Geotraceability : an innovative concept for the qualification of crop production.

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GeoTraceAgri Final Project Report (GTA)

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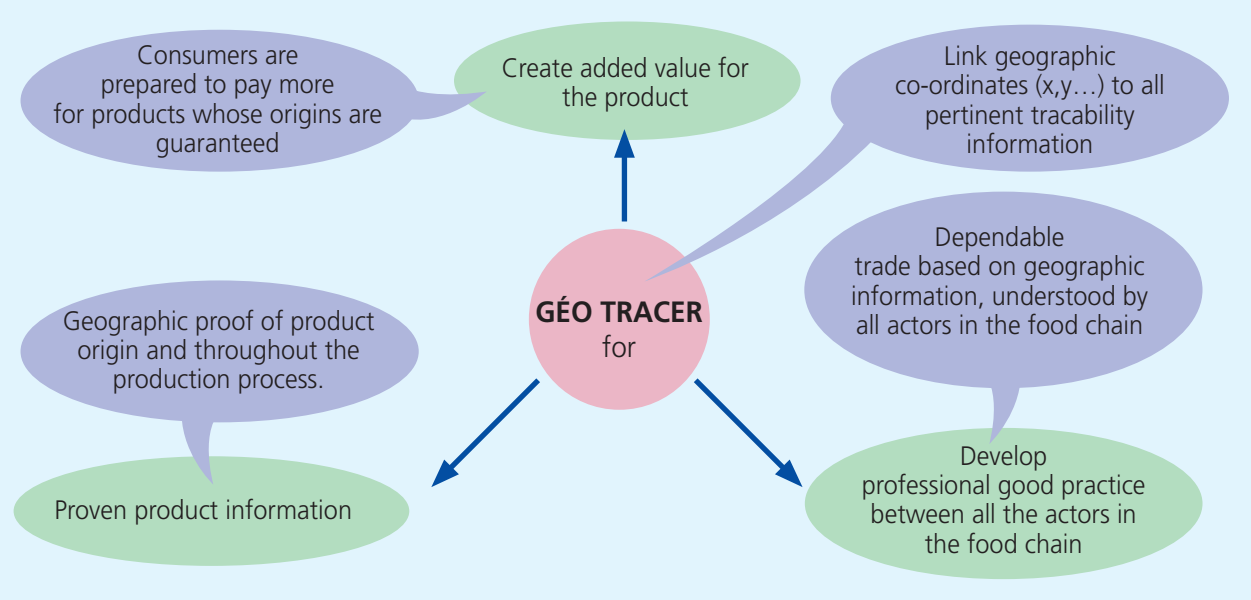
GeoTraceAgri at the origin of the concept of geotraceability

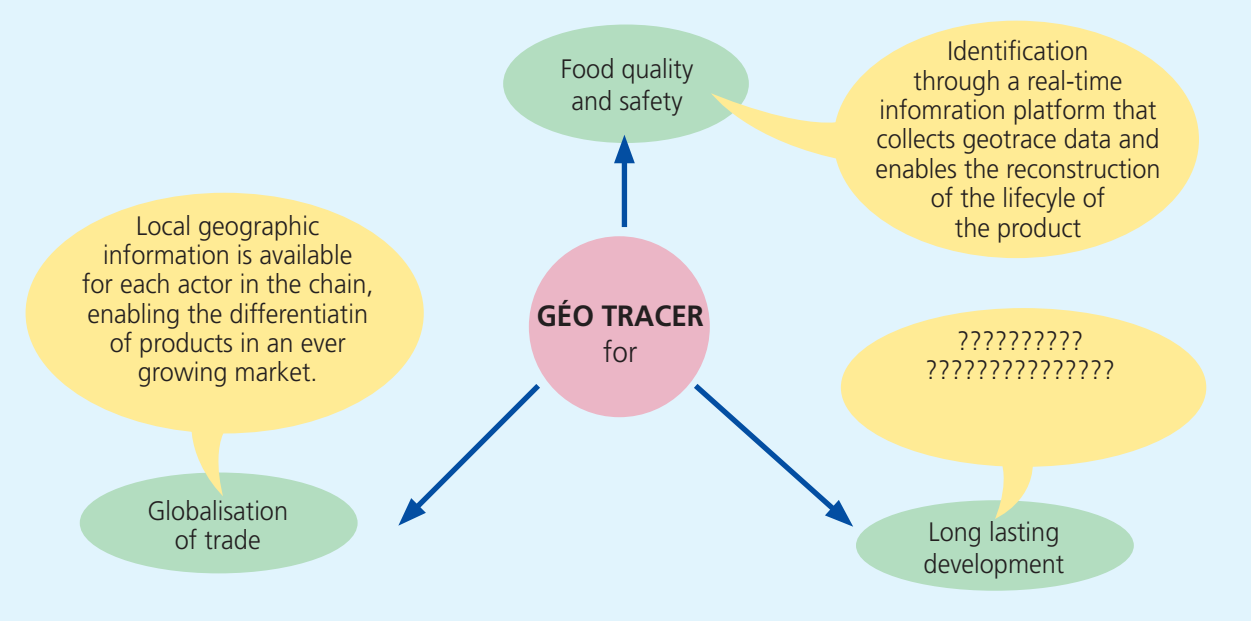
The three diagrams below illustrate the importance of geotraceability in the context of globalisation of trade.
- the objectives of creating added value for producers and animal feed manufacturers
- the strategic stakes covered by geotraceability

GLOBALISATION		LOCALISATION
Standardised/uniformity	↔	Quality certification
World-wide locations	↔	Specific geographic locations
Commonplace products of unidentified origins	↔	Products with identifiable roots/origins
Development of global brands	↔	Develoment of regional quality products
Mass consumerism	↔	Selective and demanding consumerism

The objectives



The stakes



Summary

Abstract

Are the universalisation and the globalisation of trade exchanges synonymous with a standardization in which agro-food products uprooted of their soil will no longer be differentiated from manufacturers or supermarket brands?
Original food products belong to the inheritance of the territories and the consumers are attracted more and more by their authenticity. The GeoTraceAgri project resolutely supports agriculture and the sustainable promotion of the territory as opposed to universalisation which standardizes and moves away those who produce for consumers. Geotraceability aims at associating information of geographical nature with the traditional data of traceability.

Farming origin and operations have become factual and verifiable data is available everywhere in the world, thus making it possible to bring additional guarantees to the signs of quality. The GeoTraceAgri (GTA) project largely contributed to the realisation of geotraceability. With the implementation from January 1,2005 of the new Common Agricultural Policy and its regulation imposing on the Member States a single system of declaration, all the agricultural parcels now form part of a European database of geographical references.

This new regulation reinforces the basis of the concept of geotraceability, whereas throughout the project it was necessary to define geo-indicators for integrated or crop production with very few geographical data on the farming precedents.
The development of the GTA prototype rests on a decentralized architecture and Web services. It was indeed necessary to conceive a system which is readily accessible on Internet for farmers, co-operatives and collectors, and potentially with the administrations which have control responsibilities. In term of acceptability, the potential users realise the potential economic benefits of the concept and of the indicators of geotraceability in their plan of exploitation, on the other hand sociological acceptability is less evident which induces the need for communication to make for its adoption.

This final report final illustrates the first stage : the GeoTraceAgri partners are continuing their research on the definition of an integrated system of geotraceability for the Common agricultural policy and the plan of analysis of the results of GeoTraceAgri should lead to the marketing within two years of an application making it possible to integrate the geo-indicators into management software for the actors of the agro food chain.

The project and the project schedule

The Project Starting Point

With the universalisation of exchanges, citizens became increasingly demanding consumers informed on the origin of what they consume and on the use of the territory of production of the agricultural produce. These requirements result in an increasingly large request for traceability starting from producers, through the intermediaries of the transformation chains and to the distribution of the products. The GeoTraceAgri consortium regards the geographical origin as a key element of traceability. The initial objective of the project was to answer the question how and until what point one could trace the geographical origin of the phases of production of crop productions. To be clear we want to show that it is possible to qualify the origin and the mode of production by geotraceability.

