A monitoring system for preventive control of Desert Locust in West Africa

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Abstract

Agricultural pests like the Desert locust, *Schistocerca gregaria* (Forskål 1775), often migrate across borders and cause major losses and emergencies. In the past, such damage often led to famines and sometimes triggered trade restrictions. An international preventive strategy is currently recommended in each country on early warning and reaction capacities. As a result, the extent and frequency of invasions were considerably reduced during the last 50 years. However, countries are frequently unable to react sufficiently quickly to nip outbreaks in the bud, and late extensive emergency operations, with large use of pesticides as well as international assistance, became necessary. The Emergency Prevention System for Transboundary Animal and Plant Pests and Diseases (EMPRES, Desert Locust component) was established by FAO in order to minimize the risk of such emergencies. In Western and Northern Africa, EMPRES was implemented in 2006 to develop a more effective early survey and a better preventive management of Desert locust populations in their reproduction areas. Enhancing national capacities and building a common system for monitoring each national preventive control was considered as a priority. Such a tool was developed by French CIRAD in 2009 and is a main component of the "National Locust Risk Management Plans". This software, using a simple web interface, is built around a database. All data from 10 West African national Locust control units, about infrastructures, materials, human resources and financial means, were collected and organized in the database. The frequency of the updates is connected to the nature of information, from 3 to 12 months and performed at the country level. Real-time consultations, codifications and outputs are made easily by the internet. This system allows a real-time collection/dissemination of information and a better organization of preventive control at the regional level, key points to improve management of Desert locust risk.

Introduction

The desert locust, *Schistocerca gregaria* (Forskål 1775), is a pest with economical, social and environmental impacts over a wide area ranging from Mauritania to India, and as far the Himalaya foothills. In Africa, locusts cause widespread agricultural damage in the Sahelian and North African regions. Insecticides remain the only effective means of control, but they pose many environmental problems (van Huis et al 2007; Magor et al 2008). Sustainable strategies for the prevention and early control were developed following the two recent invasions in the late 80s and in 2003-2005, which were very costly, both financially and environmentally (over $ 1 billion and 43 million ha treated).

The risk posed by the invasion of the desert locust is considered a natural hazard, which can be effectively managed by implementing a preventative strategy (Lecoq 2003, 2004, 2005). It is the objective of the FAO Commission for controlling the desert locust in the Western region (CLCPRO), comprising ten countries, whose mandate is the implementation of the EMPRES programme in this region.

The preventive control strategy is based not only on increased knowledge of the biology and ecology of the locust and its habitats, but also on the implementation of "**risk management plans**" to promote the involvement of the all stakeholders in the different stages of the locust control campaign, from preventative control to emergency operations. In the case of the desert locust, preventive control consists of monitoring the outbreak areas, located mainly south of the Sahara in the four frontline countries (Mauritania, Mali, Niger & Chad), to destroy the first group of locusts that have begun a phase transformation (gregarization) on a large scale.

Risk management requires an interdisciplinary and systemic risk-analysis approach combining natural sciences and social sciences. Many studies refer to it as part of natural hazards management (floods, earthquakes) (Kerven, 1995).

The application of such approaches to risk management of the desert locust is essential for long-term prevention. However, it is difficult. Indeed, so far, the proposed solutions have remained technical, biological and economical; the sociological and political dimensions of the risk are seldom taken into account.

Yet, preventive control depends on the regional coordination of all the measures necessary as swarms of locusts can move over long distances and move from one country to another in a few days. The determination of the international community to implement a truly holistic approach to the desert locust risk results in the need to rethink the management and governance methods that support and define monitoring and control (Dore et al 2008).

With this in mind, and with financial support from the French Ministry of Foreign Affairs, the CLCPRO was endowed in 2010 with a system to monitor the operational means for preventive desert locust control, made available to all countries concerned in the West African region. This information system, called Watch system on national devices of preventive control (WSND), was developed by CIRAD. It is one of the cornerstones of locust risk management plans.

The principles of co-construction of Information Systems (IS), based on the establishment of an actuated information system (Norlin and Morris, 2000) were used. This document analyzes how these principles were applied, by presenting them quickly and describing the different phases of their implementation in the design of the information system.

Basic concepts for developing the Information System

An actuated information system is used to implement a set of processes to perform an action. As part of preventive control, the information that we consider actionable is the real-time knowledge of the status of all devices in desert locust control. The action that can be implemented is the financial support of structures responsible for implementing national locust control in order to improve their control methods or coordination of a temporary deployment of control methods by transfer of materials and men from one country to another, or from one region to another, within the same country. The WSND data must be continuously updated as they are used both in emergencies (e.g. massive gregarization, swarm groups, etc.) and in remission status as a tool for regional management.

