

A WebGis System to Support Implementation of Sustainable Development Policies

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Abstract— Nowadays, Geographic Information Systems (GIS) appear as important management tools in regard to planning, decision-making help and monitoring of policies. This paper relates the development of such a tool and aimed to identify and select various tools necessary for the development of a reliable and effective system. In order to meet needs, we set an organizational planning throughout the life cycle of the system. The development method adopted is the Unified Process 'UP'.

In this study, we apply our system to data related to socio-economic considerations. From the various kind of views and reports, analysis can be carried out and lead to a better use and allocation of available financial resources.

Keywords-component; GIS; Web Application; Economic Analysis; Mapserver; Network

I. INTRODUCTION

In any society, information plays an important role in implementation of development policies. Widely disseminated, such information can help to raise the political debate both within government in one hand and between government and citizens in the order hand. During last twenty years Geographic Information System (GIS) becomes a field of information technology increasingly used in public decision making process, including planning and management [1]. In fact, a large number of GIS applications concern management of space in many scales and all forms (design, planning, environment, etc.).

In our countries, implementation of economic and social development policies often faces to lack of economic data indicated at regional scales. This leads to proposals of policies which are not fair and equitable. It is then important that implementation of policies includes not only wise (sustainable) resource space territory, but also a better allocation of financial resources which are becoming scarce.

This should lead to development of infrastructures necessary for the satisfaction of needs of population wherever they are.

To carry out such a policy, the introduction of GIS tools could be a significant contribution. And it is in this context that we set a goal of designing and implementing a GIS centralizing data on socio-economic areas of a region and serve as a tool for analysis and decision support throughout the many treatments and uses for which it could lend.

II. EASE OF USE

A. GIS Evolution

Thanks to advances in computer and space technologies, GIS developed in recent decades [1]. One often cited application of spatial analysis in epidemiology is the study successfully by Dr. John Snow during the outbreak of cholera in the Soho district of London in 1854. Indeed, he represented on a map the location of patients and where they drew their water, he then determined that it was the water of a certain well which was the source of contamination [2]. The amount of geographic data thus acquired, as well as geological interpretations produced and published by researchers, led a discussion to a group and coordination of work [1]. Such work led to the creation of the GIS field.

In Europe and America GISs quickly developed and are very useful. In Africa, their development has been marked by the creation of AFRICAGIS, which is the most important conference - exhibition dedicated to GIS technology and its applications in Africa [2]. However, in many countries in West Africa, the use of GIS is still in its infancy, and governments know relatively little the benefits of these systems [3]. GIS are indeed mainly used to develop digital maps and rarely as an analytical tool for decision making and scenario analysis based on simulation of the effects of changing values of key variables.

B. GIS and economic analysis

Used in many fields to create, store, analyze and display geographically referenced data, GISs have experienced in recent years, rapid expansion and cover areas such as tourism, urban planning, civil protection, transport, marketing, etc. In the field of data analysis, they lend themselves well nowadays, to analysis of population distribution, wealth and income. They also allow development of health maps, school maps, and poverty as well as socio-economic indicators maps.

Indeed, analysis through GIS is a tool which uses spatial data from a database and presents the results in map form. It allows overlying layers of geographic information (giving the exact location of an item on a map) and mapped economic data (eg on economic activity and employment). It thus provides a powerful spatial analysis tool of the economy.

GIS allows, through spatial representations of poverty indicators, to identify the place "where poor people are", to analyze and to explain relationships between factors underlying poverty and finally end by understanding "why people are poor" [4]. This spatial representation known as poverty map is essential in the careful identification of the impact of poverty and can play an important role in guiding public expenditures for poverty reduction [4].

C. Related works

GIS have long been used by countries in their policies of planning and management of natural resources. Indeed, access to safe drinking water, especially in rural and semi-rural areas is a key factor in economic development. In Ivory Coast, thanks to GIS, the unequal distribution of water points in the area Daoukro were found and contributed in the search for areas suitable for the establishment of productive water points to ensure good coverage water requirements of the region [5]. In Laos, GIS has proven to be an essential tool for the study of spatial disparities in health in the city of Vientiane [6]. Indeed, they were used to define and to characterize the city of Vientiane, to sample design of survey and identify health disparities within urban health.

With the development of GIS users, tools and diversification of fields of application, engineering systems information facing today growing needs customization of GIS [7]. It has become common to rely on existing solutions in the design and the implementation of GIS and to identify functional architectures in order to meet user requirements. In this vein, a GIS tool has been developed to support management of BSS equipments capacity under MapBasic using MapInfo [8]. Another study allows the establishment of a new Digital Elevation Model (DEM) analysis technique

to allow identification of runoff concentration areas on upstream catchments where significant flooding may possibly occur [9]. More recently, an Internet GIS system have been developed to support water resource management in India [10].

