Combatting Soil Degradation and Desertification in the Far North Cameroon Through A Webmapping Application using Opensource Tools

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Abstract-- **ReviTec® is an ecological approach to combat soil degradation and desertification in the world. The activities of ReviTec require information on plants that are spatially distributed in the experimental sites. In the light of the management of spatial data in the experimental sites, ReviTec® researchers realize the difficulties to collect and analyze these data so that they might come from different sources and especially from different formats, which makes this analysis tedious. Geographic information systems (gis) try to respond to this problem, by coupling them to the WebMapping, it makes easy to disseminate and manipulate objects directly on a map for a very relevant and effective management of these data. Our work is to integrate and to adapt the webmappping technology in the monotoring system for the management of the activities of ReviTec using Open Source tools.**

Keywords : ReviTec, webmapping, gis, disseminate objets, manipulate objets.

I. INTRODUCTION

In many parts of the world, man's exploitation of terrestrial resources overstressed the ecosystems'resilience, which becomes evident in the degradation of the soil and desertification. [1]. To combat soil degradation and desertification in the world, environmentalists of soil and vegetation of the partnership KeKo (Kesel, Koehler & Associates biologists) and the Centre for research on the environment and sustainable technology (UFT) at the University of Bremen [1] have developed ecological rehabilitation called ReviTec ® technology. This ReviTec® technology aims to combat soil degradation and desertification in restore specific sites by tree-planting and soil rehabilitation. To carry out its activities, ReviTec must have information on the growth and the exact distribution of plants in experimental sites in real-time. In addition, the spaces of cultures and the consideration of the space occupied by plants requires the spatial information. In view of the management of data on plants to spatial reference by ReviTec, it therefore appears necessary and urgent to develop a geographic information system integrated in a web environment via the concept of WebMapping which will serve as a tool for spatial analysis. This tool will enable the monitoring online of the activities of ReviTec (monitoring) which was formerly manual and stored on the Excel files.

The development of the geographic information system, the Internet and Web technologies has enabled the emergence of the WebMapping in the 1990s. This technique of dissemination of maps via a computer network continues to make its evidence especially in the exploration and the manipulation of space objects. With the evolution of the Internet, WebMapping, or online mapping and Location Based Services (LBS) are today a new environment of consultation, management and creation of geographic information where the user is seeking and manipulates information on a spatial basis rather than instances of type keyword. Mapping and geolocation of objects, services, activities or even ideas, took considerable importance in the daily practices of Internet users. Mapping online, offers any type of public, ways to overlay the traditional geographical maps, information and services, thereby substantially improving the added value maps. In addition the development of mapping platforms online such as Google Map and Open Street Map allowed the geolocations of places in the globe and whose most is not limited only to the display and dissemination of spatial information of statically. But also the interaction with geographical objects on the map. However these platforms of internet mapping do not allow to manipulate personal data because the data is stored in their own database.

The use of geographic information sciences allows to modeling and manage localized data using digital representations. The creation of maps and the management of geographical data using Geographic Information systems (GIS) provide greater speed and offer tools constantly innovating in the analysis, understanding and solving problems based on real data. Tools exist, but because of their cost, access to these software limited users and companies with sufficient financial means for the acquisition of

software, very often the user must acquire the pack while in most cases, there is need for some functions. In addition, they require familiarity, if not trained in the software as well as the development language accompanying it [6]. It is therefore important for us to study the setting up of such a system by using free products and open source that exist.

II. OPPORTUNITIES OFFERED BY ONLINE MAPPING

Online GIS are very great importance especially for structures manipulating data spatially localised. Although the outcome mapping allows easier understanding of the surrounding space, implementation of such platforms requires transversal skills both in computer science and geography [4].