To achieve this objective, information systems must produce useful information, usable and used. Beyond the “slogan”, these terms are relatively restrictive and are composed of a framework for the development of the IS. These concepts have guided the organization of data collection, as well as the analysis stages, and the design and the development of the monitoring system.

Information must be useful and should allow fulfilment of the information system objectives
Useful information must be relevant in regard to the objectives of the information system. The information gathered should be relative to the terms of these objectives. It must show the cause / effect

relationship between an event and the action that will be triggered. The challenge is twofold: initially these relationships must be characterized and modelled and then the report information must be identified. The design and expression of the needs phase is fundamental. The stakeholders must have the same level of decision-making in order to meet the real needs of everyone, while not forgetting the general target fixed by the information system. The data catalogues should be identical for all stakeholders. This standardization of collective data enables an immediate qualitative and quantitative analysis of the state of each national device in locust control in the regional context.

Useful information is identified among redundant or fragmented information in the analysis of the requirement phase. Any data submitted by the stakeholders must be qualified in terms of relevance to the objectives of the information system and must reflect the needs of the stakeholders in the system.

Another aspect in the availability of data is a criterion of selection and must be verified in all countries. Data that the WSND are unable to provide must not be requested.

The information must be usable by the stakeholders
Usable information needs to be designed and appropriate tools need to be implemented for the users and their environment. The information system should be designed according to the international standards for the Internet, but it must also relate to the actual land. Thus, compromises must be possible to allow the use of materials by the stakeholders. Data quality should also be guaranteed, whether for updating or traceability.

The information must be used by stakeholders
For information to be used, stakeholders must be able to fully understand its meaning and relate it to their functions, uses and decisions. The development of an information system should be geared to facilitate the ownership of the tool by the users. The user should be able to retrieve the data necessary to the information system in its national structure.

Accomplishment of the Information System

All the elements that shape the information characterizing the means of pest control form the information system known as the Watch system on national devices of preventive control against Desert locust (WSND).

The two objectives that should enable the establishment of the WSND are, on one hand, the strengthening of national capacities in terms of preventive control, and on the other hand, the monitoring of operational capabilities of each national unit of preventive control to ensure maintenance of the device regionally. Sharing these objectives allows a mutual surveillance means of control implemented under the authority of the CLCPRO. To ensure the effectiveness of the WSND at a regional level, each WSND must perceive, from this device, the advantages that make it useful, usable and then used at a local level.

The sequence of steps for the project is shown in **Figure 1**.