D. Goals

This work is also part of the same logic, but the architecture proposed here and the various features developed, are different from the existing solutions. It was for us, through this project, to help respond to the following questions:

- How economic wealth is distributed throughout territory?
- What are the economic information about a city or a region?
- What are the most developed regions? And what are the less evolved?
- What was development evolution at municipal or regional scales during a certain period?
- What are the forecasts for future?

III. MATHERIALS AND METHODS

A. Theoretical framework

The goals that we set required the establishment of an organizational planning throughout the life cycle of the system. Figure 1 illustrates life cycle of the system.

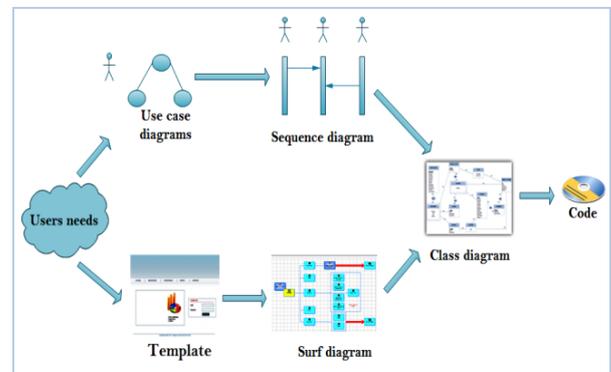


Figure 1: Development process adopted

Development method adopted is the unified process 'UP' (Unified Process). Its implementation was done following the steps:

- The expression of needs: it came here to identify the user needs and to formalize them;
- Analysis: Definition of the system architecture and its features;

- Design: it consisted in the identification and selection of the necessary components for the implementation of the system;
- Implementation: it consisted in development of various interfaces and implementation of features for the system;
- Tests and study of conditions of deployment of the system: it consists into testing and defining the required hardware and software configurations necessary to make the system function.

B. Methodology

GIS include the following five groups of features: Abstraction, Acquisition, Archiving, Analysis, and Display. Our methodology is based on the need to perform this group of functions. Implementation of these features, then allowed us to identify tools and materials required. Their choice was guided by following criteria: portability, performance, cost, and compatibility with object-oriented concepts.

Abstraction: It requires specification of needs and was conducted in following stages: modeling and intellectualization. Economic analysis is based on socio-economic indicators. There were no database organizing and structuring such indicators. It was therefore necessary to establish an effective and secured system that can allow it. To achieve this, we chose UML as modeling language, and Visual Paradigm as software development tool.

Data acquisition: It was about to collect data to be used by the system which are: the geographic data (coordinates, geographical boundaries of localities) and some data on selected indicators. For data, we investigate in collaboration with National Remote Sensing Centre of Benin. Geographic data formats are *shapefiles (shp)* for vector files and *gif* as raster files are concerned.

Data archiving: To facilitate organize and manage data, we use a Geographic Database Management System (GDBMS). Our choice fell on PostgreSQL (version 8.4) which is the database project the most successful in the field of free software and PostGIS its spatial component (version 1.5).

Data analysis: This feature, for which MapServer the open source cartographic server were selected, allows geographic data format so that they can respond to end user's requests. MapServer is a CGI program that runs on a web server and used to generate maps. Its role is to dip into databases and other resources to generate images that will be transmitted to a client via a web server.

Data display: It gathers all the means to implement and to restore the stored information. Development technology used is Ajax because of the numerous advantages it offers. It

does not require any plug-in and operates with technologies integrated by default in all browsers, including: CSS, DOM, XML object JavaScript and XMLHttpRequest. The dynamism of web applications is managed through server scripts. There are several server-side scripts languages. Our choice fell on PHP because of its varied features.

C. Materials

The solution adopted to meet the requirements is a WebGIS. Its architecture is shown in figure 3.

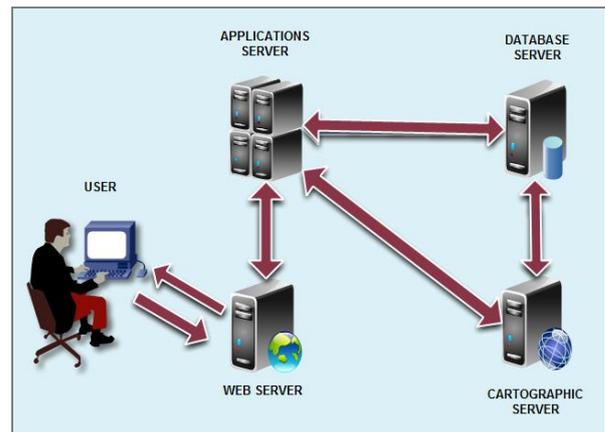


Figure 2: The proposed system architecture

So when the users query on their local machine to request a specific result, the map server will interpret this request and return the card in the form of a raster image (gif, jpeg, png, etc.) or vector (svg, shp, flash, etc.). The map server is managed by scripting languages that allow it to dynamically load a card in response to the request. It is installed on a server that also hosts the database server.

