Locust Geographic Information System (GIS) Workshop
Tashkent, Uzbekistan, 6-8 November 2013
Introduction on GIS, remote sensing and other technologies for locust information collection and management

- Item 3 of the Provisional Agenda -

As per Activity 3.3 of the Roadmap for implementing the "Five-year Programme to improve national and regional locust management in Caucasus and Central Asia (CCA)", it is planned to develop monitoring and analyzing systems for locust management in CCA countries by using Geographical Information System (GIS) and remote sensing technology.

Activity 3.3 of the Roadmap envisaged several steps over the five-year period:

- Year 1 (2012): Collect information on nature and availability of remote sensing and weather data at national level (National Consultants) and carry out a study on existing national Geographical Information System (GIS) in CCA (GIS International Consultant);
- Year 2 (2013): Organize a regional workshop to identify the main features of a regionally compatible GIS;
- Year 3 (2014): Design/adapt GIS system, compatible at regional level;
- Year 4 (2015): Install the GIS system in at least two pilot countries.

This working paper presents the work carried out and main decisions taken during Year 1 of the Five-year Programme.

In 2012, the first step was the **collection of information on nature and availability of remote sensing and weather data at national level in CCA countries.** It was carried out by Consultants from nine out of the ten concerned countries, as follows: Afghanistan, Armenia, Azerbaijan, Georgia, Kazakhstan, Kyrgyzstan, Russian Federation, Tajikistan and Uzbekistan (none from Turkmenistan). Collected materials included: detailed information on the availability of the Remote Sensing data and of databases (or other forms) for data collection, storage and analysis related to agriculture and natural resources; a description of the existing systems for locust and weather information collection, transfer and storage, including available mapping resources; and an assessment of the national situation regarding spatial equipment and software used in locust monitoring and management.

The second step was a **study on existing national Geographical Information System (GIS) in the whole CCA.** To that end, an International Consultant, GIS Expert, summarized and analyzed the information provided by the National Consultants and collected additional data, including on the GIS systems used for locusts in Kazakhstan and Russia and for Desert Locust monitoring in its whole distribution area at FAO-headquarters. A report was produced, whose main conclusions and recommendations towards the elaboration of a common system of collection, storage and sharing of standardized and chrono-, geo- and taxo-referenced locust information in CCA countries were presented to all countries during the Technical Workshop on Locusts in CCA, held in Bishkek, Kyrgyzstan, in November 2012.

The **main conclusions of the Report** on features and availability of remote sensing and weather data at national level and existing national Geographical Information System in Caucasus and Central Asia were as follows**:**

1- Overview on the current situation in CCA

All CCA countries have Plant Protection Services conducting regular monitoring for at least one of the three locust pests – the Italian, the Asian Migratory and the Moroccan locusts - as well non-swarming grasshoppers. Regardless of the status of the pest population (recession or outbreak situation), each country carries out one to four annual surveys, namely: early spring survey (egg-pods), spring-summer survey (hoppers), summer survey (adults) and autumn survey (egg-beds). The Locust Survey Form and the Locust Spray Monitoring Form, which had been agreed by CCA countries in 2009, are not used everywhere.

No GPS are used for data collection during locust surveys in CCA countries, except in Russia, Kazakhstan and Afghanistan where each province has at least one GPS.

After the collapse of the Soviet Union, some Plant Protection Services faced financial problems, which affected locust monitoring, personnel turn-over and record keeping. In many cases, most of the historical information on locust was lost. According to the national reports, current locust monitoring services (except Afghanistan) have series of data, mostly during the last decade, both in paper and electronic formats.

The GIS technology for locust monitoring and control is used in no CCA country except in Russia.

Remote sensing data for locust monitoring are not regularly used in CCA countries. There are scientific projects of satellite data application for locust monitoring in Kazakhstan, Russia and Uzbekistan.

In all CCA countries, weather monitoring is carried out on a daily basis by organizations usually called “hydrometeocenters”. Open access to these data is limited within the list of World Meteorological Organization (WMO) weather stations.
Cartographic materials (physical and topographic maps at a scale of 1:1 000 000, 1:500 000, 1:200 000, different maps of natural and mineral resources) are available in all countries both in electronic and paper formats. However, all of them were created in the USSR and rarely updated in the post-Soviet period, i.e. over the past 20 years.

Specialists of the Plant Protection Services conducting regular monitoring of locusts in CCA are capable to use computers and Microsoft office software.

There is a telephone and mobile phone communication network, with Internet access, everywhere in CCA countries.

2- Review of the GIS created in 2002 in Kazakhstan

A GIS was created in 2002, based on experience gained with the Desert Locust information system (DLIS) developed by FAO, the Natural Resources Institute (UK) and the University of Edinburgh: SWARMS at FAO-HQ, and RAMSES at country level. In Kazakhstan this system was adapted by an International GIS Expert, Ms. Judith Pender, to the three locust species (the Italian, Asian Migratory and Moroccan locusts) as well as to non-gregarious grasshopper species. It was named the Kazakhstan Locust Information Management Tool (KLIMT). The major principle of KLIMT is that locust data should be held in a database allowing to build maps, reflecting information on surveys and pesticide treatments against locusts, and statistical tables for any given time periods and areas. Finally, KLIMT was introduced in 2002 to the Republican State Enterprise “Fitosanitariya” (Committee state inspection in the agricultural sector of the Ministry of Agriculture) and 14 oblast departments of plant

protection of territorial divisions of the Ministry of Agriculture (MoA). They were provided with 16 sets of computer equipment with Windows 98, Access 2000 and Arcview GIS 3.2a software. The specialists were trained on the use of the GIS.

