and difficult to update. Lastly, it is not compatible with eLocust3 data.

For these reasons, work started in 2012 to update the system to RAMSESv4, taking advantage of latest GIS advances by using open-source, platform-independent, license-free GIS software, a spatial database, and designing a core system that can be easily updated by developing individual plug-ins, including different languages, specific analytical tools and other functions as desired by countries in the future. Therefore, the upgrading of RAMSESv3 involves completely redesigning and restructuring the entire system. RAMSESv4 will also include a unified database that contains data from all locust-affected countries. While each country will be primarily concerned with its own data, FAO's Desert Locust Information Service (DLIS, AGP) will use the global data set as the basis for the Organization's Desert Locust early warning system. The first release of the operational version is expected by 2015.

3. SWARMS

RAMSES export files received by FAO DLIS from national locust information officers in affected countries are checked for duplicate and incomplete data. The locust information assistant or Senior Locust Forecasting Officer in the DLIS will immediately contact the relevant national locust information officer to clarify any inconsistencies in the data. The data are then imported into a custom GIS called SWARMS (Schistocerca Warning and Management System) that uses ArcGIS 9.3 for GIS functionality and Oracle as the database. SWARMS was developed in the mid-1990s by the FAO in collaboration with the University of Edinburgh and the Natural Resources Institute, United Kingdom. SWARMS contains nearly one hundred years of historical locust data dating to the 1920s.

SWARMS is a platform that allows the forecaster to query, display, compare, and map locust, ecological, rainfall, and historical data. The vector data can be combined with raster data such as daily, decadal, and monthly rainfall estimates, MODIS imagery, and MODIS-derived products and overlaid on to static base maps such as topography, roads, towns, hydrology, and administrative, and political boundaries to better understand the spatial relationship of locust infestations to the environment and to assess the current situation. In order to do this, the forecaster must try to determine the source and scale of initial populations; the timing and scale of migration into the currently infested areas; the timing,

location, scale, and success of subsequent breeding; and the efficacy of survey and control operations. This involves knowing where, when, and how much it rained; the response of annual vegetation to recent rainfall; and the direction of the current and expected winds. Once the current situation is understood, SWARMS helps to identify similar or analogous situations in the past that can be used to predict how the current situation will evolve and develop in terms of the scale, location, and timing of breeding and migration. Much of this portion of the analysis depends on the experience and intuition of the locust forecaster, since there are substantial gaps in the locust, ecology, rainfall, and historical data sets.

The results of the analysis are summarized and presented in a monthly FAO Desert Locust bulletin. The bulletin is written for a wide-ranging audience that includes locust technicians, decision makers, scientists, researchers, administrators, politicians, donors, international development agencies, and the general public. Therefore, the most salient points are presented in one overview paragraph on the front page of the bulletin. On the same page, single-paragraph summaries of the situation and forecast are presented for the three locust regions: western, central, and eastern. On the subsequent pages, ecological and weather conditions are summarized for each region, and country control operations totals are listed. Thereafter, a detailed summary of the current situation and forecast for the next six weeks are presented for each country—some 50 countries in all. A map shows the location of locust infestations, undetected breeding areas, and the six-week forecast. A color-coded banner on top of the first page of the bulletin indicates the perceived risk or threat of current desert locust infestations to crops as green for calm, yellow for caution, orange for threat, and red for danger. Appropriate response actions are suggested for each level. This same system is used on the Locust Watch Internet pages (www.fao.org/ag/locusts). The bulletin is issued in the first days of each month in English, French, and Arabic. FAO DLIS has issued more than 430 monthly bulletins since 1978.

During periods of increased locust activity, FAO DLIS issues submonthly updates every week, 10 days, or fortnight, depending on the situation. When specific threats are detected, FAO DLIS will send locust warnings directly to the concerned authorities in the affected country. If the situation is potentially serious, a locust alert will be issued in English, French, and Arabic and disseminated in a similar manner as the monthly locust bulletins.

FAO DLIS relies on e-mail and the Internet as the mechanisms to provide accurate information, warnings, and alerts about the current locust situation and expected developments to the widest possible audience, as well as to specific target audiences in the shortest amount of time. Locust alerts, updates, and bulletins are distributed by e-mail as a compressed portable document file (PDF) with copies posted on Locust Watch. Social media, such as Twitter and Facebook, are used as another means of sharing and disseminating locust information to a broader audience. For example, FAO DLIS posts short overviews of the latest situation in a particular country as a tweet of up to 160 characters on Twitter, designated by #unfao and #DesertLocust. This is often done within minutes of receiving and confirming field data from the locust-affected country.

4. DeLCoPA

The Desert Locust Contingency Planning Assistant (DeLCoPA) was developed in 2009 to help national Locust Control Units to be better prepared to cope more effectively with Desert Locust emergencies. It provides guidance to identify and mitigate constraints, gaps or operational weaknesses. The process should help to reinforce response and coordination mechanisms and to clarify roles and responsibilities before an emergency. DeLCoPA can help the decision maker to put in place measures that enhance preparedness prior to an emergency developing and to provide a valuable reference document for approaching donors for assistance to respond to the emergency. DeLCoPA is managed by AGPMM (Locust and Transboundary Plant Pests and Diseases (EMPRES)) at FAO Headquarters. Locust Directors, in consultation with the Locust Information Officer and the Campaign Officer, can use DeLCoPA as a management tool. It can be used to identify gaps in

organizational structure, operations, and contingency plans; to perform “what if” scenarios before implementing changes; and as an instructional tool to teach the important aspects of a Desert Locust Unit, its interrelations with other agencies, any why its activities are important.

Further information

FAO Desert Locust early warning system – LocustWatch
www.fao.org/ag/locusts
www.facebook.com/faolocusts
www.twitter.com/faolocust
www.slideshare.net/faolocust

eLocust3 training videos
www.youtube.com/playlist?list=PLjxRk5CAwvG_0iFxjZ5C2fLByF3jhvHOx

eLocust3 Master Trainers workshop
http://www.slideshare.net/FAOLocust/2014-clcprocrcswac-desert-locust-information-officer-workshop

eLocust3 3D (Trilogis Srl)
http://www.trilogis.it/eLocust3D/

Panasonic ToughPad
http://www.panasonic.com/business/toughpad/us/best-android-rugged-tablet-overview.asp

NASA World Wind
http://goworldwind.org

Rainfall estimates and greenness maps (IRI, Columbia University)
http://iridl.ldeo.columbia.edu/maproom/Food_Security/Locusts/

Climate change and Desert Locust
http://www.fao.org/ag/locusts/en/activ/1307/index.html

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