Spreading Matter Management in France within Sigemo

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Abstract

Several million tons of matters are spread on the agricultural soils each year in France. Spreading is a usual way of recycling but it requires a meticulous monitoring in order to avoid all types of pollution. Likewise, an excessive and irrational spreading would be harmful for the natural environment. Presently, no national computerized system for spreading monitoring has been developed in France. The processing and the study of spreading project proposals is "manually" carried out i.e. without information system. However, a computerized tool will be really useful for the matter spreading data capture, the investigation, the data centralization and the crosschecking analysis. Thus, in the framework of a "multi-actor" project, Cemagref research institute is the contracting authority of the design step related to a French GIS-based information system called Sigemo. This e-government system is dedicated to the data centralization as well as the monitoring of the spreading operations through Internet. A main goal of the system is to improve the capability of producing easily analysis and indicators. After presenting the environmental stakes of spreading, this technical paper describes what Sigemo will be and emphasizes on the expected impacts of such a tool from an environmental and an organizational point of view.

Key words: GIS, Organic Matter Spreading.

1 The environmental issues at stake of spreading

Spreading on the croplands is an excellent way of recycling the organic matters; see for example (Bouanani, 2001). This technique consisting in spreading the matters on the fields enables the farmer to contribute to the fertilization of the plots at a very low cost, while enhancing the value of the waste. The plants have to take mineral and organic components from the soil which are brought, in a large part, by spreading (nutrients made of nitrogen, phosphorus, potassium, various trace elements). Beyond the direct benefits for the farm production, spreading of organic matters also reduces the use of mineral fertilizers, which presents the major advantage of decreasing the use of the natural, mineral, and energy resources which are needed for fertilizer manufacturing. Finally, farm spreading avoids using methods which strictly eliminate (incineration, dumping). On the whole, nowadays concerning organic matters, the recycling through spreading is considered in France as the best from the environmental, sanitary and economic point of view. Several million tons of matters are spread on the agricultural soils each year in France and the theoretical surface that can be concerned by this practice is evaluated to 10-15 million ha. As presented below, spread matters are principally composed of farm effluents, the sludge issued from the waste treatment plants, and the waste from the agri-food industries.

Because of the high quantity of products spread in France and in spite of their many advantages, the farm spreading practices need a fastidious monitoring. Indeed, an excessive and irrational spreading could quite simply lead to soil pollution; for instance, when the matters happen to disturb the balance of a water stream or of a soil which is unable to eliminate them. Typically, this is the case of pollution by excess of nitrogen driven by a high matter concentration. Nitrogen is a vital element for plant production. Nevertheless, if too much nitrogen is brought, it is leached by the rains and takes part to the pollution of surface or underground water. It is the same for the excess of phosphorus and potassium. It is therefore

crucial to have an accurate vision and a monitoring of the spreading over all the French territory, in order to:

- Know and check the concerned geographic areas, the matter composition and quantities (according to European regulation),
- Evaluate and watch, in an even finer manner, the effects of the practices on the near and far environment; this implies indicators and crosschecking studies from various geographic areas and various periods.

Presently, no national computerized system has been developed to monitor and to analyze spreading practices in France. However, such a tool will be really useful for the matter spreading data capture, investigation, and study; at the present moment, matter producers make up spreading project proposals and the checking of these projects by government services is "manually" carried out i.e. without information system. Depending on their type, spreading information are checked by different government actors. In the French case, the first advantages of a computerized system will be to improve government productivity and also enable the ***data sharing between the different actors*** implied in the spreading monitoring so that crosschecking analysis can be possible before accepting a spreading project. Thus, in the framework of a "multi-actor" project, Cemagref research institute is the contracting authority of the design step related to a French GIS[1]-based information system called Sigemo. This national e-government system is dedicated to the data sharing as well as the monitoring of the spreading operations through Internet. The next section will present the current "manual" spreading management procedure and will show the expected advantages provided by the future information system Sigemo from an environmental and an organizational point of view. After several years of studies, the conceptual modeling step of Sigemo is now completed; thus section 3 will present the main points of the Sigemo and the associated architecture.