The GDBMS stores both attribute information that describes the space like spatial objects such as points, lines and polygons. Consultation data will be handled by a web server that will allow other servers to return information through the network. The link between the servers and the user is provided by the application server which centralizes all scripts and functions to be called for the execution of a request.

IV. RESULTS OF THE GIS APPLIED TO SOCIO-ECONOMIC DATA

The system offers a number of features, among which could be listed:

- rapid establishment of mapping;
- location in space and time
- sorting by superimposing separate layers;

- displaying details on maps thanks to zoom and pan features

Figure 3 shows that in the department of Collines, Dassa-Zoumè's electrification rate is the highest while Glazoué presents the lowest rate. From this result, governments then know which towns should be taken into account in the future investments plan in electrification field.

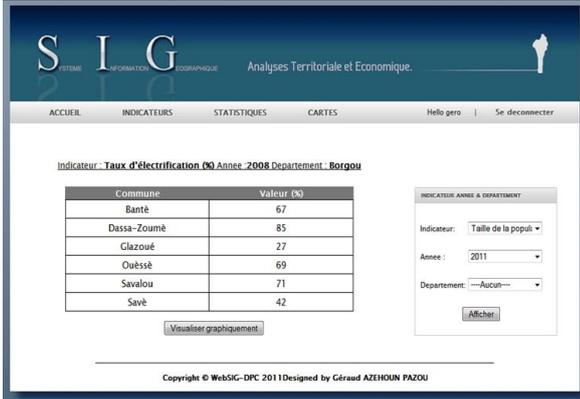


Figure 3: Regional statistic table

In figure 4 the same analysis is possible but results are presented in graphic form (pie chart). This type of view is a kind of more interesting to highlight the spatial disparities between regions, hence its interest.

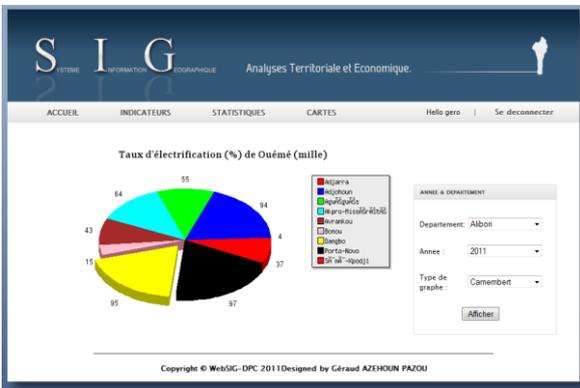


Figure 4: Regional statistics in graphical form

Figure 5 shows infant mortality rate's evolution in the town named 'Banikoara'. For example, from 2005 to 2007, this rate decreased significantly compared to previous years. This is the result of measures taken by the government. The system therefore can allow to appreciate impact of actions and to improve them if necessary.

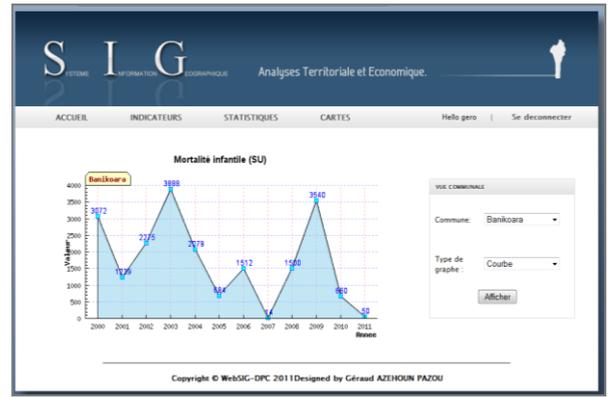


Figure 5: Evolution curve of an indicator

A helpful result in decision making is geo-location. Indeed, data visualization over a rich base map could help to appreciate their distribution in space, and therefore to be more likely to take necessary decisions. Figure 6 and 7 show a local community and road network in Benin, with the administrative map as base map.