Currently, filling the database by seasonal information is being carried out only in four oblasts (Almaty, Karaganda, North Kazakhstan and Zhambyl). Mapping and analysis of GIS information are not done by the "Republican Methodological Center of Phytosanitary Diagnostics and Forecasts", which has been responsible for locust monitoring since 2003.

During KLIMT implementation, its developers met the following constraints: limited and insufficient computer knowledge of local specialists to work with database and use GIS; high local staff turnover; unavailability of GPS units and geospatial information from ground locust surveys; job description of plant protection staff did not include database and GIS-related responsibilities.

Lessons learnt are the following: specialists involved in GIS system design should have sufficient knowledge of database management and of GIS programming; alternatively, two different specialists could be involved; adequate time (minimum one year) should be allowed for GIS development; at least two local specialists from each oblast need to be trained on the use the GIS; computer hardware and software need to be periodically updated.

In conclusion, it is not recommended to use KLIMT as the base for the upcoming GIS system in CCA countries for two main reasons: (1) ArcView3.2 software is outdated and no longer supported by the producer (ESRI); (2) Database management in MS Access involved a very time-consuming data checking on inputs.

3- Review of the GIS used in Russia

Implementation of the GIS, the Locust Information Management Tool, started in 2010. It is used to store and analyze the information of early spring (egg-pods) and autumn (egg-beds) surveys. The system was developed by the use of GIS "Map 2011", a software produced by the Russian company "Panorama". Cartographic material includes topographic map at scale of 1:100 000. At present time, Plant Protection Services of 22 Russia regions have experience with GPS units to determine the coordinates of locust survey itineraries and places and record this information in the GIS data base by using GIS "Map 2011" software. Full implementation of the GIS system for locusts monitoring in Russia requests to equip 1 661 local Plant Protection Services with 4 265 GPS units and 3 885 PCs with proper software. Additionally, about 500 GIS specialists must be trained.

4- Review of the GIS used for Desert Locust at FAO-Headquarters

The Desert Locust Information System (DLIS) of the Plant Production and Protection Division (AGP), FAO-Headquarters, was developed during the four past decades. It includes modern and regularly updated communication, computer and satellite technologies. The primary recipients of the FAO early warning system are the National Desert Locust Centres (NDLCs) –autonomous or semi-autonomous governmental units within the Ministries of Agriculture– and the Plant Protection Services of 33 countries of north-western and western Africa, the Middle-East and South-West Asia (i.e. the whole Desert Locust distribution area).

The DLIS relies on field data collected by NDLCs national teams during locust survey and control operations. The national teams record their observations in a standard form, the FAO Locust Survey and Control Form (LSCF), which contains site-specific information, details of locust situation and habitat, control operations and damage. Starting from 2005, the field officers have been using a handheld, touch-screen data logger (eLocust2) with custom database, mimicking the FAO LSCF, linked to a mapping program. The eLocust2 system operates on a device (Wescor) with a built-in GPS and transmission capabilities using the International Maritime Satellite Organization (Inmarsat) satellite systems, which allows geo-

referenced data to be transmitted in real time from the field to the NDLCs in each country.

The DLIS has used the GIS called SWARMS (Schistocerca Warning and Management System) that operates on PC and Unix workstations using an Oracle database and ARCGIS software. SWARMS GIS is used at FAO-Headquarters for managing and analyzing the survey and control data received from Desert Locust affected countries. This data is combined with data from other sources such as rainfall estimates, MODIS/NDVI and EVI vegetation indexes, satellite greenness map, NOAA synoptic data, etc.; some of these data are free. SWARMS GIS houses an extensive collection of maps of varying types and scales. The system contains historical locust data from the 1930s to present time, which allows to assess the current situation and establish forecast on the scale, timing and location of locust breeding and migration. An egg and hopper development model and a wind trajectory model are used to estimate the timing of breeding and the location and duration of migrations, respectively. In the next future, an open source system will be available.

On this basis, FAO issues a monthly Desert Locust bulletin in three languages (Arabic, English and French) summarizing the current locust situation and providing six-week forecast on a per-country basis. During period of increased locust activity, FAO DLIS issues also alerts and warnings and contributes to press releases.

The main lessons of SWARMS GIS were the following:

(1) A robust network of rapid data collection, recording and transmission from the field to the national and international levels must be sufficiently streamlined and direct to avoid bureaucratic delays and political interference.
(2) The human component in this network is the most critical. People need to be well trained and refreshed on a regular basis, and benefit from technical and scientific assistance as well as from financial support.
(3) A centralized forecasting unit such as DLIS is required to act as a central repository of information in GIS where all locust and environmental data can be analyzed in unison at global, regional and national levels.
(4) The use of eLocust2 for locust survey and control operations is the example of the best way for field geo-referenced data record and rapid transmission of results from anywhere in the field at any time.
(5) Warning system must issue simple well-targeted outputs for national decision makers based on the results of thorough, non- biased analysis.