2 The monitoring of the spreading in the present and in the future

In France, each organic matter producer who wants to resort to spreading must transmit a spreading plan file (i.e. a spreading project proposal) to the Government services. Then these public services allow or not the planning proposed by the matter producer depending on its environmental acceptability. This section describes the main lines of the present spreading management procedure. The current procedure is schematized in figure 1.

2.1 Present procedure

From the study offices to the Government examining services. At the present time, the information on the spreading project proposals are notified in the form of paper files addressed to the administration. One can find, among other things, in these administrative files, the quantities to spread, the composition of the organic matters, photocopies of maps indicating the concerned geographic areas or, much more simply, the concerned agricultural parcel identifiers. The files are made up by non-governmental ***study offices*** on behalf of the producers of matters (mainly the farmers, the waste water treatment plants and the agro-food industries). These files are then centralized by Department[2]; indeed, they are sent by the study offices to the Prefect administration offices before being transmitted by this administration to the relevant public bodies. The choice of the relevant public bodies, enumerated below, is directly dependent on the type of spreading; each of these institutes is a ***government examining service*** and is specialized in studies related to a certain type of files i.e. a certain type of spreading (sludge of waste treatment plants, farm effluents…). The government examining services are:

- The Departmental Veterinary Services Authorities (DDSV – French acronym) or the Departmental Agricultural Authorities (DDAF) which are dependent on the ***Ministry of Agriculture.***
- The Regional Authorities of industry and research and environment (DRIRE) which is dependent on the ***Ministry of Ecology*** and on the ***Ministry of Economy.***

[1] GIS : Geographic Information System. See (Aronoff, 1989; Laurini and Thompson, 1996) for general information on GIS technologies.

[2] France is geographically divided into "Regions". These regions are subdivided into "Departments" - metropolitan France is made up of 22 Regions and 96 Departments. In the paper, the term "Department" is related to this geographical definition.

- The Departmental Authorities of the Social and Sanitary Affairs (DDASS) which is dependent on the ***Ministry of Health.***

These services are present in each French Department (or Region for the DRIRE). These various Authorities make up the adequate checks on the practices, "manually" (without the help of any dedicated computer software). They make the decision to allow or reject a spreading project, depending on its environmental acceptability; then they inform the concerned matter producer of their decision.

The expert independent bodies. In some cases, expert Departmental commission (for instance Chambers of Agriculture) can be charged of evaluating in a more deeper manner, the products and the soils which are involved in the spreading, as well as the possible outcomes of the practices on the near or far environment. Their action also involves the management of several soil samplings used to study the areas concerned by matter producer projects. In the future, resorting to such bodies should tend to generalize (Gallian, 2001). These commissions are named ***expert independent bodies***.

At the national level. Finally, at the national level, other governmental institutions are interested by indicators and aggregated analysis on spreading. This is the case for the Agency for Environment and Energy Management (ADEME), the Ministry of Agriculture (MAAPR), and the Ministry of Ecology (MEDD).

To sump up, many bodies must have access to the information related to spreading. Unfortunately, the management and the monitoring of the practices under a "paper" form don't facilitate neither the exchange of information, nor the study and the crosscheck of the files. However, before to make a decision related to the acceptance (or not) of a spreading, it is important to facilitate the data exchange between the different government services for cross-analysis and control. For example, suppose that each file concerning a spreading practice around a river is monitored by a specific governmental service because each file concerns a different type of spreading. In this case, it could be important to compare data handled by the different government services before making the decision to accept new spreading practices in the concerned area. Crosschecking analysis can, of course, imply several governmental services from several Departments.

Moreover, some isolated initiatives have appeared in very few Chambers of Agriculture (expert independent bodies) to input data into computer systems and to perform spatial analysis with GIS. At the present time, no data exchange initiative came into being; the information remains scattered among several organizations.

2.2 Computerization of the monitoring

In order to increase the efficiency and the reliability of the current procedure, the e-government Sigemo project has been launched. The acronym of Sigemo is "Information System for the Management of the Organic Matters Spreading" in French. Historically, this project is at the crossroads of a double approach: that of the two French Ministries in charge of agriculture and ecology (MAAPR, MEDD) but also that of the Chambers of agriculture.

