Geographic information system and local development: Panorama assets

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Abstract

We live in a complex world where a wealth of information have to be processed, interpreted and explained. The manipulation of information, especially geographic information, has reached unprecedented levels. Needs of geographic data of course always existed, but it was difficult to satisfy. Today, humanity has the most sophisticated tools ever created for it to get a considerable amount of geographic information on the planet. These tools and instruments had to help manage space and phenomena behind it.

The aim of this research is to shed new light on the character of geographic information and explore how it is useful for the development of a local territory. Our analysis calls for a broader vision of geographic information system (GIS) according to how it actually unfolds in the economy. This paper summarizes the genesis of the concept of GIS and some of the points on which crystallize the raised controversies. Such a perspective is needed to make the contribution of GIS to local development our concern.

However, modeling such a phenomenon does not make sense if we don't confront the theory with field experience. In this perspective, we first describe the main characteristics of geographic information. Then, we focus on the functionality of GIS in relation to the storage, analysis and visualization of geographic data. Finally, we try to focus on the place and role of GIS in local develop on three levels: territorial planning, urban dynamics and reorientation of environmental policy.

Keywords: GIS, local development, urbanization, territorial planning, environment.

Introduction

Geographic data needs have of course always existed, but they were difficult to meet, because it is so recent that information systems could handle this data efficiently and massively. By the end of the 20th century, the rapid expansion in various systems had been strengthened and standardized on relatively few platforms and users were beginning to explore viewing GIS data over the Internet, requiring data format and transfer standards. More recently, a growing number of free, open-source GIS packages run on a range of operating systems and can be customized to perform specific tasks. Increasingly geospatial data and mapping applications are being made available via the World Wide Web.[1]

In this paper, we first describe the main characteristics of geographic information. Then, we focus on the functionality of geographic information systems in relation to the storage, analysis and visualization of geographic data. Finally, this paper will examine how geographic information system (GIS) technology significantly enhances the applications and services that are part of a typical set of economic development programs.

A. Focus on geographical information and geographic information systems

The geographical information is a representation of an object in which a real phenomenon located in space at a given time. Geographic information is characterized by a purely spatial component and a semantic component.[2]

At the first light of the third millennium, the digitization of spatial objects or phenomena proved effective and efficient in the better management of local development issues. Tools and instruments are invented and help to manage the space and phenomena behind it. Among these tools, we note the Geographic Information Systems. GIS is a system designed to capture, store, manipulate, analyze, manage, and present all types of geographical data. The acronym GIS is sometimes used for geographical information science or geospatial information studies to refer to the academic discipline or career of working with geographic information systems.[3]

A.1. The geographic data

The geographic data that describes our world allows for city planning, flood prediction and relief, emergency service routing, environmental assessments, wind pattern monitoring and many other applications.

Geographic data is processed with GIS software which can, as one aspect of its functioning, produce maps. We will define semantic, temporal, and semantic components into the primary elements of the Geographic Information (theme, location, and time) to improve spatio-temporal analysis of geographic phenomena.

Computer database containing boundaries for areas such as census areas, postal areas and political or administrative areas, area centroids (points used to represent areas) and related associated attribute information such as area names, identification numbers, latitude/longitude

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[1] Fu, P., and J. Sun. 2010. *Web GIS: Principles and Applications*. ESRI Press. Redlands, CA.

[2] Degréne and Salgé, 1997.

[3] "Geographic Information Systems as an Integrating Technology: Context, Concepts, and Definitions". ESRI. Retrieved 9 June 2011.