Based on the services that can offer online GIS, Green and Bossomaier [5] divided them in two categories. The first category offers one of the most prevalent features of the GIS online: the spatial location-based queries. It involves the selection of space objets such as regions or points. An example would be a system offering a flexible interface and widely accessible to the user by offering several options (layers, colors, textures,...) and that is to create his own map by selecting layers. The user performs no modified data and it remains limited by the options that offers it such a system. An example is the virtual tourist (The Virtual Tourist) [7].

The second category allows design and dissemination maps online. In contrary to the first category the user can add his own data in database which involves control access. It gives as an example of this category, online GIS offers the user add its own information as propose Charles Sturt University in Australia [10].

- **mapping solution of Implementation a webmapping platform**

This kind of solution, uses a map server which is a program in the form of CGI application, servlet Java or other form [2]. A map server is designed to create maps at the request of the remote client and, depending on the settings chosen by it [9]. Located on the server, it works with the Web server and is an interface between the sensible communicate with the client through Internet and the cartographic data server. It can also play the role of a Server Web [2]. There are two categories of map servers: open source and owner. Open source servers have the advantage of being inexpensive. Very malleable, they can easily be customized. However it requires solid knowledge and regularly updates and programming skills. There are multiple servers mapping open source, among them Geoserver. Proprietary solutions look like GIS desktop in terms of features. These are turnkey solutions, requiring a simple familiarization training.

GeoServer operates under a three-tier architecture: a client for display, a Web server and a database server. It is also possible to integrate a spatial DBMS such as PostGIS. GeoServer has the advantage to settle on various operating systems. Anyone with a browser can access a Geoserver application. An owner such as ArcIMS solution offers its application development tools, the formats used are also specific even if other formats are sometimes tolerated [8]. The acquisition of the licence cost is quite high and depends on the chosen formula (number of posts, volume of data, etc).

The features offered in this type of solution are numerous and varied [8]. GeoServer allows the display of a large number of formats of raster images and vector. It is easy to get through the setup of the shapefile files. The zoom, the displacement map and advanced options are available (transparency for example is available) and dependent on the configuration of the shapefile file. Advanced options are also available. Note that for both solutions, each Zoom performs is loading a new image, where a certain heaviness.

III. THE CURRENT MONITORING SYSTEM OF REVITEC SITES

ReviTec® is an ecological rehabilitation technology developed by the Bremen-based partnership corporation KeKo (Kesel, Koehler & Associates Biologists) in co-operation with the Center for Environmental Research and Technology (UFT) of the University of Bremen [15]. It aims at combating degradation and desertification by the re-establishment of site-specific ecosystems with their peculiar ecosystem services. This is achieved by erosion control, substrate management and fostering of site specific biodiversity. The measures include soil and water conservation, restoration of degraded and polluted soil and ecological afforestation [15].

The ReviTec® approach focuses at the initiation and acceleration of ecological succession (conservation in a dynamic sense) with a mosaic-type exposure of a special substrate mixture which may be filled in biodegradable bags for erosion control [15]. The ReviTec® bags can be exposed flexibly to the topography and modularly arranged to structures, such as small islands, bunds, half-moons, etc. [15].

- *Data collection and processing*

To follow the growth of plants, the data collection in both sites was organized in three repetitions in time. The first collection was carried out in April that was the beginning of the rainy season; the second was in July ins the middle of rainy season while the third one was in September. It consisted of monitoring of vegetation in both sites including herbaceous and woody plants which were existing on the bunds and demilunes exclusively and in the other hand of the microclimate measurement and site soil characterization.

These three periods of data collection on the ReviTec site of Ngaoundéré are marked by a significant amount of data to be processed and the processing of these data is performed with the excel software and then stored on file in this program.