Thus on the basis of the example of agricultural geomatics - applied to the agriculture of precision, the consortium of the GeoTraceAgri project contributed to the development of indicators and tools for processing agronomic and geographical data which are relevant and likely to bring credible answers to the geographical traceability of the agricultural productions:

- to citizens concerned for food safety and environmental protection,
- to producers who aim at a durable agriculture to guarantee their sustainability and their profitability,

Scientific and Technical Objectives

On the one hand, there is a large variety of data necessary for better management of the rural environment: occupation and land use, topography, climatology, the type of ground, the hydro graphic network, outputs... These characteristics, associated with the cultivation methods inter or intra parcels (variety, fertilization, date of harvest...), are key elements to qualify agricultural produce and the impact of its production on the environment. In addition, the recent technological developments in the field of geomatics (development of aerospace or embarked sensors of teledetection, yield sensors, GPS...) currently have major consequences on acquisition, the processing and the representation geospatial data.

Because of the significant number of data of different sources and formats, it is necessary to standardize the mode and the format of acquisition in order to support the exchange between the users whether they are producers, advisers, agronomists, distributors or others.

GeoTraceAgri proposes to develop **a structured methodology of sampling, use and processing of georeferenced data**, which makes it possible to produce georeferenced indicators of traceability and agro-environmental follow-up of the vegetable productions on various scales.

This step must also take into **account the human dimension** by prioritising by a participative approach interaction between the whole of the actors within agricultural sector. The validation of the approach and the **use of a demonstrator prototype** contributed directly to the sensitizing of the users while ensuring a better use, access and geographical information management essential with the traceability of the food products.

The objectives of GeoTraceAgri:

The first task consisted in defining relevant indicators for the geographical traceability for integrated crop production by considering the various scales of space reference used (the agricultural parcel, the field, the catchment area and the area of label of origin controlled). Then the members of the GeoTraceAgri consortium proceeded to the development of a reference frame geomatic for agricultural traceability for each pilot integrated crop production. The third stage consisted in developing the data-processing infrastructure of support, accessible via the Web, for geographical traceability. Finally to prepare effective dissemination of this research, an evaluation and validation of the transposability of the GeoTraceAgri approach and its prototype were carried out amongst the users groups.

The Results

1) Selection and definition of relevant georeferenced indicators for the support of geographical traceability of the agricultural productions accompanied by a universal methodological framework.
2) Definition of a geographical reference frame and a methodological framework of support to geographical traceability which are based on the exploitation of information at the farm and at field production level, via the plan of farm and the graphic matrix (register).

1 Agricultural geomatics - A discipline with the objective to manage agricultural data with spatial reference and which uses science and technology related to their acquisition, storage, treatment and dissemination.

3) Development of a prototype to process, visualize and communicate on the Internet in complete safety the data essential to the geographical traceability of the integrated crop production selected.

4) The dissemination of the GeoTraceAgri approach to the whole of the European Community.

The major innovation of the project is the use of geomatics for traceability means of crop productions. Georeferencing of the data used (or which will be used) for traceability adds considerable value to with the current methods. The indication of origin (soil, region, country) becomes thus objective data because it is measurable instead of current indication based primarily on declarations.

Major Events during the Project Schedule

The forced departure of the industrial partner (Group AMI and of its subsidiary companies under contract) at the end of the first year necessitated the search for a new partner able to evaluate the scientific results by key actors of the food chain and to propose to the consortium a plan of analysis of the results to implement after the end of the project.
Several groups were approached and finally the CDER was retained by the partners because it brought essential experience in the exploitation of management and traceability systems at farm level.

In addition it was necessary to adjust the initial approach planned for the development of the GTA prototype to take account of specific competences of the new partner. An amendment to the initial contract was signed at a later stage, but the partners continued their effort without any interruption. An extension of three months to the initial contract was approved in order to finish as envisaged work as planned.

The research consortium

The Chamber of Commerce and Industry of Gers (CO1) coordinated the management of the project and intervened mainly on the exploitation and the dissemination of the results.

The Laval University of Quebec (CR2) coordinated all work relating to the definition of the geo-indicators.

The CIRAD had the responsibility to develop the prototype of decentralized architecture of the SIGWEB allowing the communication and the analysis of results via the Internet.

The Luxembourg University Foundation (FUL), attached to the University of Liege (ULg), coordinated all work relating to the standards and norms.

The Agronomic Research centre of Walloon (CRA-W) had the responsibility for the evaluation of the results.

The initial SME partner (The Agro Marchés Internationaux Group) had to withdraw in the course of program and was replaced by the Centre d'Economie Rurale (CDER) which coordinated the exploitation and dissemination of the results.

Three subcontractors (of the AMI Group) were replaced at the end of the first year by Intermalta, subsidiary of the Malteurop Group to validate the results amongst the key actors of the food chain.

The human resources devoted to the project represent 458 person/month (instead of the 408 envisaged initially). Each partner declared monthly and by name the human resources used in each workpackage. The total budget engaged over the 33 months of duration of the project is of 3,230.000 euros with a contribution of the European Union of 1,230.000 euros.

The working methodology

An Intranet website was set up at the beginning of the project to ensure collaboration between the partners. 6 meetings of two day consortiums were used to coordinate the whole of the work, 11 technical meetings by workpackage made it possible to solve the encountered technical problems. 36 one hour telephone meetings when all the partners were represented ensured good monthly work coordination. An Internet site (www.geotraceagri.net) made it possible to disseminate information on the project to all the scientific community and the European Commission departments.

4 Commission reviews and the involvement of two experts made it possible to evaluate the project every six months, the final review being concluded by an overall assessment of 4/5 "successful project".

The principal results

The concept of geographic traceability

Geographical traceability can be defined as the result of the association between geographical information and traditional data used in a traceability scheme. In the agro-food sector and more particularly in the vegetable productions sector, it is interested in the existing relations between a parcel production, its geographical origin, its environment and agricultural practices. In order to be implemented, it requires a spatial analyze and the use of tools, which are associated with Geographical Information Systems (GIS) and other data acquisition and treatment systems.

The objectives of geographical traceability such as defined within the framework of this project, are restricted to the upstream of agricultural productions and mainly concern :

- the promotion of quality and origin of products;
- the valorisation of specific agricultural practices based on written specifications and regulated by the sector or the competent certification body in the country ;
- a better risk management with regard to the food safety or quality of the products (impact of the environment on the product, respect of the written specifications).

Geographical traceability not only consists in the association of a geographic coordinate to information related to a production unit. One of the key elements of geographical traceability is the definition of specific indicators. Generally, an indicator corresponds to a synthetic vision of a whole system. It makes it possible to simplify the information and thus to simplify the communication process providing relevant information to end-users. A geographical indicator of traceability uses information with spatial reference relative to a product and its parcel of production by exploiting tools derived from geographical information systems (GIS). Like any indicator, a geographical indicator of traceability must meet various criteria, which are related to its relevance compared to the objectives or expectations of end-users and being based on reliable and easily accessible data.

Geo-referenced traceability indicators provide verifiable facts on the geographic origin of foodstuffs for both human and animal consumption, as well as information on adherence to quality and environmental production standards. At the farm level they able to better monitor production practices, thereby enabling them to bring an added value to their foodstuffs through certifiable provenance as well as through other measurable benefits that integrated farm and rural area management system should provide.

With respect to the nature and the quantity of data exploited, geographical traceability supposes an organization and a standardization of the information flows which is necessary for the calculation and the definition of the indicators. One of the goals of geographical traceability is to be able to respect a good practices guide coupled with acquisition or treatment standards and the diffusion of spatialized agricultural information through geographical information systems shared via Internet.

The normative aspects were studied in the technology watch part starting from the ISO and OpenGIS consortium specifications. The standardization on Internet (WEB SERVICES) were the object of a particular development just as the semantic aspects of the information and the interoperability of the information systems.

Taking into consideration these characteristics, geotraceability in agriculture puts together various scientific disciplines currently working in food safety and quality, plant production, environment, geomatics and database management including experts in standards and codification of data.

Acquisition, treatment and diffusion of the information on the geographical traceability

The issue of the GeoTraceAgri project was to propose a user's handbook together with standards for acquisition, treatment and diffusion of the georeferenced agricultural information through Spatialized References Information Systems (SIRS) shared via Internet. Analysis of spatial data acquisition methods is a major element of the set up of the geotraceability concept insofar as it relates to the sampling procedures and the quality of the information used for the calculation of the indicators. This analysis made it possible to establish the bases for the definition of the concept of data quality ranking.

With regard to the data treatment itself, a detailed attention was paid to the structure of the data as well as to the geometrical or typological correction necessary for their harmonization. The geocoding operations are particularly detailed.

The spatial or thematic databases requests tools were analysed as well as the creation of new attributes of spatial or non-spatial operators. One grants a large place to the spatial analysis and in particular to interpolation procedures taking as an example the climatological data. In the bibliographical part related to data representation, the emphasis has been put on the SIRS(Spatialized References Information Systems installation via Internet with many references relative to its architecture and the characteristics of its various components.