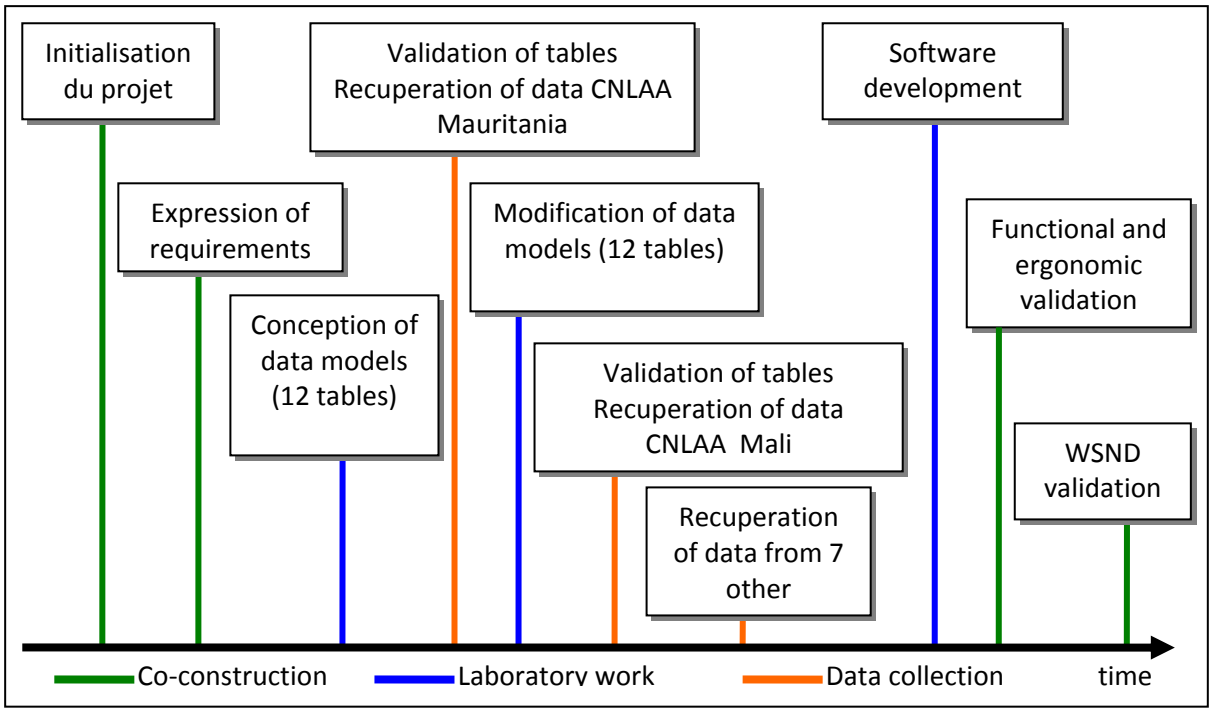

Fig 1: Project chronology

Co-construction of the expression of requirements

All stakeholders involved in preventive control in the western region of Africa took part in a meeting during September 2008 in Agadir (Morocco):
- Commission for controlling the Desert locust in the Western region (CLCPRO).
- Officials from the National Unit for locust control in affected countries.
- Locust experts and logisticians.
The main objectives of the WSND were then discussed and shared.

In this phase of discussion, the establishment of the responsibility of stakeholders passes through the co-construction of roles within the information system to share the overall WSND goal.

Three types of stakeholders were identified:
- The national leader, who is responsible for information entered and ensures the quality of the data entered in the WSND for the entire national device. The WSND is its responsibility and they should have global knowledge of it.

- The national correspondent is the local WSND manager. It supplies the data and updates the information. Nationally, it is responsible for the cohesion of WSND information with the national leader.

- The regional facilitator is the WSND regional manager. It verifies that all countries maintain updated information that concerning them. It triggers the necessary actions to ensure that all devices remain operational (refinancing, coordination of method transfers, etc.).

The objective of this first phase was to differentiate relevant information from unnecessary information. The different stakeholders emit heterogeneous needs and the goal of discussions is to move towards a consensual identification of all the data comprising useful information. All data is analyzed from different viewpoints: is it available? Is it more valuable? Is it necessary for the achievement of WSND overall objectives?

Thus, for local stakeholders to monopolize and use the WSND, it should not be a simple tool used at a regional level: it must provide local stakeholders with indicators and summaries of the overall state of their device. What the WSND performs at a regional level, should be accessible at the local level.

A shared design

A consensus approach to the choice of data used in the information system has been conducted on the basis of discussions during the inception workshop. From the expression of the needs of local and regional stakeholders, we have created 14 data tables that we submitted to the two WSND to validate their ability to complete them.

In this phase, simple spreadsheets were used, particularly for representing data models to the stakeholders. Thus, the exchanges between the stakeholders participating in the construction of future data structures were simplified and made readily available for everyone's understanding: the stakeholders did not need to master any conceptual modelling language, such as Merise or UML.

Collecting information on the first two countries (Mauritania, Mali) allowed identification of the inaccessible data at the WSND level. The number of data tables was reduced to 12. Once they were consolidated and validated, the data were collected in seven other countries (Morocco, Algeria, Libya, Tunisia, Senegal, Niger and Chad).

Finally, IS modelling was based on the contents of data tables. The list of data management types was well known. The design was therefore limited to reflect the table structure in a conceptual data model.

A simplified and uniform presentation of the development of standards

The use of the Internet and online systems is the easiest method to enable all stakeholders to share their data. To ensure the continued availability of the WSND, a centralized architecture was selected, which was under the responsibility of the CLCPRO. The WSND comes in the form of a website whose server is located in the CLCPRO premises in Algiers.

Implementation
To ensure certified interoperability and portability, the WSND was conducted in compliance with standards developed by the World Wide Web Consortium (W3C). This ensured that all users have the fundamental right to use the browser of their choice that best suits his or her environment or needs. Compliance with these standards has enabled us to ensure equal access to all the WSND features, whatever the browser used. The WSND was implemented in XHTML, PHP and JavaScript. We have used style sheets (CSS) for the visual rendering. The use of AJAX technology (with the jQuery framework), allowing the partial reloading of web pages, has helped minimize the network flow.

A single entry system was created. It is used in all the WSND data tables, which ensures that the user will not be confused by switching from one data type to another (Figure 2). Various features are available, such as a search tool or sorting by columns.