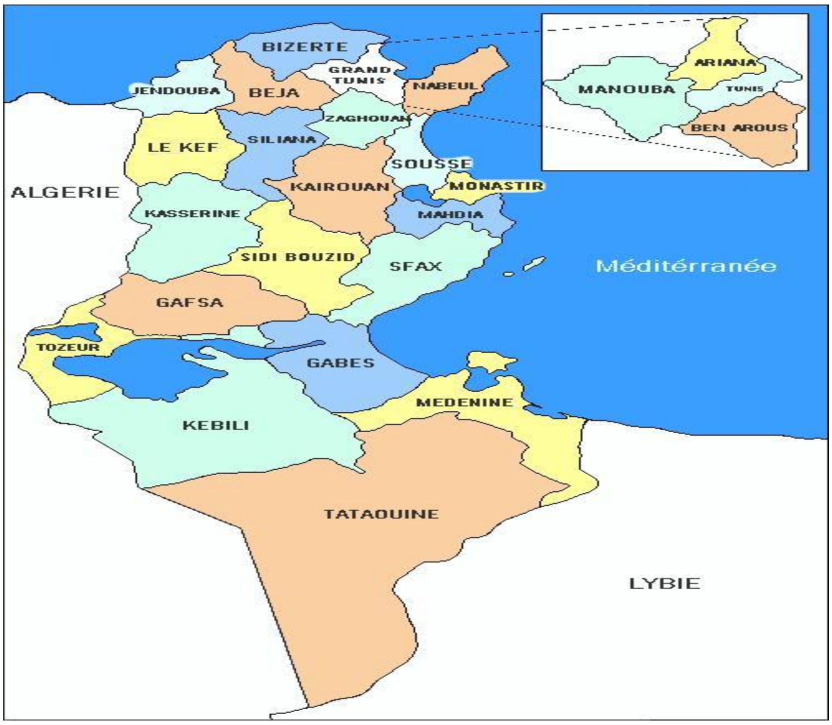
coordinates, polygon area calculation, demographics, inventories relating to area, precision of boundary nodes.[4]

A.1.1. The spatial component

The spatial component represents the position on the Earth's surface and the shape of a real world object. Position is described in a reference system such as an explicit coordinate system. This component is used to represent the shape of the object itself and its position in relation to other phenomena or real world objects.

In Figure 1 is shown the spatial component of geographic information representing the departments of Tunisia. Each department has a form and occupies a specific position relative to other departments.

Figure 1. *The spatial component departments of Tunisia*



A.1.2. The semantic component

The semantic component represents information on the nature, appearance and descriptive properties of an object or a phenomenon of the earthly world, such as a department is described by its name (Sfax), population (881000) etc.

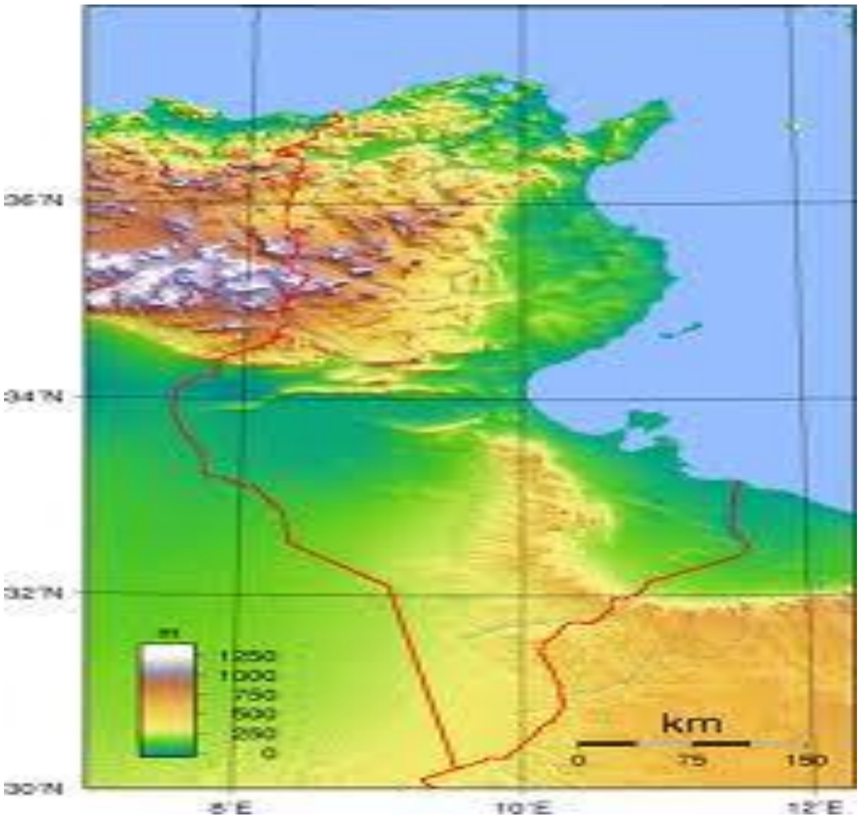
This information may also include relationships with other objects or phenomena, such as the department of Sfax belongs to the South-East region. A semantic aspects that distinguishes GIS data is its classical multiple representation at different scales (Laurini and Milleret-Raffort, 1993) (Weibel and Dutton, 1999).