The various data formats were largely commented and detailed. The concept of interoperability as well as norms and standards relating to data models, data exchanges and metadata were largely documented, mainly starting from the specifications of the ISO and OpenGIS consortium. The standardization on Internet as well as Web services are subject of a particular development taking into account the semantic aspects to ensure interoperability.

The data necessary for geographical traceability

The calculation of the geotraceability indicators is based on various data sources of raw data providing elementary information on each production parcel, its environment, and its related agricultural practices, etc. Depending on the situations, the contents of the used geographical databases can vary. To make sure that the calculation of the indicators is possible, a minimal data set must be defined. This minimal data set necessary to answer the principal domain concerned by the indicators (food safety, quality of the products and quality) must at least comprise four main categories (fig. 1) of data :

- agricultural practices,
- characteristics of the environment in general (climatic, topography, pedology...),

- data concerning the direct parcel surroundings (woodlands, hydrography, roads....),
- events data (taking into account of temporal dimension).

The analysis concerning this minimal data set requires taking into consideration elements that are the types of data needed, the scale of work, the availability and the quality of these data.
The majority of the geotraceability indicators are defined at the land parcel level which is the basic unit of the geographical traceability. It is directly connected to a production unit, which represents the unit of technical and strategic level of decision for the farmer. The data used must therefore be compatible with this scale of work. Traceability requires managing a history for which the temporal dimension is of primary importance and must thus be managed at the database level.
The geotraceability indicators are interested in the existing relations between a product, a parcel and its environment. Their implementation thus requires having information on all the parcels of a given area. The availability of these data is a key element to take into account in order to allow the development of the indicators. Whatever its relevance and its interest, an indicator will not usable if it is based on difficult to reach data. It is thus necessary to be ensured, at the time of the definition of an indicator, of the availability of regularly updated data. It is also necessary to have sufficient information on quality of data in order to be able to correctly interpret the results obtained and to identify the operational limits of each indicator.

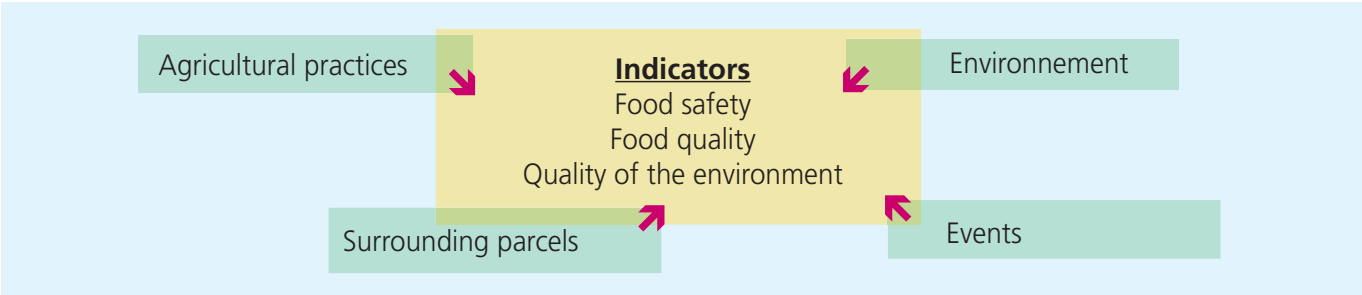


Fig. 1 : Categories of data used to calculate geotraceability indicators

The principal results

The indicators for geographical traceability

As part of GeoTraceAgri project, various geographic indicators of traceability were defined to be implanted in the prototype GTA (cf. WP7).

1. Definition of the geographic indicators of traceability

As any indicator, a geographic indicator of traceability has to answer various criteria such as : (i) to bring a synthetic view of a problem to facilitate the understanding of it, (ii) to be based on reliable and easily accessible data, (iii) to be sensitive to waited changes and (iv) to be understood and accepted by all the users.

But the geographic indicator of traceability has also to satisfy specific criteria. Indeed, it must also have a spatial character :

- **explicitly spatial :** it brings in a model which takes into account explicitly coordinates X, Y and operates spatial algorithms. The calculation of the indicator can be made only by the use of a Geographic Information System (examples : use of models of neighborhood, definition of an exclusion zone …)
- or **implicitly spatial :** it uses data connected with geographic objects (for example a polygone) but can be calculated without the support of a GIS. The GIS brings then simply a cartographic representation of data and\or indicator (example : contributions of nitrogen in kg / ha …).

Furthermore, within the framework of the GeoTraceAgri project, these geographic indicators have also to answer to a need of traceability ("capacity to redraw the history, the use or the localization of an entity by means of registered identifications", ISO 8402).

The innovative aspect of these geographic indicators of traceability lies in fact they heavily rely on the spatial relationships that exist between a parcel, its production and its environment (cf. figure 2).

The geographic indicators of traceability aim to facilitate communication among the various actors of an agri-food sector to allow (i) a better valuation of productions and good agricultural practices, (ii) good management of sanitary risks level and of the product quality as well as (iii) support in the decision (choice of agricultural practices, etc. …). Some of these indicators can also serve as tool of control for local, regional or national administrations, certification organization, etc. …

These indicators were defined with the various actors (from the producer to the consumer) of different food sector defined at the level of our five demonstration regions (cereal for Luxemburg, cereal and vineyard for Gers, cereal, feeds and animal productions for Belgium, banana for Guadeloupe and potatoes for Quebec).
The conception of these indicators leans mainly on production contract specifications of these sectors but also on the national even European statutory requirements (directive Nitrates, for example).

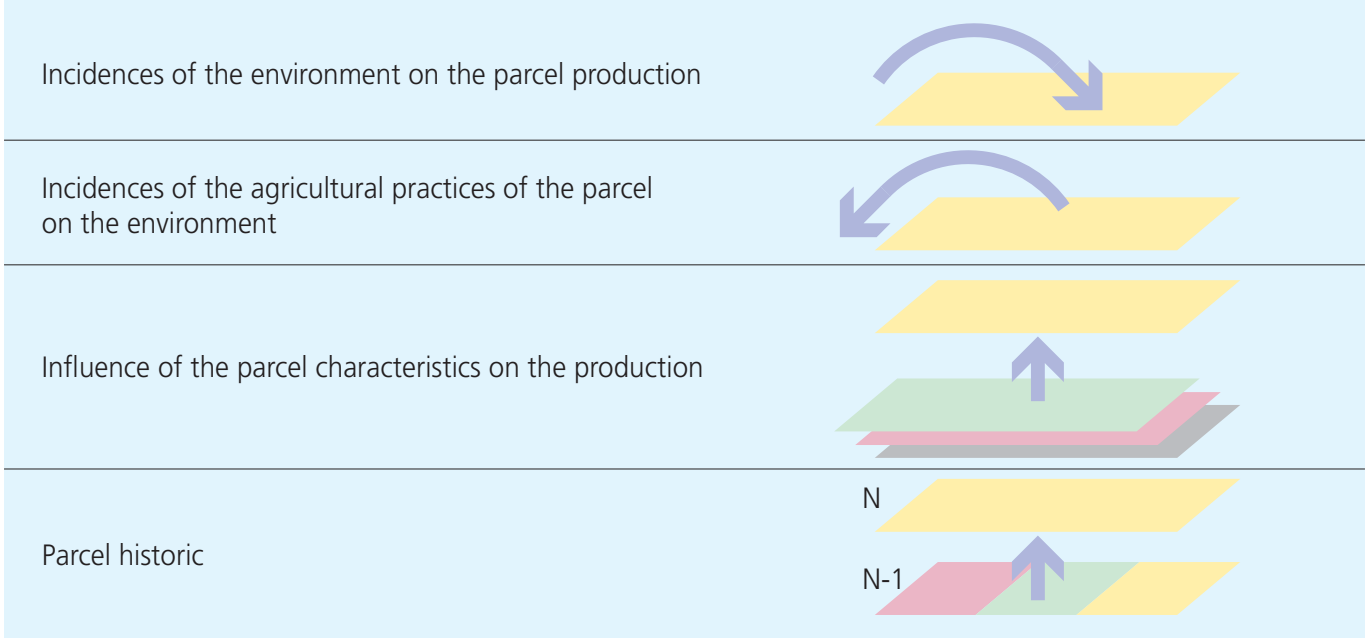


Fig. 2 : Spatial logics on which the geographic indicators of traceability are based

They deal with the main issues marked as priority ones :
- food safety,
- product quality,
- environment quality (impact on the environment).