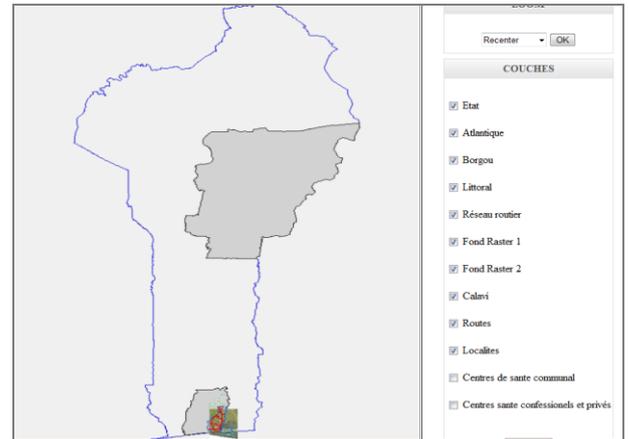


Figure 6: Overview of the map of Benin with the possibility to add other data layers

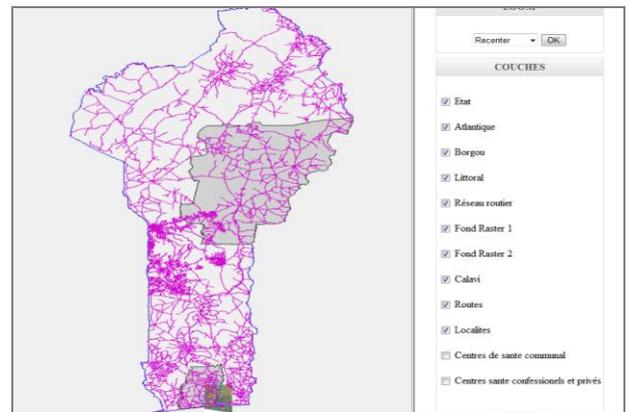


Figure 7: Thematic map: Road network

Figure 8 shows zoom's result a locality with health centers as thematic layer.



Figure 8: Zoom on Atlantic department in order to visualize some health centers

With the such of view of this figure, it is possible to see if in the same department, there are people better off than others in matters of access to health care. Therefore decision can be made about what action is necessary to take in order to solve that problem.

V. DISCUSSION

A. Discussion on features developed

The system brings a significant improvement about data management and storage. Indeed, most used map data solutions which are: ArcGIS, ArcView, MapInfo, etc. are licensed GIS and their storage system doesn't use a GDBMS. Data are available as files (vector or raster) on the hard disk. This way of storage is neither safe nor reliable for backup in case of disasters (fire, damage to server, etc.) The solution brought here is to gather, to organize and to store data in a GDBMS. Thus in case of disaster, the safeguard policies could help to recover data stored.

Another important advantage of the system is that its architecture is client-server. Indeed, the solutions of the same type sold by companies such as ESRI require the acquisition of licenses for both server and client versions. But this system could be used just with a web browser and its use is further facilitated by user-friendly interfaces. Deployment costs are thus minimized. As far as the functions performed by the interface are concerned, they are customized in terms of the numerous uses to which it could lend.

However, the system has some functionality gaps. Mapping systems available online nowadays as Google Maps offer advanced tools such as info bubbles, ability to

add markers or objects on maps etc. The implementation of these various features will be future implementations.

B. Discussion on choices of tools

It is important to note that as far as abstraction layer is concerned, the chosen modeling language (UML) is not the best for formalizing spatio-temporal data. Others like MADS used by [7] or MECOGIS are much more specific for GIS modeling. But they often require the use of other methods to formalize attribute data. Thanks to object-oriented concepts, UML allows taking into account of geographical information components. It has also been used by [8] and [6].

At analysis layer, MapServer is a tool increasingly used for designing GIS client-server architectures. It should be noted that the grip is not easy, but the fact that it was adopted by companies like Google and Camptocamp, favored its rapid expansion.

More generally solutions based on Mapserver client as: Cartoweb (used by [7]) or Ka-Map are useful too. With them, developers are exempted from personalized interfaces realization.

Regarding the last layer (display), technologies such as J2EE (Java Enterprise Edition) and .NET are better solutions to the requirements of GIS. But J2EE runs very slowly on some machines and .NET works only on Windows systems. PHP and AJAX technology were thus preferred.

VI. CONCLUSIONS

This study aimed to develop a WebGIS system. Based on the needs expressed, we model the system using UML as modeling language. A pilot platform was then developed based on the technical choices made. To justify such choices, some tests on the features were implemented.

As results, the system can allow a lot of kind of analyzes. Indeed, it allows one hand to view maps showing geographic information on a web browser, and to view the attribute data associated with, on the other hand. It can also generate statistical reports that will be used to develop economic analyzes. From these results, analysis can be carried out and lead to a better use and allocation of available financial resources. This shows that the system offers many opportunities for exploitation.

The system is also flexible (might be installed on most OS, accessible from any web browser), and ready for future improvements in order to make it more useful. Regarding to

prospects, an evolution of the database to a data warehouse is a possibility. It could therefore enable data mining tasks.

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