The semantic component of geographic information representing topographic map of Tunisia is shown in figure 2. We can clearly see that the morphology of Tunisia is very varied and

[4] GIS glossary, West Research Agency definition.

landscapes differ considerably: mountainous regions to the north and west, central steppes, facade eastern coastal desert of south-Saharan Africa.

Figure 2. Topographic map of Tunisia with attitude in meters



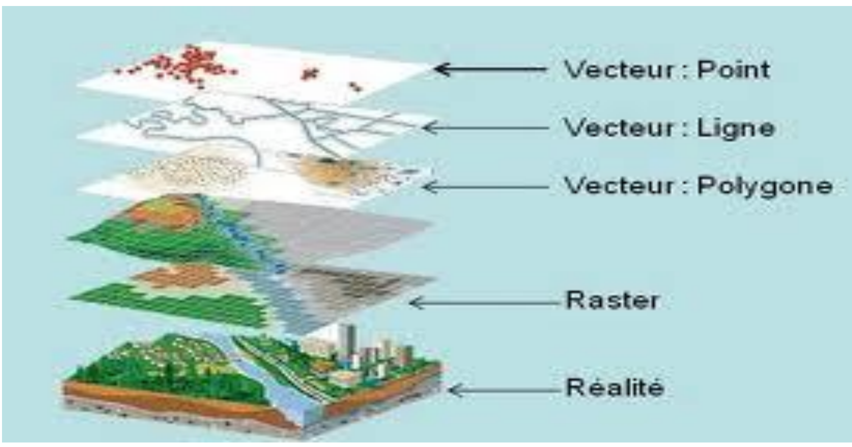
A.2. Features of GIS: a process to decrypt

A.2.1. The vector and raster models, and the layers

Geographic information is represented through two types of models or data structures: vector and raster models (Rigaux et al., 2001). The choice depends on the nature of geographical data and their use (Couclelis, 1992).

These two modes synthesized image in the following manner (figure 3):

Figure 3. *Models of representation of geographic information*



A GIS usually contains several kinds of geographical objects that are organized into themes that often appear as layers. Each layer contains objects of the same type.

In the vector model, information is grouped in the form of x, y coordinates. We associate a location at an entity descriptive.[5] Field is represented by graphics primitives (points, lines, surfaces). Only the educated locations are stored. There is a notion of object. Point type objects in this case are represented by a single point. Linear objects (roads, rivers ...) are each represented by a series of x, y coordinates. Polygonal objects (geographical area, plot ...) are, in turn, represented by a series of coordinates defining a closed surface.

The raster model, in turn, consists of a matrix of dots which can be all different from each other. This is a raster based on a regular grid of field. The information is stored in row-column. Each pixel contains information (that is to say that the vacuum is also encoded). There is no notion of object. This representation is the most suitable for the modeling of purely spatial (e.g. temperature, pollution, etc.)., but given that the pixels of the matrix have no overall meaning, only a thematic analysis performed using the "Map Algebra" (Tomlin, 1990) is possible. The "Map Algebra" is the algebra maps. It can create new themes and spatial information in the form of a matrix.

A.2.2. The spatial databases

A spatial database is a database that is optimized to store and query data that is related to objects in space, including points, lines and polygons. While typical databases can understand various numeric and character types of data, additional functionality needs to be added for databases to process spatial data types. These are typically called *geometry* or *feature*. The Open Geospatial Consortium (OGC) created the Simple Features specification and sets standards for adding spatial functionality to database systems.[6]

One of the functionality of GIS is to integrate data from different sources in a common conceptual framework and software. For storing geographic information associated to different layers, two different approaches are used: weakly or strongly integrated approaches (Rigaux et al., 2001).

The highly integrated approach is used to store spatial data with sensitive data of the application by reducing the complexity of the system, and allows a standard access to spatial information. In addition, spatial DBMS enables GIS applications to enrich the main characteristics of database security, concurrency, flexibility and scalability.

The following query types and many more are supported by the OGC:

- Spatial Measurements: Finds the distance between points, polygon area, etc;
- Spatial Functions: Modify existing features to create new ones;
- Spatial Predicates: Allows true/false queries such as 'is there a residence located within a mile of the area we are planning to build the landfill;
- Observer Functions: Queries which return specific information about a feature such as the location of the center of a circle.

An example of creating a spatial table is representing the departments of Tunisia through the vector model and a spatial query that aims to select the departments with an area greater than

[5] Le modèle vectoriel est particulièrement utilisé pour représenter des données discrètes.
[6] OGC.