For more detail on the definition of the geographic indicators of traceability, one will be able to refer to the deliverable 4.4 ("Report on indicators").

2. Conception of the geographic indicators of traceability

The geographic indicators of traceability are calculated using spatial data from existing spatial data bases in the various demonstration regions, farmer's record and the exploitation of satellite imagery or aerial photography.

Data availability is an essential parameter to take into account in the implementation of indicators. It is necessary to look for the best ratio availability /quality of data while taking care of their relevance.
For every indicator, a minimal data base is defined and contains four categories of information : agricultural practices, characteristics of the physical environment, the direct environment of parcel and data relative to relevant events.

Indicators are developed mainly at the parcel scale which is the basic unity for geographic traceability. Used data must therefore be compatible with this working scale.

The choice of a calculation method for the geographic indicators of traceability is guided by numerous criteria (objectives of the evaluation, available knowledge and models, etc…).
Geographic indicators of traceability calculation can be done in several ways (mathematical model, expert systems, etc…) and have, as part of the GeoTraceAgri project, to valorize as much as possible the GIS functionalities.
Limitations relative to these different geographic indicators of traceability calculations may arise that should not be forgotten to support decision in a rational way (to manage food crisis, etc…).

Difficulties encountered during the elaboration of the geographic indicators of traceability

Several difficulties were met during the elaboration of the geographic indicators of traceability.
These difficulties are in connection with: i) the indicators identification, ii) the implementation of the models of calculation and iii) the availability of data necessary for the elaboration of these indicators.

Concerning the geographic indicators identification, the majority of those which are existing in the literature has different objectives from the GeoTraceAgri project (durable development for indicators developed by the OECD, for example). Consequently, it was necessary to elaborate new indicators which answer specifically to the requirements and priorities of the user groups.

Concerning the implementation of mathematical models, proposed models are often too complex for an application in the GeoTraceAgri project (input parameters too numerous or difficult to estimate) or are not adapted to the geographic traceability. So, in the framework of this project, we insisted on the development of a specific methodology to elaborate geographic indicators of traceability which clarifies the purpose of the indicator, the type of user, the information connected to data, etc…

Concerning the availability of required data, ideal case would consist to have data at the "parcel level" covering all the territory. Most of the time, however, some information does not exist at this scale (level N_0) but can be obtained for smaller one (level N_1) (cf. figure 3).

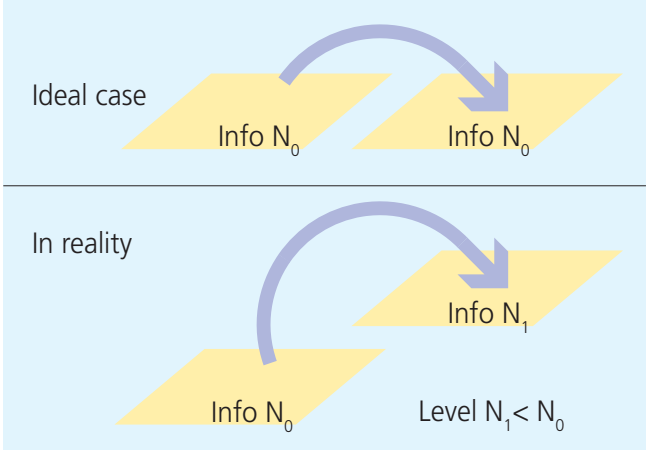


Fig. 3 : Levels N_o et N_1

The principal results

Level N_0 corresponds to the most detailed level of information, usually the parcel level for which the farmer supplies all information (declarative data). Major problem at this scale concerns the availability of data which will never be obtained for all parcels of the zone of interest.
To mitigate this lack, it was necessary to define a new reference N_1 level which corresponds to the level where an almost complete informative coverage of the area of interest is available (use of airborne data, remote sensing data, cartographic data and others).

NB : It is important to note that these levels of information are not in complete correspondence with the notion of spatial scale. Distinction between levels N_0 and N_1 is semantic before being geometrical.

The development of the geographic indicators of traceability takes into account this constraint during the elaboration of mathematical models. This multi-scale approach is one of the strong points of GeoTraceAgri and allows to disregard the main limitation of the current systems of traceability, which depend completely on the availability of declarative data to supply relevant results.

3. Definition of standards connected to the geographic indicators of traceability

The acquisition, the processing and the visualization of data used in the calculation of the geographic indicators of traceability require the elaboration of standards. These standards give information on the way how to elaborate indicators, how to get data for their elaboration and how to calculate them. The potential users of indicators and more widely of the GTA prototype can refer to it as to a guide of good practices supplying necessary information for :

- well understanding the meaning of indicators and to assure a good interpretation of obtained results,
- being able to reuse an indicator in another context, in another region or in even another country. Standards give indeed access to all the information allowing to reproduce the proposed methodology and to adapt it, if needed, to new conditions.
- to compare the results of the same indicator implemented in various regions.

The standards of every geographic indicator of traceability defined as part of the GeoTraceAgri project are defined at three different levels: the legal context, the data necessary for the conception of the indicator and the mode of calculation of the indicator.

Standards related to the problem indicate briefly the context in which were defined the indicators by clarifying rules, incentive measures or other contextual elements allowing to better understand the existing stakes.
Standards related to data necessary for the conception of the indicator concern the definition of the data, its precision, its spatial coverage, its mode of use, its units, its update frequency as well as the potential sources to purchase the data.
Standards related to the mode of calculation of the indicator explain the methodologies of calculation proposed to assure their reproducibility.

4. Validation of the geographic indicators of traceability

The validation of the geographic indicators of traceability is indispensable and can be broken down into three sequential approaches: validation of the indicator conception, validation of indicator results and validation of indicator use.

Most often, validation methods used are based on comparisons between indicator results and measured data (in situ, in laboratory). However, as part of GeoTraceAgri project, the measured data are available only for certain situations (climate, soils data, agricultural practices) while in the other situations (indicator of risks, for example), only opinions experts will be available.

So, the accent was put on the validation of indicators using opinions and critics of experts, the user groups of our demonstration regions and other potential users that are the producers, producers' associations, cooperatives, collectors and in a general way the set of actors of the vegetable productions sector.

The validation of the end use of the geographic indicators of traceability realized with an inquiry with about twenty potential users shows that the geographic demand of indicators of traceability is real. However, this one is far from being homogeneous and each of sectors has its own expectation and very precise criteria to satisfy.
One of the main qualities for an geographic indicator of traceability, except its accuracy and precision, is

The principal results

certainly its flexibility. Although a lot of persons were already conscious of the importance of the geographic dimension in traceability, indicators presented during the interview of validation allowed them to suspect the potentialities of this geographic integration.
This deliverable also presents recommendations relative to the quality control of the geographic indicators of traceability by insisting on three fundamental principles guaranteeing good results : input data with a controlled quality, model of indicator limiting the distribution of the error, and a user warned of the limits of the model which he uses.

5. Examples of geographic indicators of traceability

Numerous examples of geographic indicators of traceability were proposed within the framework of the GeoTraceAgri project. These indicators deal with the three main priority issues retained : food safety (examples : phytosanitaire and mycotoxin indicators), product quality (examples : seeds indicator, fodder indicator) and environment quality (examples : nitrate indicator, agro-environmental indicators) and are presented according to the spatial logic operated in table 4.

An biologic potato indicator was also proposed by the user group from Quebec. This indicator sums up the different issues involved in potato production and allows evaluating whether this production answers the requirements.

These characteristics are taking into account in the technical conception of the GeoTraceAgri final prototype.

For more details on these indicators, one can refer to the deliverable 4.4 ("Report on indicators„) which presents the problem, the objective, the necessary data, the frequency and the method of calculation, the precaution of use, the mode of representation, the bibliographical references which are associated to every geographic indicator of traceability defined within the framework of the GeoTraceAgri project.

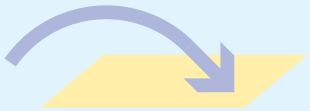
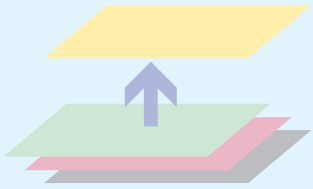
Spatial logic / Thematic			
Food safety		- Respect for minimal distances - Phyto-sanitary risk due to the neighborhood	Evaluation of the risk of presence of mycotoxins
Product quality		Respect for the rules of culture for the production of guaranteed seeds	- Quality of tossing of the hay - Evaluation of the Hagberg Falling Number - Effect 'soil'
Environment quality	Risk of surface water pollution by nitrates		- Intensification of animal productions - Respect for agri-environmental measures

Fig. 4 : Examples of geographic indicators of traceability define as part of the GeoTraceAgri project

The principal results

The proposed tools : the GTA prototype

A prototype of information system on the web has been defined and developed to address the specific needs of geographic traceability. It was used to perform experiments for validation and demonstrations.