Since its installation in April 2012, the activities of the ReviTec site of Ngaoundéré generated each year a significant amount of data. And these data are processed and stored on Excel files. However, the storage of these data in the Excel files

represents a limitation in the dynamic view of the data regularly collected. And also in this way the treatments applied on the data is carried out manually. In addition, the information are not centralized to a simultaneous consultation which makes the access and manipulation of data difficult and leads in general to enormous losses of time, or does not favor the decision-making based on actual data. On the other hand the data that ReviTec manipulates are localized informations spatially. We can say that the current monitoring of ReviTec does not allow a space view of the elements manipulated nor a automatic processing of data.

IV. IMPLEMENTATION OF A MONITORING SYSTEM INTEGRATED IN THE WEBMAPPING TECHNOLOGY

Several platforms of GIS online exist for the geolocalisation of places. However, these platforms do not allow personal use of data and are not suitable for a follow-up the activities of a structure. That is why we propose a system of monitoring for the sites of ReviTec integrating and adapting the concept of Webmapping for the management of its own activities.

Our approach consists in a first time to implement the mapping solution cited above, namely the achievement of a spatial database that contains the spatial data, the deployment of a map server that uses these data to produce map layers according to the requests of the web application. Then, we have developed a web application that interacts with them. The web application provides two main functions, namely the management of dynamic side of the system and the redirection of requests from the client to the map server to retrieve map images requested by the client. We have integrated a cartographic client in the web application to allow for the display the map.

The main idea is to create a new item on the map by adding the geographical coordinates through an interface of the Web application. Once add on the map, the element becomes interactive using the JavaScript API of the cartographic client allowing to update the data on the element newly added.

We have proposed the zoom feature as well as the module of interaction enabling the interaction with the elements of the map. We have proposed several layers to display on the map and it is possible to display or hide according to need.

The one of the features introduced allows View information concerning elements on the experimental site of ReviTec (demilunes, islands, bunds, etc.). The display is done by the click of the mouse on the item in question. It is also possible to perform a search, it uses for this the spatial indexes.

Another feature allows you to update the information allottees items on the map with the help of an interface of the web application dedicated to this effect.

In summarizing the features offered by the proposed system are:

1. Explore and interact with the elements on a map;
2. update attribute information items on a map;
3. search for items on a map;
4. display the information updated in real time;

- *system architecture*
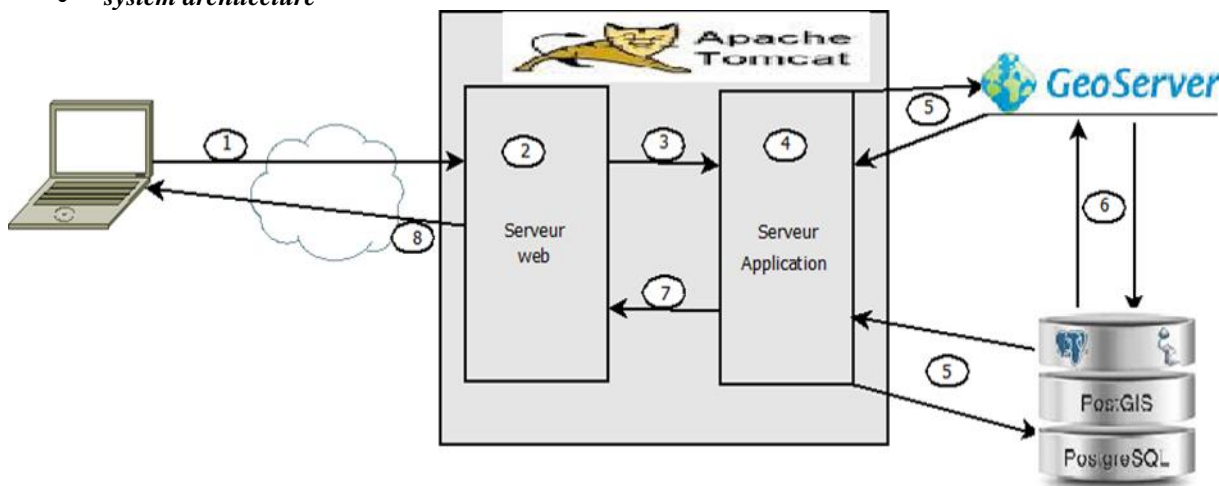
1. The request of the client to ask a resource on server.
2. The Web server assure the treatment of the HTTP request.
3. If the HTTP request received is for the applications server, then the web server passes it to applications server. The two servers are connected by a channel, appointed connector.
4. The application server receives the request to its tower. It therefore performs instruction (the Servlet) which is intended the query, in function of the URL. This implementation may require a map image of where the call of the server mapping (example: GeoServer directory) or the consultation of the data sources as allottees of databases (example: PostgreSQL, on the figure).