5000 km2 using the Oracle extension for spatial data, are shown respectively in Figure 4a and 4b. The insertion of a tuple[7] in the table and its mapping are shown in Figures 4c and 4d.

***Figure 4.** Example of Oracle spatial application*

4a) Creating a Spatial Table

```
CREATE TABLE DEPT (

NAME VARCHAR2 (30),

AREA NUMBER,
```

4b) SQL Query which uses spatial predicate

```
SELECT NAME,POP

FROM DEPT

WHERE SDO_GEOM.SDO_AREA(GEOM, 0.005)>
7545;
```

4c) Insertion of a geographical object in the table

```
INSERT INTO DEPT VALUES(

'SFAX',

7545,

881000,

SDO_GEOMETRY(2003,NULL,
NULL,
```

4d) Representation of tabular mapping

Name	Area	Pop	Geom
Sfax	7545	881000	…
Tataouine	38889	144100	…

In weakly integrated approach, GIS applications store spatial and alphanumeric attributes separately. Representations of spatial objects are managed by file management systems, while the descriptive component is stored in conventional DBMS.

A.2.3. Spatial analysis

Spatial analysis operators play a very important role. The term spatial analysis refers to the analysis of a distributed phenomenon in space that also has physical dimensions (location, proximity, orientation, etc.). It aims at estimating the prediction, interpretation and understanding of real world phenomena, highlighting structures and recurrent forms of spatial organization

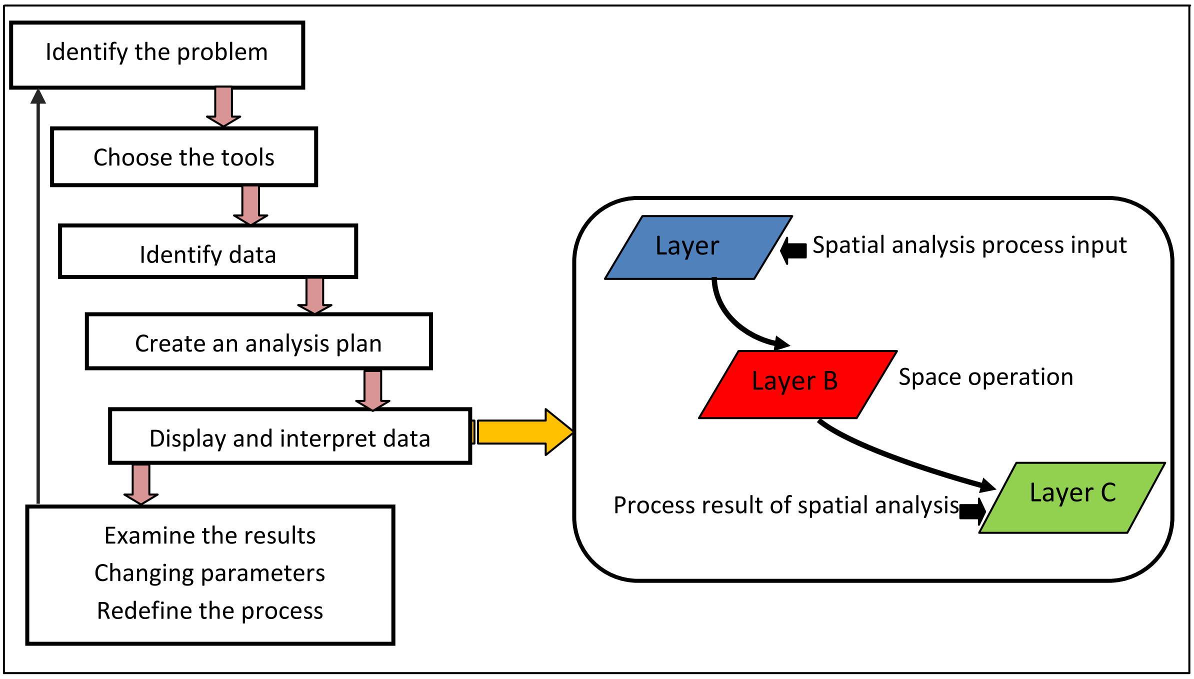
The spatial analysis methods have been classified by Longley et al. (2001) as follows:

- *The interrogation and reasoning methods*: GIS is used to answer questions in the form of queries that use spatial or alphanumeric predicates or to select a set of geographic objects;
- *The measurement methods*: used to obtain numerical values that describe geographic objects;
- *Processing methods*: are space operations that change data by combining them to obtain new spatial data;
- *Synthetic methods*: synthesize a set of data in one or two numeric values;
- *Optimization techniques*: are used to select the ideal position for geographic objects according to defined criteria.