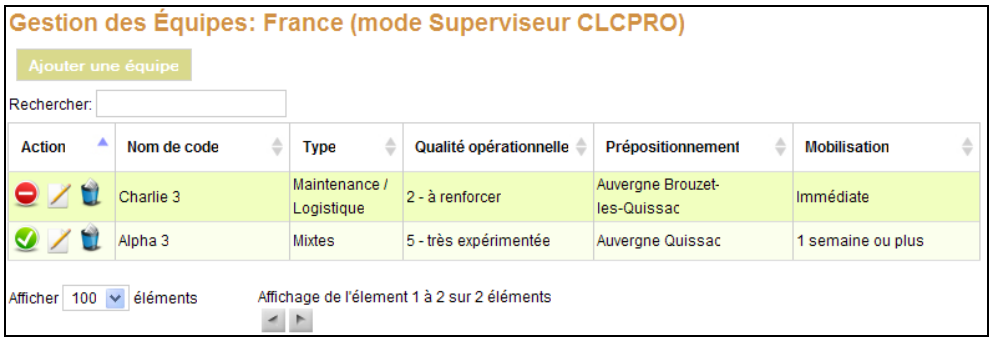

Fig 2: Data management system

Data quality

Relevant information is updated information. The WSND allows each user to use indicators on the updated data (Figure 3). These are defined by the minimum update frequency for each type of data. On connection, the managers are informed of the need to update their data. The regional facilitator also has access to these indicators. Traceability for all of the information system is implemented in order to know which user searches or modifies the data.

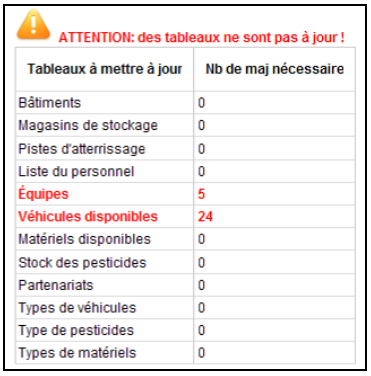

Fig 3: Update indicators

Available output data

The output states are provided in a file format compatible with most spreadsheets on the market (Microsoft Excel, OpenOffice). This format allows the manager to rework the data, to use them and to verify their quality. The data extraction allows access to the information in real time. The regional manager and also the WSND managers can quickly obtain a **comprehensive** understanding of the stored information and the operational level of the device.

The data describing the national devices of preventive control were collected locally. This allowed the characterization of the operational levels of the WSND at the end of 2009. Local partners were sensitized on the need to control and indicate the operational status of their device. The indicators provided by the WSND allowed, for example, the identification of future problems, such as an unbalanced pyramid of the age of the prospector agents (Figure 4).

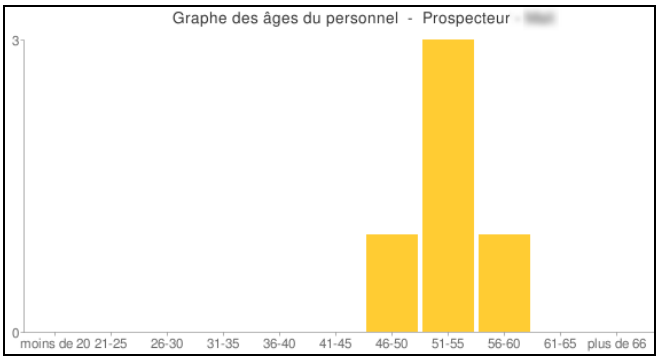

Fig 4: Histogramme of ages

The WSND website (Figure 5) has been online since February 1, 2010 (http://sv-clcpro.cirad.fr/ and http://sv.clcpro-empres.org from May 2010). The national managers update the data regularly. Updated information is available globally to WSND managers, but it is also available for the CLCPRO regionally.

Fig 5: WSND homepage

Conclusions

This application, implemented for monitoring of the devices for the preventive control of the desert locust, is a fundamental element of preventive control, developed in the EMPRES-RO project. Indeed, for the development of preventive control provided by the anti-locust control national devices, the countries must be given the tools to monitor their system and its relevance to locust risk in real time. This will enable them to have the responsiveness necessary in case of problems, especially their ability to provide sufficient anticipation for themselves, or to mobilize regional and sub-regional resources through risk management plans (currently under construction).

This tool can also be used at the regional level for preventive control, which is the CLCPRO. The Committee will have the opportunity to monitor the status of the national devices in real time, coordinate efforts and organize mutual assistance and pesticide triangulations when necessary.

Any monitoring system or database is valid only if it is kept up to date regularly with reliable information. This system is developed so that countries use the real stakeholders of the application who

will consult it themselves. As a result, the data entry managers in each country will have sufficient interpersonal skills and human resources to regularly obtain reliable information from the different WSND services. This is essential for the sustainability of the system. The real challenge lies not in the development and the availability of the system, but in the ability of the stakeholders to update the databases regularly and to use it in the long term.

Options for future developments were discussed with users. The application can evolve into an integrated Geographic Information System (GIS). For the database, geo-referencing of various devices already exists and it was included in its design. It would be interesting to integrate these data within a GIS using a free application like Google Earth. This would give a clear positioning of certain components such as vehicles, runways, pesticide stocks, etc.

These results show that it is possible, even in socio-economically vulnerable environments, to use the strengths of new technologies, to implement actions at the regional level and to create synergies. All stakeholders in this process must implement a co-construction strategy and the development of national capacities.

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