Sigemo clearly has a national vocation and more specifically aims at helping the management and the evaluation of spreading plans, as well as the data capture.
Sigemo will be a national web-based solution that will integrate a national database storing information on the spreading applied all over the French territory. In a more accurate way, the Web-based interface of Sigemo will allow:

- **For the study offices in charge of the files building up**: the computerized input by the web, of the geographic areas concerned by the spreading as well as other associated alphanumeric information (types of matter, quantity…). With Sigemo, the study offices will remotely input data related to spreading project proposals. This includes the drawing of spreading parcels on orthophoto maps provided by Sigemo. All captured data will be directly integrated to the national database thanks to the GIS-based web application, and study offices will also have the possibility to modify or complete "old" data. This method will facilitate data input management for study offices, and will enable the Government Services to easily obtain digital copy of the files (in a common format).

- **For the other authorized actors (examining government services and expert independent bodies):** the direct access, through internet, to the information which are inserted in the national database, and under a digital form making easy the processing and the spatial analysis with a GIS. Specifically for the independent expert bodies, Sigemo will also computerize the management and the analysis of the soil samples.

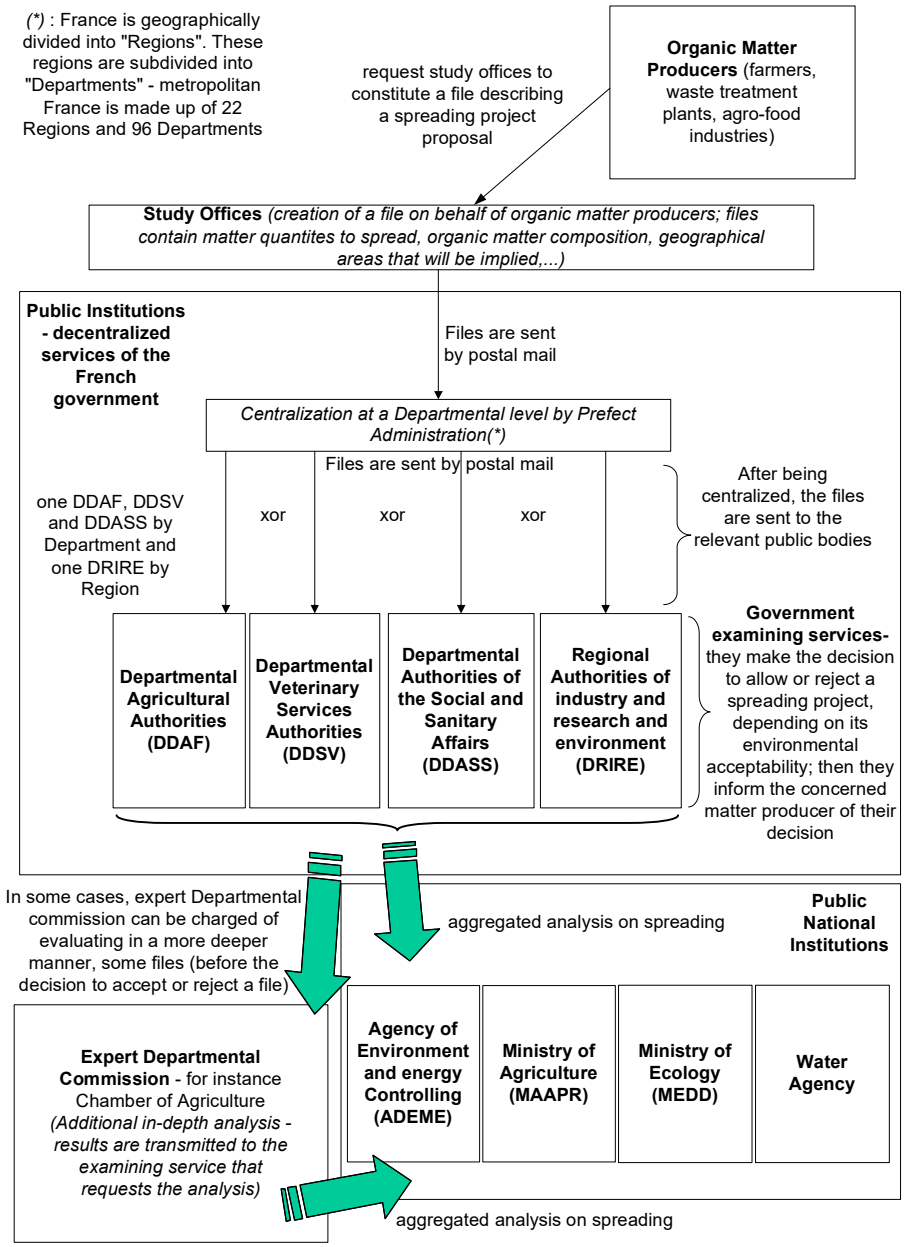

Fig. 1 Present spreading project management

Thus, the digital data capture at the source and the access to a shared database will greatly facilitate the crosschecking of the information and the setting-up of Departmental, Regional, and National spatial analysis with GIS tools (like for instance the study of the spreading impact around a lake). Sigemo is, for the time being, a real innovation in terms of spreading monitoring. Figure 2 is a synthesis of the use of Sigemo in its multi-actor context.

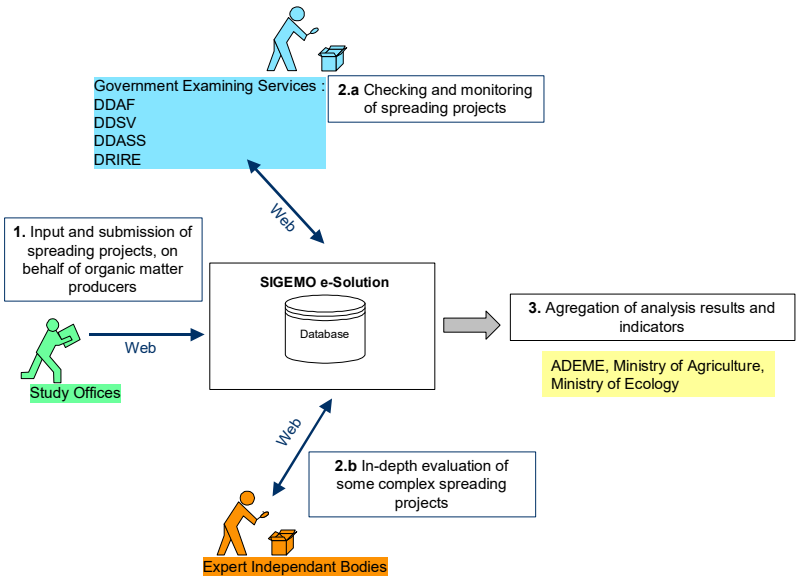