5. . When the processing of the query uses a map image, Application server fact uses the geographical server that produces the corresponding image and sends.

6. To produce a map image, the cartographic server has need of geographic data that request the DBMS (PostgreSQL/PostGIS) via a query.

7. Once its response generated, the server applications the returns, by the connector, to the Web server.

8. The answer is now of the simple HTML code, understandable by a browser. The HTTP server returns the response to the client.

- ***The technology***

The application is developed with free and open sources.tools

At the application level, we opt for Tomcat for its flexibility, its dual functionality of Web server and application server. In addition, Tomcat is available under a free license [14]. For the generation of map layers, GeoServer has been chosen as the geographic Server guaranteeing a better rendering of maps and a better security [13]. Implemented in Java, its choice allows us to have a homogeneity at the level of the entire system put in place.

As regards the RDBMS brands studied, our choice is PostgreSQL/PostGIS the fact that it is free [11, 12]. it is easily accessible by our geographical server. GeoServer.

As the operating system installed on the server, we used the Linux distribution Debian 8 under GNU license.

The programming language chosen is the Java in its web version (JSP and servlet) that allows you to generate dynamic Web pages. Other web programming languages have been used such as: HTML5, JavaScript, and CSS. The platform is located on a single machine (server).

In summary, we propose a system which corresponds to an architecture Four Thirds comprised of the following elements:
- a cartographic client : OpenLayers;
- an application server: Apache Tomcat;
- a map server: GeoServer directory;
- a data server: PostgreSQL/PostGIS.

V.   RESULTS

The implementation of the solution has been carried out with the vector map of the site of ReviTec of Ngaoundéré. This map has been obtained with the help of geographic coordinates identified on the ground.
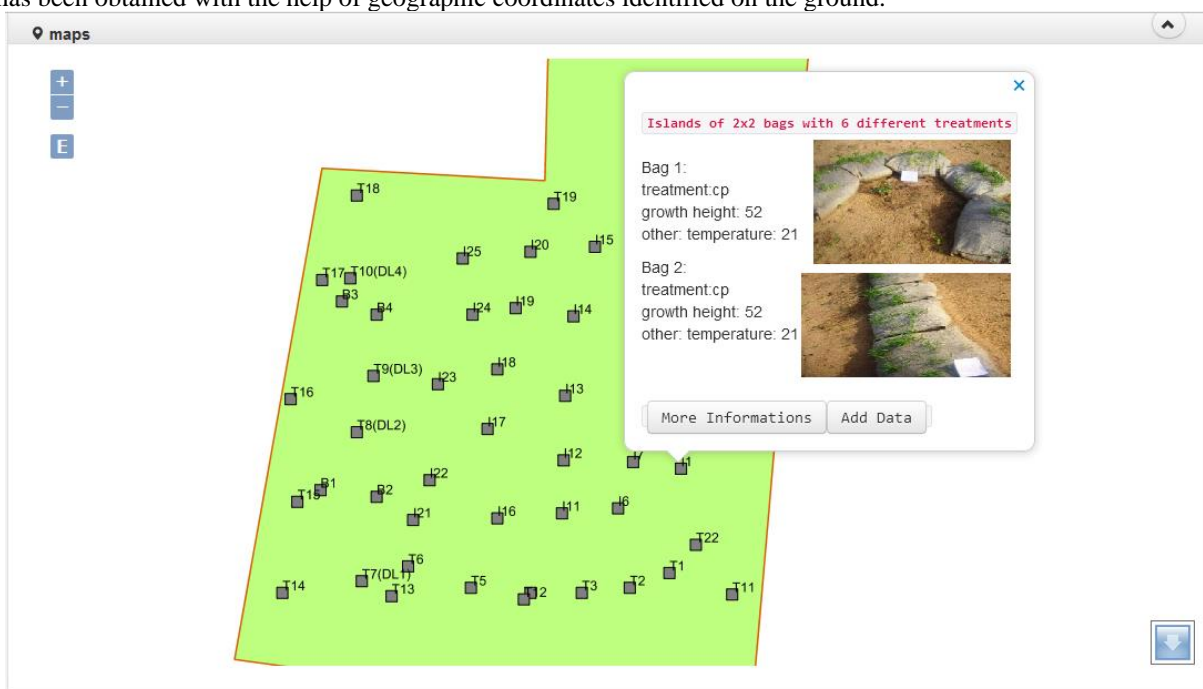
The home page contains the client map which allows you to view the geographical map of the site of ReviTec of Ngaoundéré. This map client is JavaScript library OpenLayes which allows to display the maps from several geographic servers. We have implemented for it supports any map vector and raster and zoom features and interaction module