1. System definition

The objectives for the GTA prototype were specified after defining the concept of geographic indicator of traceability. Three principal objectives were listed:

1. Calculate geo-traceability indicators

Defining geographic indicator of traceability is an important topic for GeoTraceAgri project. Calculating such indicators implies the importation and manipulation of spatial and non-spatial data, and the usage of spatial analysis operators.

2. Provide GIS capabilities on the web

A very important development effort has been made in the recent years to migrate geographic information systems to the Internet and the Web. Some tools and technologies have already reached a good level of maturity. The objective here is to take advantage of those developments and use recent state of the art technologies to bring geographic traceability capabilities to a broad range of final users through the worldwide web.

3. Seamless integration with legacy systems

The agro food industry is already using different kinds of information systems for management and traceability purposes. An information system dedicated to geographic traceability cannot be conceived as an entire system on its own, it is important to integrate that new kind of system with already existing platforms as seamlessly as possible.

From the objectives specifications, and after studying the work organisation of agro food industry, several constraints have been identified. Those constraints played an important role in the further design of the system architecture.

- Calculating indicators often based on spatial analysis operations, and in some cases on remote sensing images processing, require a high level of expertise and the usage of specialized tools. It means that such a work would most probably be achieved by external service providers who are specialized in spatial data processing.
- The information system for geographic traceability would have to adapt to an already existing environment of the agro food industry which is a set of heterogeneous software platforms. That constraint highlights the importance of interoperability when designing the GTA prototype.
- The exchanges of information between different actors of agro food traceability chain are organized as a network. Each actor being one node of the network and exchanging information with its neighbours. The structure of that network can change and evolve with time. It is an important constraint to take that evolution in consideration.
- Ownership of data and responsibilities must also be respected: every member of the traceability chain should remain the owner of the data it produces and everyone broadcasting information is responsible of its content.

2. System architecture

A centralized system was first imagined at the beginning of the project but the idea had to be abando-

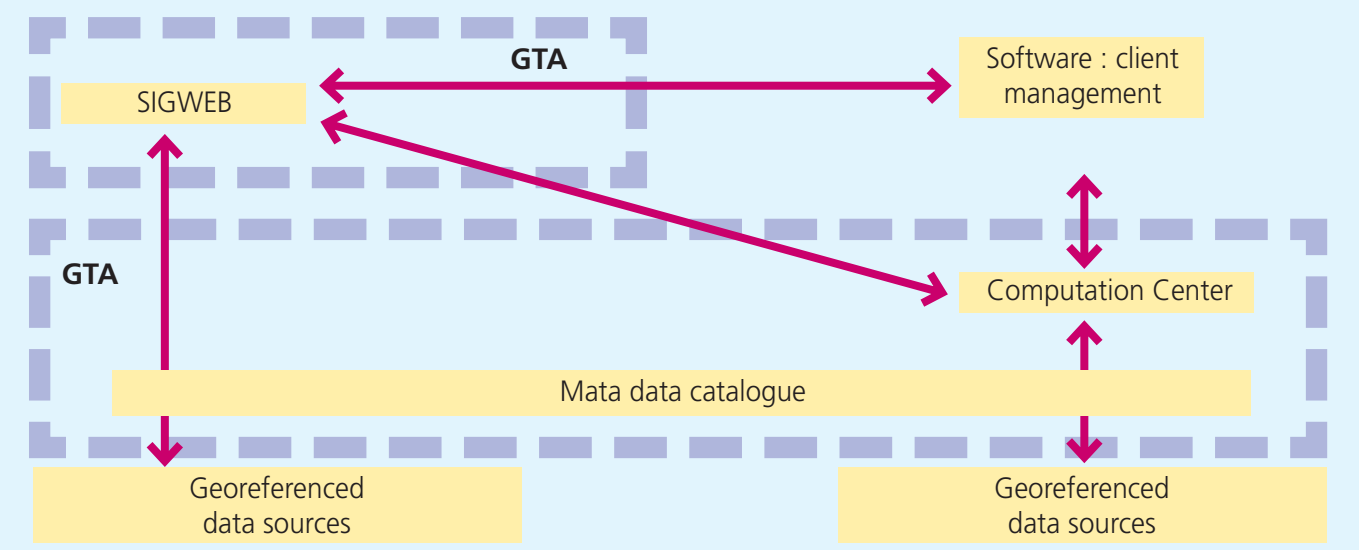


Fig. 5 : ??????????????????

ned because it was very difficult to meet the two later constraints: a changing network structure and data ownership and responsibilities.

The general system architecture that was finally adopted is a distributed system: a network of sub-systems communicating with each other using web services.

Every sub-system can provide one or more service to its environment in the network, and specialized tasks can then be treated by specialized providers. The structure of the network can grow and evolve without affecting dramatically the implementation of sub-systems. The actors of agro food traceability chain can remain the owners of their data and provide some information only to a restricted number of users. The usage of web services technology (which is a broadly adopted recommendation of the W3C) ensures that every sub-system is defined by the way it communicates to others rather than by its inner implementation details; hence it is possible to communicate with many different kinds of platform, addressing the constraint of integration in a heterogeneous environment. Web services being supported by a rapidly growing number of software platforms, it is expected that an important choice of tools will be available in a close future.

Of course, using web services is not enough to make sure that all sub-systems will communicate with each other seamlessly. The content of messages that are exchanged must also be structured in a way that is well known by both sides: the sender and the receiver of the message. To address those important interoperability aspects, a set of specifications are defined by ISO and the OpenGIS consortium. It was decided to rely on those specifications as much as possible in the implementation phase of the project.

3. Implementation works

Even though that system architecture could be used on the full scale of an agro food traceability chain, it has been necessary to reduce the scope of experiments to the beginning of the traceability chain in the context of GeoTraceAgri project. Two reasons are at the origin of that decision :

1. Many geographic indicator of traceability defined in the project are related to agronomic practices or the environment of plots.

2. The management and traceability information system on which GTA prototype has been attached is specialized on the beginning end of the traceability chain.