It is recommended to use the four key principles of the Desert Locust early warning system as the base for new GIS system in CCA countries:

(1) Regular surveillance and accurate GPS field data;
(2) Rapid transmission of data;
(3) Complete analysis of locust and environment data within GIS at national and regional levels;
(4) Simple well-targeted outputs for decision makers.

Besides, several other aspects will have be considered at the national level:

(1) Field teams need to be dedicated, well trained in collecting, recording and transmitting data; they also need to be well equipped and be given the tools to do the work appropriately (GPS, vehicles, mobile phones, tablets).
(2) Financial support for technical capacity and locust monitoring and control must be provided by the Government on a regular basis.
(3) Every country needs to own the data and to receive feedback from the other countries; they need to maintain interest in regional locust early warning GIS system based on ground surveys, remote sensing, meteorological and modeling data.

Certain directions exist for improving SWARMS GIS's experience for the new GIS system in CCA countries, as follows:

(1) Ensure routine use of GPS and mobile devices (as an analogue of eLocust2 system) for ground surveys and data input.
(2) Use open sources of DEM, cartographical, meteorological (in grid form) and remote sensing data.
(3) Develop WEB-GIS-technology for region level.
(4) Standardize the GIS output products, methods of analysis and forecast.

The **main recommendations of the Report** on features and availability of remote sensing and weather data at national level and existing national Geographical Information System in Caucasus and Central Asia were as follows:

a- Recommendations towards the elaboration of a common system of collection of standardized and georeferenced locust information in CCA countries:

(1) Encourage all national services to use FAO standard forms for locust monitoring, as agreed by CCA countries in 2009.
(2) Use the experience of eLocust2 (and new version eLocust3, now under development) of the FAO DLIS for gathering ground information in customized database, mimicking the FAO LSCF, linked to a mapping program. Adapt the software for the CCA countries, i.e. prepare a version of the menu in English and Russian, develop an electronic glossary in English, Russian and all other languages of the CCA countries, link the search of the name of local place with Google Earth navigation maps.
(3) As for the equipment which will host the software to collect ground information, it is recommended to use a tablet or smart phone with built-in navigation (GPS and GLONASS); a battery with a capacity of 4000 mAh (up to 7 hours of battery life), and more, able to carry mobile communication in GSM (using, for example, by the communication operator "Beeline", whose services are widely distributed in CCA, and the network and roaming campaign includes 200 countries).

b- Recommendations towards the elaboration of a common system of storage and sharing of locust information in CCA countries:

(1) The structure of a GIS database for the collection and storage of locust survey and control data should be based on information collected using the standard FAO forms.

(2) Users should not have direct access to the database. Special interface and tools for reporting should be developed for end-users.
(3) Storage of information should be organized at two levels - national and regional. Only authorized users will have access to the regional database.
(4) The database software should be using an open access SQL system such as MySQL or other (free of charge).
(5) Database programmer must provide the module for the control of parameters entered into the database.
(6) Historical information on locust monitoring to be entered in the database should go back at least to 2000, wherever possible.

c- Recommendations towards the elaboration of a CCA GIS

(1) Use open source GIS software.
(2) Determine the list of maps and their scales, which will be used in the GIS for future deliverables and forecasts. Actually, it is necessary to have administrative and

topographic maps, soil maps, land use map, vegetation map, digital elevation model at scales of 1:1,000,000 and 1:200,000.

(3) Define a list of weather stations, meteorological parameters and frequency of their collection, source of weather forecasts of temperature, precipitation, wind on a regular grid for CCA.
(4) Use the remote sensing data of medium spatial resolution for characteristics of soil moisture, precipitation, state and productivity of vegetation by different vegetation indices, habitat mapping locust, flood zones, etc.
(5) The products of GIS should include tables and maps of current and historical locust infestations, ecological conditions and control operations. Long term trends in population dynamics will be estimated on the base of historical data.
(6) Information needed by plant protection services of individual countries, due to their reporting and operational obligations, should be prepared with using the GIS.

During the annual workshop held in November 2012 in Kyrgyzstan, the representatives of all CCA countries came to the conclusion that the elaboration of a common system of collection, storage and sharing of standardized and geo-referenced locust information was needed for CCA countries.

It was agreed that during Year 2 of the Five-year Programme, the main features of a regionally compatible GIS should be identified and that a Locust GIS Workshop would be scheduled to that end, immediately before the annual Technical Workshop on Locusts in CCA, to be held in Tashkent, Uzbekistan, in November 2013. During the Locust GIS Workshop, it was decided that discussions would concern in particular the following issues:

- the GIS data base structure and outputs;
- the name of the CCA locust monitoring system;
- technical and software environment;
- methods of locust regional forecasting.

It was also planned to make demonstration of remote sensing applications and training for the use of ground data automated system collection on the base of FAO forms.