- **Updating the information in the system**

First step

The application process for data visualization of a point on the map starts by clicking on a point on the map. Then the system displays a tooltip containing the Button "Add Data".

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Second step

After having clicked on the button "Add Data" The system redirects the user to the interface of updates to data. As well, it accesses to the form to update the figure below:

This interface has been designed according to the layout of the bags on the site of Revitec. The above form is a form of update of the islands.

- **Visualization of information**

The visualization of the data on the map has two phases:

First step

The application process for data visualization of a point on the map begins by a click on the point on the map. Then the system displays a tooltip containing some information on the point.

Second step

The second step of viewing information points of the card passes by the click of the button More Information To view all of the information concerning the element in question.

The figure bellow shows an example of the page of the result:
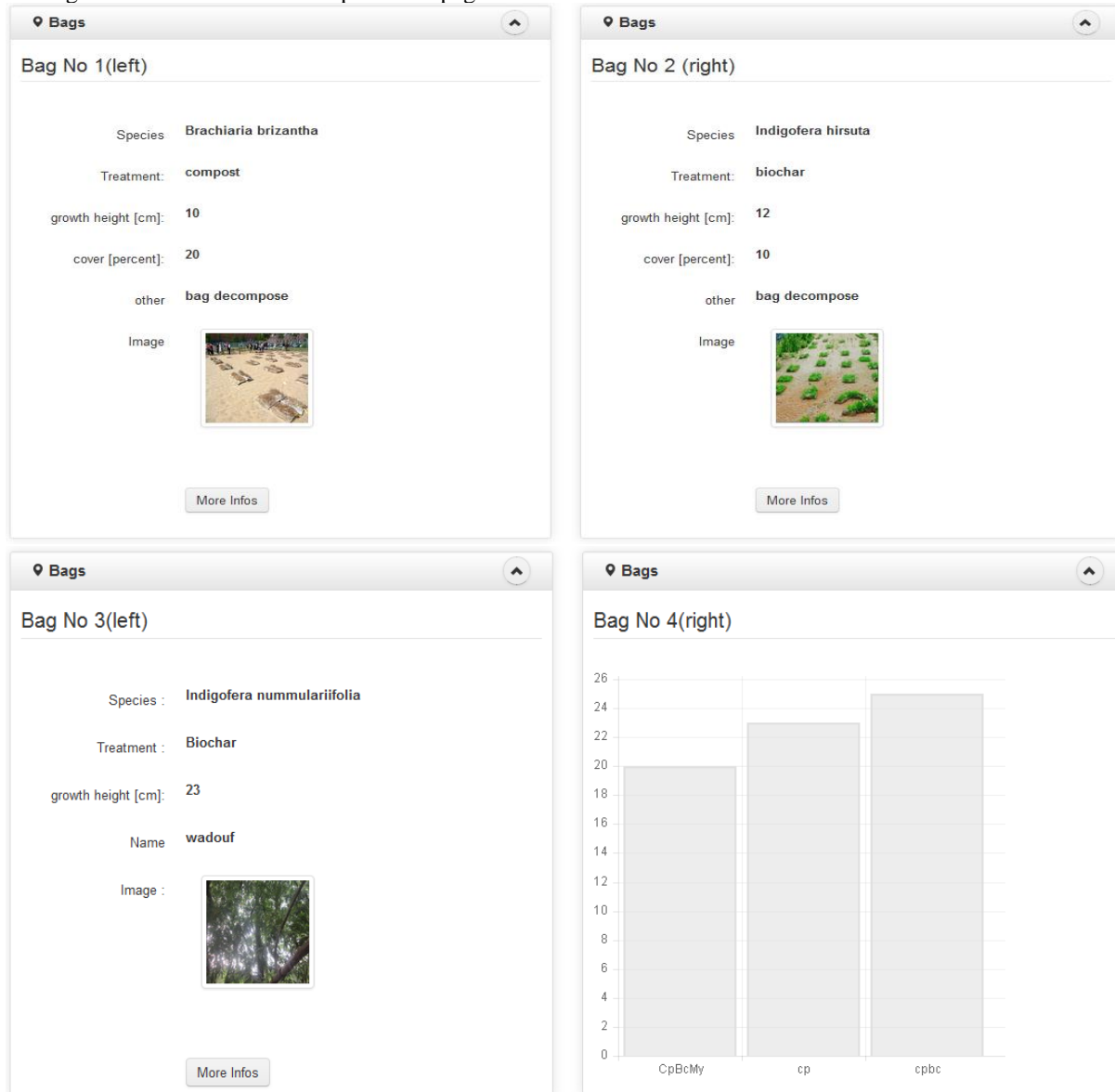
- **Description of results**

The system that we propose implements the funtioning of experimental site of ReviTec of Ngaoundéré.

The system allows you to view the items such as treeIslands, Demilunes, bunds and islands on the map of the site of ReviTec of Ngaoundéré. These elements are represented by the points on the map and are identified by the identifiers.

The system also allows the interaction with these elements on the map that is to say the system offers the latest information recorded in a tooltip when you click on the item on the map.

The system also offers the possibility to consult the whole of recent information of the plants belonging to an item on the map by clicking on the button "More information".

The result obtained contains information such as:
- The species of the plant;
- The treatment applied on the plant;
- The growth of the plant;
- The image of the plant;
- The biovolume of trees
- The diagram in stick which describes the growth of the plant in function of the treatment.

The treatment can be: compost, Biochar, loamy sand, mycorrhiza. It is possible from the interface of Update to update the data on plants.

VI.   CONCLUSION

GIS are so important for spatial analysis in recent years that is not feasible to limit them to simple isolated software. In the era of technologies of information and the Internet, GIS had to evolve to accessible software of any point of the earth. This evolution has seen the birth of a concept of WebMapping favoring a multitude of solutions, each with its own philosophy. The systems of WebMapping constitute a means more important in the exploration and remote manipulation of spatial objects on maps. In this work, we are given as the main aim, the integration and adaptation of this technology in a system of dynamic monitoring at the service of the site of ReviTec for the management of its activities.

The proposed system allows to disseminate the geographical maps and follow the samples of the data on the plants. Its dynamism allows users to interact with the elements on the maps to perform the various actions planned to this effect. It has a large possibility of extension and is portable with Java technology.

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