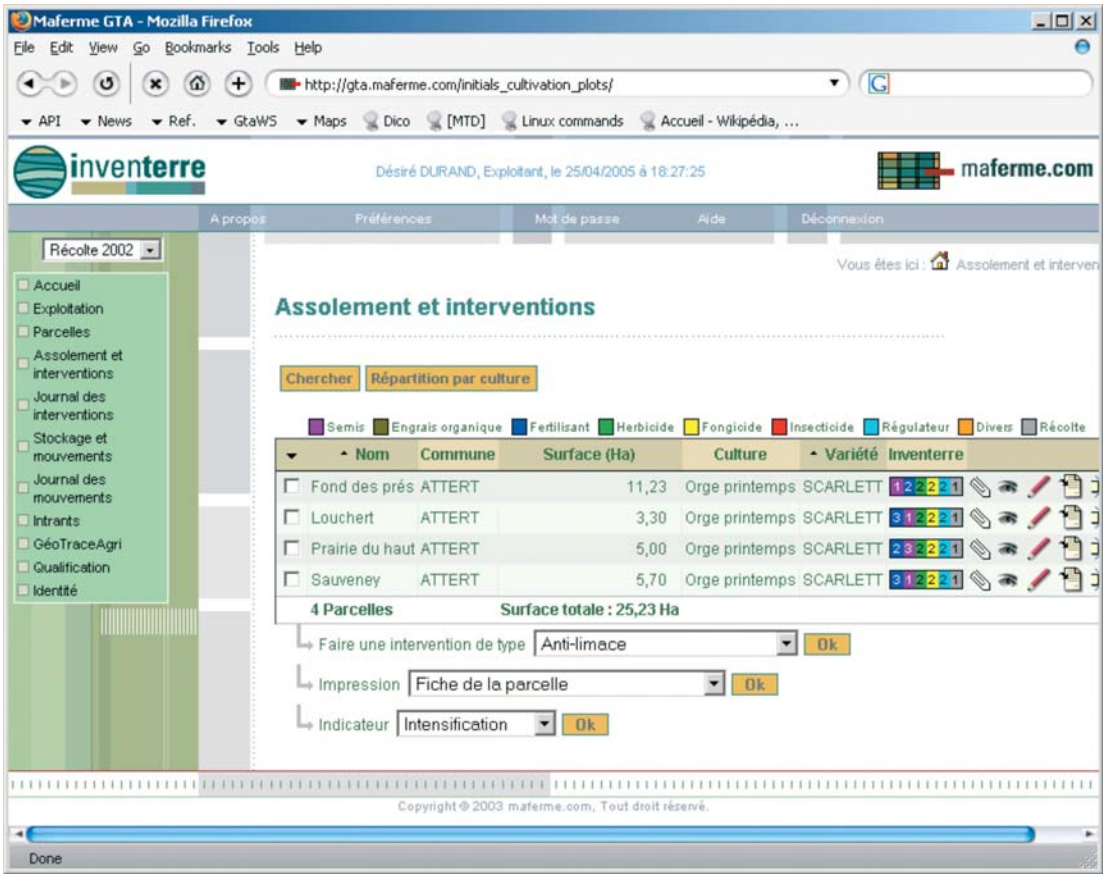


Fig. 6 : Screen capture of the management and traceability web user interface

The principal results

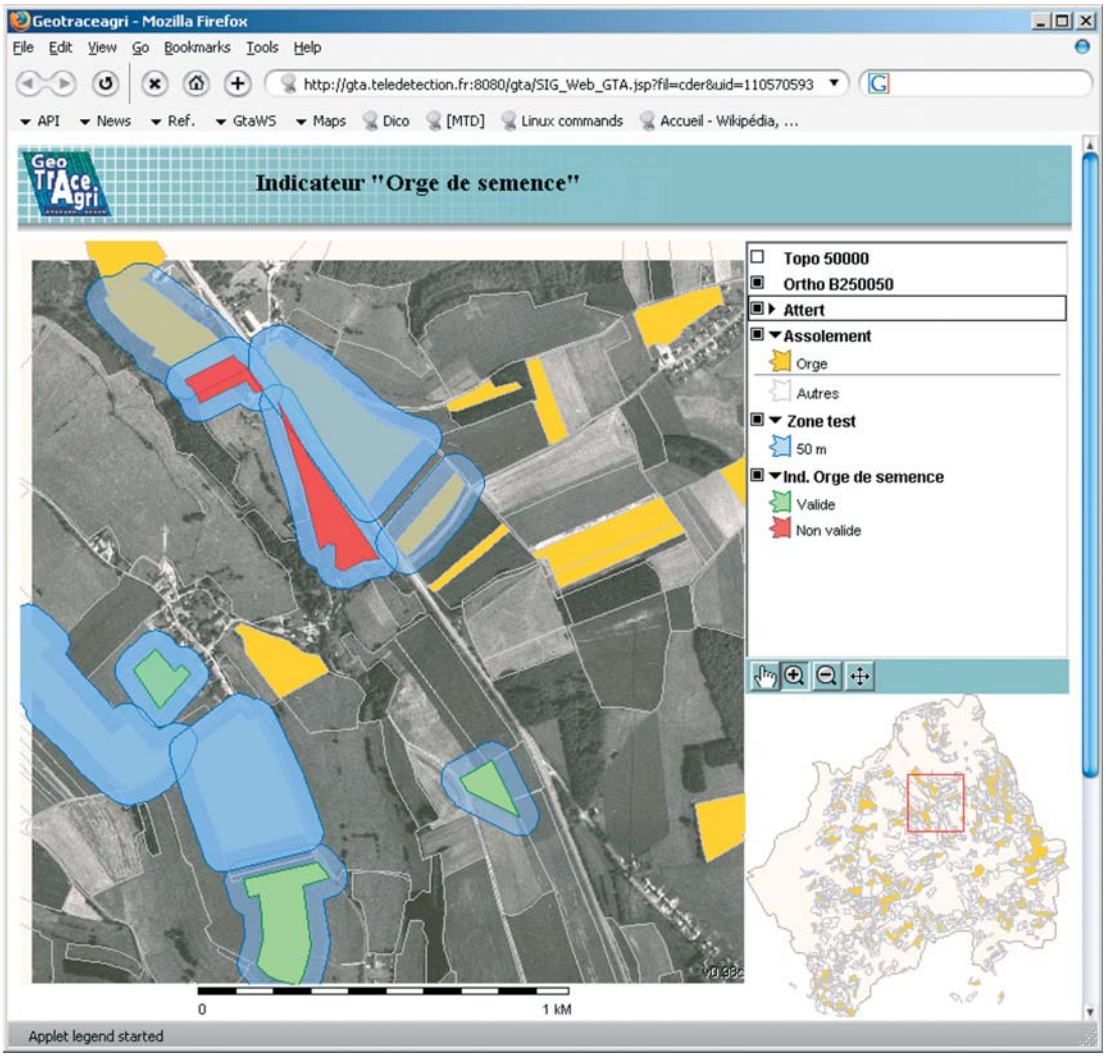


Fig. 7 : Screen capture of the GIS/Web module cartographic web user interface

Considering that experimental context, a set of specialized software modules were defined for building the GTA prototype, each module being an independent sub-system and playing a specific role.

Four types of modules for the GTA prototype :

1. The management and traceability module

That module was built by adapting an already existing system. Its role is to manage agronomic data and keep the history of work that is being done on the plots. It is also to provide a unique user interface entry through a web server.

2. The GIS WEB module

This module extends the management and traceability module to provide several services related to geographic traceability :

- It manages the demands of indicator calculation
- It submits calculation demands to the appropriate calculation module
- It produces cartographic representation of the results and returns the maps and result data to the management and traceability module.

3. The indicator calculation module

It is an expertise service module, specialized for instance in spatial analysis or remote sensing image processing. The calculation demands sent by the GIS WEB module are treated and the result is returned. To perform its calculation task, this module has to locate the source of data it needs and import data from that source. This can be done by consulting a meta-data server module.

As different members of GeoTraceAgri have defined their own set of indicators of geographic traceability, more than one indicator calculation modules were built; every module being specialized for the calculation of a series of indicators.