Fig. 2 Main interactions of each actor with Sigemo

Once the tool is tested in the pilot Departments, the MAAPR will be the main contractor and supervisor of Sigemo. Cemagref is the decision body of Sigemo for the design stage; after several years of study within Cemagref, the system specifications have been modeled and a public invitation to tender has just been launched for the implementation phase of the system.

3 The Architecture of Sigemo

This architecture of Sigemo integrates a national database storing all the French data related to spreading practices. The Web server gives the access to all types of applications; thus, all actors in France can make a connection to the national server by the Web, and access to applications they need. This facilitates crosschecking analysis of data and optimizes costs.

Figure 3 schematizes the details of the architecture chosen for Sigemo. According to their access permissions and their missions, the remote users of Sigemo will have the opportunity to input (study offices role) or to check (government examining and expert independent bodies role) the data in a Web environment. The server workstation is composed of three "sub-servers": the Web server, the applications server dedicated to processing, and the Map server for the on-demand creation of maps. In accordance with the French Ministry of Agriculture recommendation, the Map server chosen to produce maps is MapXtreme (MapInfo Corp, 2004). The study offices will remotely input spreading parcel related to spreading projects; this includes the drawing on orthophoto maps displayed by Web applications of Sigemo. All input data will be directly integrated to the national database. Data will be stored with the Database Management System named "SyBase" with an additional spatial extension. SyBase is the system chosen by the French Ministry of Agriculture for its software development. As specified above, depending on their roles and their permissions, the clients (study offices, government examining bodies, expert independent bodies) can input, update and/or visualize data by making a Web connection to the server. The architecture will support two types of procedures associated to two separate technologies:

- **Alphanumeric forms and HTML pages dynamically generated by the server.** Client will input alphanumeric data of administrative spreading files by means of electronic forms provided by the server. The client will then be able to "post" the filled alphanumeric forms to the server; in a second step, the server will insert these data into the national database. The clients will can also display HTML pages presenting the results of their alphanumeric queries. In this case, a specific module on the server side will generate the pages dynamically (i.e. on-demand). Depending on the type of client, the query can be related to spreading files visualization, data

monitoring, soil sample display, etc... Of course, each type of clients will have specific permissions on insertion, update or visualization.
This module will be based on the J2EE i.e. “Java 2 Platform enterprise Edition” technology and more particularly on Java “Servlets” (Sun MicroSystem, 2003). This method enables automatic generation of Web pages and simply needs some HTML pages that possibly integrate a short JavaScript code; this technology is commonly used by e-business or e-administration sites managing alphanumeric data (e.g. French income tax return Web site).

- **The study offices draw parcels with a specific Java Applet and these geographic data are then automatically sent to the server.** The previously mentioned technology makes the input of geographic information difficult. Indeed, study offices have to input geographic data (such as spreading parcels) and in this case, it is difficult to use JavaScript or HTML codes. Indeed, these languages do not offer high-level functionalities to precisely draw/modify parcels, or obtain a real-time map browsing. This is the reason why we plan to integrate Java “Applets” inside Web pages. These “Applets” will be ran by the clients and will be written in a high-level programming language (Java). In order to reach an acceptable map rendering, these Applets will use the MapJ Java Beans (developed by MapInfo corp.). On the server side, the use of the MapXtreme tool will facilitate the production of formatted geographic data (with colors and labels) and “background” orthophotos, as well as the insertion of discrete spatial data inside the Sigemo. Indeed, thanks to MapXtreme, maps can be sent from the server to clients in order to respond to their visualization queries. Geographic data can also be sent directly to MapXtreme (i.e. on server side) from the client. MapXtreme has become a reference in terms of Map Server; it has also been used in the French project related to the CAP parcels input by the Web (Common Agricultural Policy).

Information stored in the Sigemo database can also be remotely imported into a Geographic Information System (MapInfo, ArcView,...). The goal of this functionality is to facilitate spatial analysis, as well as the crosschecking with other information (lake, natural objects, soil layers,...). In the same way, an import / export with other identified systems is planned. In this case, XML (eXtensible Markup Language) will be used (Ray, 2003). Data exchanges are planed with the existing “National DataBase of Users belonging the Agricultural World” (BDNU) handled and managed by the French Ministry of Agriculture. Several updates and a coherence checking between Sigemo and the BDNU will therefore be possible. In addition to this architecture definition, we described diverse technical constraints**:** display speed of Web pages, number of “simultaneous” users, access security, data confidentiality…

4 Conclusion and expected impacts of Sigemo

The data input at the source by the study offices will facilitate the monitoring of the spreading operations as well as the data processing for analysis. To give an overall picture, the main expected consequences of Sigemo will be:

- Data input from the study offices; this makes possible an immediate use of an electronic version of the files by the government services,
- The possibility of quick corrections, through the Web, of the data by the study offices,
- Feeding a national database which will make possible an access for authorized actors through internet,
- For the government examining bodies (DDAF, DDSV, DDASS, DRIRE) that examine the files, a risk decreasing of human mistakes and a gain of productivity; this will be due to the computerization of the monitoring and to the setting-up of various automated controls,
- For the independent experts in charge of the spreading studies, the use of a digital data that will makes possible numerous new analysis by means of GIS, and to other dedicated systems,
- Again for the independent experts, the computerized and unified monitoring of the products analysis and of soil samples,
- The interoperability with other future information systems thanks to data standardization (SANDRE).
- The crosschecking and the automatic aggregation of the data at the regional and the national level,
- The setting-up of technical means which favor inter-ministry communication; typically between the organizations which depend on the Ministry of Agriculture, the Ministry of Ecology, the Ministry of healthy and the Ministry of Economy,
- After several years, the simplification of old data extraction, by means of the temporal data storage; this is a good way to obtain spreading traceability.