4. The meta-data server module

Interoperability between sub-systems treating geogra-

The principal results

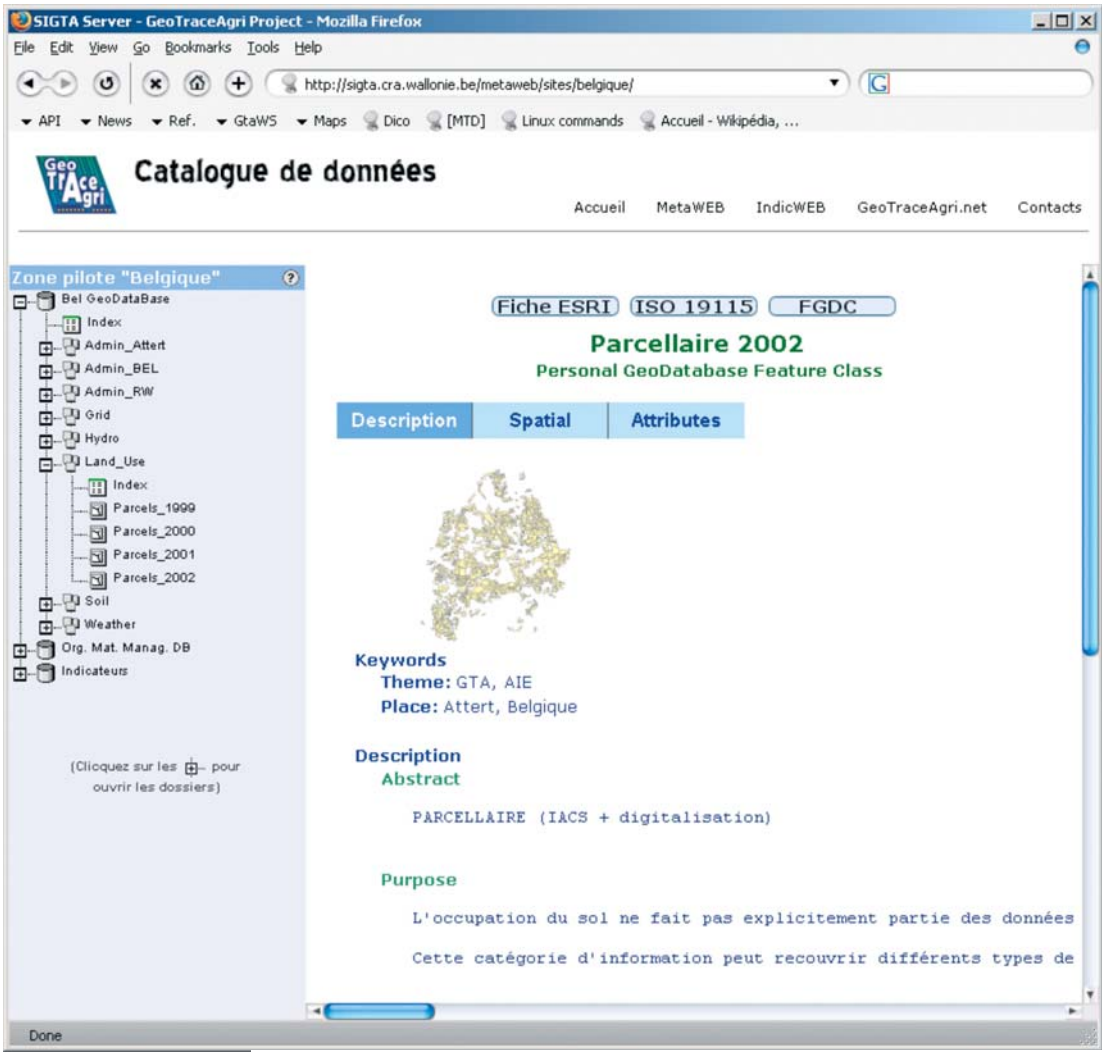


Fig. 8 : Screen capture of the meta data server module web user interface

phic information could not be achieved without associating meta-data to the available sources of spatial data. The role of the meta-data server is to provide a set of information related to the different data sources available. The meta-data server that was built for the GTA prototype could be viewed through a human user interface. In a close future it is expected that the CAT OpenGIS specification will become broadly available and it will then be possible to get meta-data information from a server in an automated way.

4 Results and recommendations

A distributed system architecture proved to be the best solution to meet the requirements and constraints of geographic traceability for agro food industry.

The separation of tasks in specialized sub-systems is also a powerful concept especially adapted to geographic traceability in the way that experts in spatial analysis and remote sensing image processing can provide their own services and integrate easily in the whole system.

The GTA prototype itself was built using several different platforms, several different languages, several different types of databases, several different mapping engines, and several different spatial processing libraries, proving by its own nature the relevance of its conception.

It would have been impossible to meet all the constraints that were identified for the purpose of geographic traceability without the recent development of international standards related to geographic information and interoperability on the internet. We expect that the important developments that are being made by software editors but also by open source communities around the world to respect all those international standards will help building complex systems such as the GTA prototype with more ease in a close future.

Exploitation of the results

The validation of the results

1. Internal and external validation

The GeoTraceAgri project has been validated by two different ways :

- A first validation concerned the geographical transposability of the GTA tool : three data sets have been collected and implemented in the prototype. Here the GTA partners judged themselves the easiness to calculate the indicator "Semences certifiées d'orge de brasserie" with different data sets.
- The second validation deals with the acceptability of the GTA project by user groups. In that way, about 25 European operators in agricultural sectors were questioned in order to evaluate economical, sociological and technical acceptability.

2. Validation of the geographical transposability

Three data sets have been collected and implemented in the prototype (developed in the WP7) for demonstration and validation purposes:

- One of them was used to build the prototype itself (Belgium data),
- The two others (two French ones) were used to study the geographical transposition of the prototype in other countries or regions.

These data were imported in the prototype by the GTA partners in order to calculate the same indicator : "Semences certifiées d'orge de brasserie" with other data sets.

For those three cases, two kinds of data were imported :

- Field boundaries (geographical data),
- Field information, including operations (attribute data).

The link between geographical representation and attribute data has been done thanks to a key based on the combination : Farm - Harvest year - Field code.

All these data were not available in the data bases of the collectors. So data are coming :

- or from the collectors themselves, either from administrations (disposal is then ruled by a contract),
- from different software and existing databases. So, they were stored in different formats.

Manipulations were necessary to fit the data with the format expected by the GTA prototype. The main transformations concerned :

- coordinates system,
- key definition,
- file format,
- operations and input codes…

And even imagination of a few fictive data to complete real data sets to have all data necessary to calculate the indicator.

This validation concerning geographical transposability put forward the difficulties to constitute a complete data set, which would fit the format expected by the prototype. These difficulties are due to:

- poor availability of informatic data set in real time,
- non exhaustivity of the data set,
- authorizations to communicate private data.

3. Acceptability measured by user groups

The second validation concerns the acceptability of the GTA project by potential user groups.

Acceptability means:

- Acceptability of the concepts of geotraceability and indicators as well as acceptability of the tool developed to treat geotraceability,
- Sociological, technical and economical acceptability.

In that way, about 25 organisms in link with enlarged agriculture (cooperatives, administrations, experts…) based in France, Belgium, Spain, Germany and Sweden were solicited to give their point of view. Productions were also diversified: cereals, viticulture, forestry, fruits and vegetables, maltery… So we had a better point of view of the farm-produce industry about geotraceability.

This validation has been led through interviews managed by each GTA partner. Before the first meetings, the partners agreed on a common progress. This homogeneity concerned :

- arguments,
- progress of presentation (alternation between slides, questions and on-line presentation),
- documents (slides, questions…).

To facilitate the way to note the answers and their analysis, a questionnaire with closed questions (multiple choice questions or notes) was elaborated.
This protocol has been followed by each partner, excepted for the meeting concerning German and Swedish organisms.

The main results are :
- Concept of geotraceability is interesting for many enterprises,
- But geotraceability is a new concept and needs to be explained,
- Indicators need to be refined (parameters…) to take into account the constraints of each country and each crop,
- Data property is a sensitive point for cooperatives (cereals) and administrations,
- The tool seems quite complicated to use and training is welcome,
- However graphic interface is convivial.

The exploitation programme

1. An environment more favourable to geotraceability

Three recent tendencies and regulations suggest that the concept of geotraceability will be essential in the medium term :

1-a. The Use and valorisation of geographical data

The tools making it possible to treat geographical data have for the last three years started to be more widely available for agro-food companies and also for farmers. The geographical dimension of information becomes thus more accessible than it is in the form of basic use (raster or of vectorial objects such as parcel contours). The knowledge and the acquisition of applications integrating a geographical dimension touch in particular the sector of crop production and the services of spreading livestock effluent or organic mater. Even if amongst farmers the number of those equipped with a mapping solution of parcel management remains a small proportion today (less than 5%), much of them have been informed about the availability of geographical data via service providers (co-operatives, seed companies, support and advisory services…). An obstacle to the exploitation of the data is consequently removed and will allow a better exploitation of the spacial data.

1-b. The graphic CAP

The graphic CAP is imposed on all the Member States as from January 2005. The development of the graphic CAP in Europe thus constitutes a crucial element to support a graphic approach of agricultural management such as traceability.
Via the Land Parcel Identification System (LPIS) there is from now on the possibility of acquiring and of using parcel contours and of having geographical data at minimal cost which was up to now difficult to obtain in a systematic way.
It constitutes for the farmers and their co-operatives or primary transformers an opportunity of follow-up and management.

1-c. Traceability

Since the 1.1.2005, regulation 178/2002 obliges the producer to guarantee the quality of its productions and to set up means of traceability.
Because of the universalisation of the exchanges the geographical origin of the products is more and more badly known. If world trade has been very quickly set up, the same does not apply for methods of control which make it possible to determine the origin of food products. There is an urgent need to develop this kind of tool, and the capacity for the actors of integrated production to find this geographical origin quickly.

2. The consortium agreement guarantees the involvement of all partners in the exploitation until 2009.

2-a. Accompaniment of the scientific contractors

As envisaged in the endorsement n° 1 with the Agreement of Consortium signed by all the partners of project AWG, CDER Informatique in charge of the exploitation

Exploitation of the results

of SIRS (Système d'Information à Références Spatiales) will be accompanied in the scientific and technical plan by the CRA-W, U.Laval, Ulg and CIRAD as regards their fields of competence and their expertises primarily in the agronomic and geomatic sector.
This scientific and technical support will be contracted case by case according to conditions to be defined between CDER Informatique and the scientific contractor(s) in question. The plan of dissemination of which they will be the major actors by their scientific papers, their research tasks based on concept AWG, the information they will dispense, will be in coherence with and relate to the exploitation programme.

2-b. Additional dissemination and marketing by the CCI Gers

The CCI of Gers which is setting up a technological pole for geomatics joining together Research, Training and the hosting of companies specialized agricultural geomatics will give its support for the analysis of the results of AWG in the following way :

- Search for funding through European, national and regional projects allowing to widen the initial partnership and to find financings
- Promotion and diffusion of the results of GeoTraceAgri within the framework of the promotion of the geomatic pole

3. The benefits of the GTIS CAP project

The Geotraceability project Integrated System for the Common Agricultural Policy (GTIS CAP) coordinated by the CCI of Gers is a specific support action of the European Commission of 15 month duration (Oct. 2004 - DEC 2005).
This new project's objective is to succeed to build advanced prototypes of integrated systems of geotraceability which meet CAP requirements of management, follow-up and control and which will give to the users added value in the management of their exploitation.

The GTIS-CAP project represents a worthwhile contribution and a real opportunity for the implementation of the exploitation programme of the GeoTraceAgri project. The fact in particular of being able to associate the traditional data of traceability with the entire parcel of one region through LPIS and to integrate into it additional data resulting from the satellite imagery to define simple indicators of geotraceability is an important element and a relevant response to the problem of the data available relating to the context of production parcels.
The implication of the administrations through the LPIS data bases and the study of the possibilities of reaching online these data and thus of bringing a greater effectiveness in the exchange of information between the various actors of an integrated production chain is likely to create new synergies on the level of the project and to identify new tracks of exploitation for GTA
In this context the analysis of the norms and the standards making it possible to ensure the exchange of the data and the interworking of the systems of management of the farms with the systems set up for the management which is envisaged in GTIS-CAP, will be able to reinforce the base necessary in order to guarantee the interworking and commercial exploitation of the GTA concept.

The realisation of an operational application

By taking into account the comments and the requests from companies which were surveyed and the current state of the prototype, we propose the realization of the product in several stages :
Design of GIS WEB engine independent of the computer centre of indicators:
The purpose of this is to make it possible to the users to profit, before or after calculation, from a possibility of work and valorisation of cartographic information that it has permanently, without having to use another GIS application for that.
Development of the integral computer centres of the simple indicators or the modelled and skeletal indicators.
The objective is to be able to approach the users under two axes :
To answer the demand for a simple use of the cartography before engaging a step of calculation of indicators.
To be able to offer a specific service to companies which would not wish to adapt the tool for regular management.

4. The creation of a support service with the assitance of scientific partners

The installation package would include in particular the following services :
- Adequacy and feasibility study.
- Modeling of the desired indicators.
- Development of the links between the internal base of the user and GTA or parameter setting of Maferme GP.
- Development or adaptation of the engine of calculation of the indicators.
- Collection of the geographical sources necessary and integration within the base.
- Integration of the GTA system definition of the parameters of confidential nature of profile access.
- Training for the users.

Exploitation of the results

- Follow-up service and maintenance: role to be defined and shared between the industrial data processing operator and the technical organization which creates the model of calculation.

5. The methods used by participant 8 person/ year over 2 years

Four methods whose realization can overlap in time : marketing, IT development, commercial network, and communication.

Marketing

Market research on definition of type of GTA tool envisaged, with the objective to ensure a potential market and the capacity to finance this type of investment. Its results could of course modify the course of the data-processing developments.

- The constitution of the target canvassing files
- The creation of supporting commercial material.

IT development

The main concern is the continuation of the development or the development of the SIG WEB Engines and the computer centres of the indicators.

- GIS WEB Engines : Before any development, it is envisaged to carry out an inventory of the tools and new technical possibilities of realization of a GIS WEB .Indeed the technology evolves very quickly in this field, and compared to the choices carried out for the creation of the prototype, and despite the availability of standards which it encompasses, there are new products today to observe one could possibly re-examine the initial choice. The goal is of course to achieve improved productivity, adapting as well as possible to the nature of the expected product, and to keep a capacity to evolve within the best technical and commercial conditions. The development will have to also take into account a multilingual use, allowing the translation of the data dictionaries.
- Calculation of indicators Engine: this development will be based on a co-operation between the scientific partners of the GeoTraceAgri consortium.

The commercial network

The diffusion of a GTA application requires that the directors and managers of agro-food companies meet to negotiate terms.

It is thus imperative to have a qualified sales network in the field : the profile would be that of a technical-commercial engineer, and agronomist. Within the framework of the diffusion in France, CDER can assume marketing by using its existing network. Elsewhere in Europe, the policy of the CDER is to create partnerships and commercial agreements for the diffusion of its applications.

It is thus planned to proceed in the same way for he GTA system

Communication

This could be achieved by the following actions: press coverage, advertising, participation in shows and events targeted at the themes of traceability or Geomatics.

The axis of GTA communication will highlight the notion of the indicator to differ from other solutions which treat cartography but without any relationship to calculations of indicators of traceability.

Exploitation of the results

EXPLOITATION PLANNING

	2005	2006	2007	2008	2009
ACTIONS (par trimestre ??????????)					
Preliminary study					
Market study					
Technical study					
Computer development					
WEB GIS					
Computation of indicator	BASIC SPATIAL REQUEST				
Dev. Specific indicator			SPECIAL REQUEST		
Marketing					
User support					
Commercial support					
Advertising					
Comitee - rules					
Launch on market place					
Commercial partner	DISTRIBUTION NETWORK				
Phase 1 first market					
Phase 2 extension specific indicator					

Conclusion of new projects in geotraceability

With the aim of sustaining their research the partners of GeoTraceAgri presented several research projects in the 6th PCRD priority 5 "Quality and Food Safety "implementing the concept of geotraceability : two actions of support specific (GTIS CAP) and a project integrated Track & Trace (T^2)

Through its project of the technological geomatic centre, the CCI of Gers wishes to develop with its partners the installation of a European platform of research into geotraceability in fields beyond agriculture, such as environmental protection and water management.

GTIS CAP

The aim of GTIS CAP is to define and to validate an integrated information system that will serve both the European and national administrative bodies in charge of the Common Agricultural Policy and the producers of vegetal products for consumers and for livestock. GTIS CAP will complete the IACS/LPIS data with other data obtained from remote sensing and will define simple geo-traceability indicators aimed at the management, control and monitoring of the CAP and which can also be used in integrated agricultural management systems.
GTIS CAP will facilitate online access to this geo-traceability data and will ensure greater efficiency in checking and conformity of good agricultural practices, in line with CAP recommendations.

The GTIS CAP project comprises four different types of work:

1. The evaluation of new functionalities necessary for the integration of geo-traceability into existing tools and for it to become a CAP management, follow up and monitoring tool which will also be useful for producers.
2. Definition of norms and standards that will enable the interoperability of IACS/LPIS geo-referenced data and functionalities for CAP management, follow up and monitoring.
3. Definition of simple and easy-to-use geo-indicators provided by satellite images.
4. Implementation and validation of the evolution of the integrated system in two test regions in order to produce after experimentation by producers groups a recommendation for European and national administrative bodies.

Track & Trace

The aim of T^2 is to strengthen consumer confidence through a sustainable, easily understood food traceability scheme that is financially acceptable by all stakeholders from farm to fork. T^2 focuses on providing (i) an innovative, economically viable mechanism for recording reliable, accurate data on the origin and primary production method of food/feed (*from farm*), and (ii) the consumer with a distinctive marque on both product packaging and check-out receipt guaranteeing the traceable provenance of a food item (*to fork*).
Through geo-referenced traceability, based on sets of standardised indicators, T^2 provides verifiable facts on the origin of food/feed, as well as information on adherence to production standards, enabling quality and authenticity to be guaranteed. In line with EU legislation due to come into force in 2005, T^2 geo-referenced data will link to the traceability information recorded by operators throughout the food chain. Using a product's standardised codification system (EAN 128, EPC etc.) as input, information on geographic origin, production methods and dates will be publicly accessible via the Internet.
T^2 will allow crises/potential crises to be better managed through accurate traceability back to its primary source, ensuring accountability from and between all operators in the food chain - as well as enabling food-safety authorities to act quickly in a crisis situation. It will also enable better monitoring of food provided in public institutions - schools, retirement homes, hospitals... At the farm-end of the chain, co-operatives/ syndicates will be able to better monitor production practices, thereby enabling them to add value for their farming communities through certifiable provenance.
As part of its take-up activities T^2 will set up incubator centres for training, demonstration and promotion of best practice in the production of foodstuffs. These centres will act as the 'seed' for a subsequent network of excellence across Europe.

For more information

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Direct contact with the project partners

Follow the project's progress, see all research material and deliverables etc. Access granted by the coordinator(following agreement by the validating committee)

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