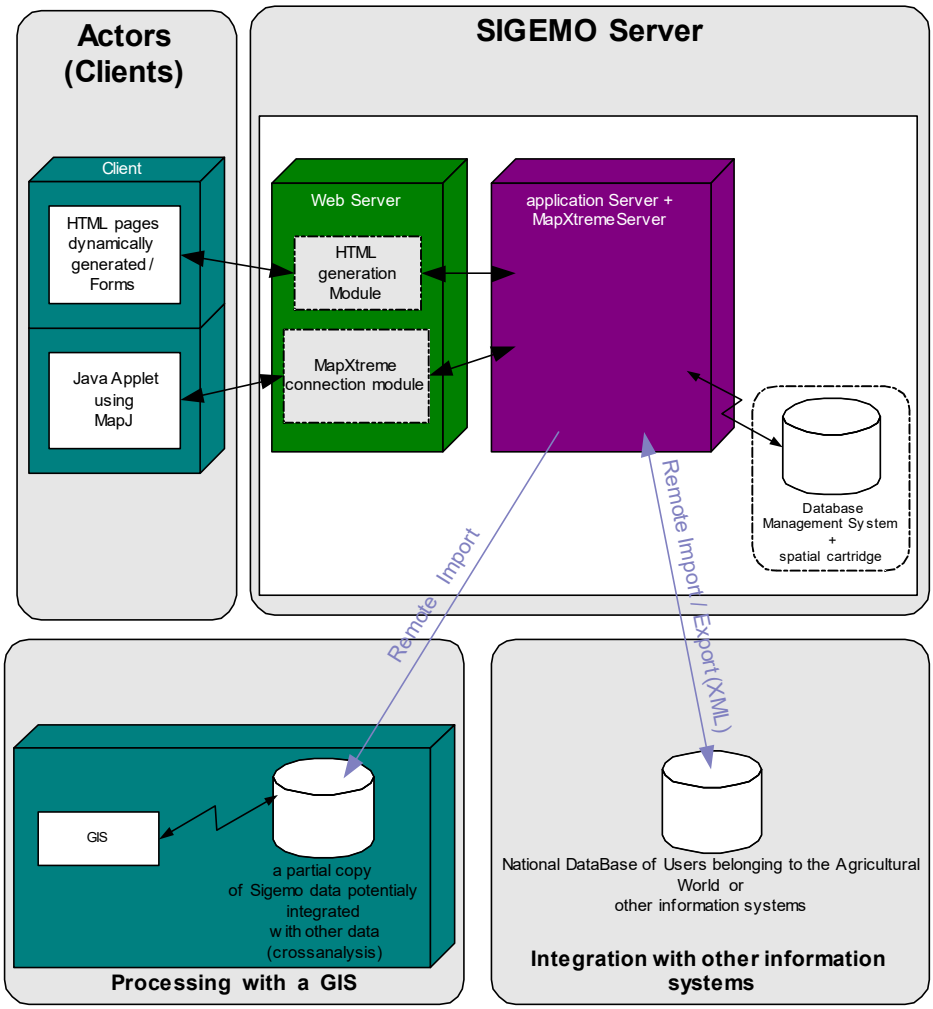

Fig. 3 Sigemo Architecture

The consequences of the Sigemo system on the monitoring of spreading and more widely on the environmental management at various scales (farms, catchments, regions, nation,…) should be very important; ***several tens of thousands of spreading files*** are received each year and the issue will be to obtain digital versions of the largest number. In a general way, the expected gain affects productivity but also quality of files expertise. Thus, some analysis will have the possibility to be performed, although they are not presently used because of the practical difficulty related to the crosschecking of non-digitalized information. The Sigemo specifications are now achieved and an invitation to tender has been launched for the implementation of the system. In order to verify that the implementation of the database will be complainant with the specification, Cemagref will set up during the database development stage, a specific consistency checking method based on technologies related to software engineering and GIS; see (Pinet et al., 2005) for details. Once achieved, Sigemo will be tested with three Departments and will be then progressively generalized to all the French territory. Sigemo has been designed so that everyone can draw an important advantage from its use. As we hope so, this will guarantee the success and the acceptance of the system by the different actors. We think that Sigemo will bring on the long term, its contribution to the setting-up of an environment integrated management, and facilitate the works of each actor implied in spreading practice monitoring in France.

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