[6] In mathematics and computer science, a tuple is an ordered list of elements.

The process of spatial analysis is often associated with a simple sequence of operations of the specification of the problem statement. Mitchell (2005) makes this process as an iterative process.

Figure 5. *The process of spatial analysis (Mitchell, 2005)*



A.2.4. The geo-visualization

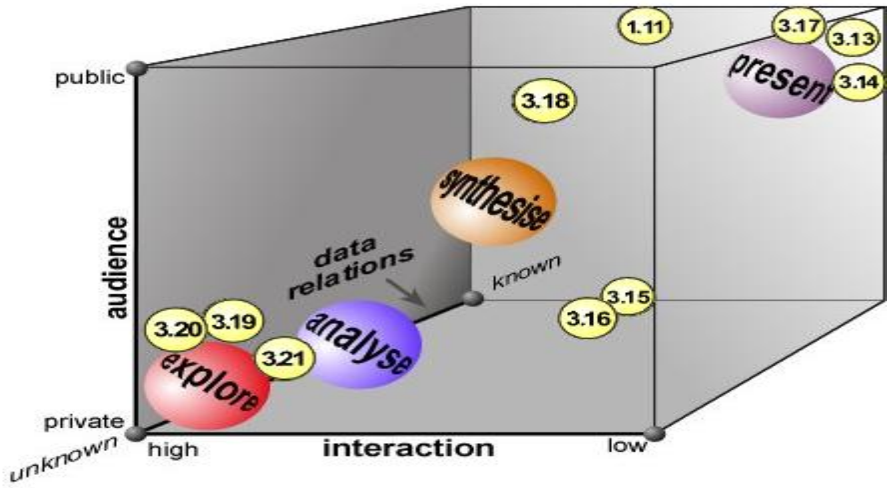
Geo-visualisation is a rather new tool for understanding, interpretation and assessment of environmental data. Geo-visualisation of landscape patterns and processes offers an innovative approach to present and discuss results of data collection, data analysis and data simulation. Cartography and scientific graphics form the roots of geo-visualisation however it is all based on the digital principles of Geographical Information Systems.[8]

Relations between the fields of cartography and GIS on one side, and scientific visualization on the other, are the foundation of a new scientific discipline: Geo-visualization. It integrates the techniques of scientific visualization, mapping, image analysis, data mining, to provide theory, methods and tools for the representation and discovery of spatial knowledge (MacEachren and Kraak, 2001).

The inextricable link between interactivity and exploration and data analysis has been well demonstrated by (MacEachren and Kraak, 1997) through the "map-use cube" (Figure 6). The "map-use cube" visually represents the degree of interaction ("interaction"), target type ("Hearing") and the degree of knowledge of the data ("Data Connections") which the user needs in stages of exploration ("Explore"), data analysis ("Analysis") summary ("Synthesize") and presentation of results ("Present").

[8] Wageningen University and Research (NL), Geo-Visualization in Environmental Research, Course No. 4

Figure 6. Map-use-cube (MacEachren et Kraak, 1997)



So in this context the interactive maps become indispensable tools for exploring and analyzing geographic data. A map is interactive if it works as an interface to other data. Through a simple click of the geographical object, the card can send other information such as maps, images, multimedia, etc. Interactivity means that the map can adapt its content and display based on user actions

B. GIS and local development : the path of renewal

If we consider the definition of local economic development to be the improvement of land and infrastructure for the benefit of the community as a whole, it is clear that GIS have a key role to play. GIS are now used extensively in government, business, and research for a wide range of applications including environmental resource analysis, land use planning, locational analysis, tax appraisal, utility and infrastructure planning, real estate analysis, marketing and demographic analysis, habitat studies, and archaeological analysis.

B.1. GIS and spatial planning

Geographic information systems (GIS) have emerged in the last decade as an essential tool for environmental and resource planning and management.

Spatial planning refers to the methods used by the public sector to influence the distribution of people and activities in spaces of various scales. Discrete professional disciplines which involve spatial planning include land use, urban, regional, transport and environmental planning. Other related areas are also important, including economic and community planning. Spatial planning takes place on local, regional, national and inter-national levels and often result in the creation of a spatial plan.

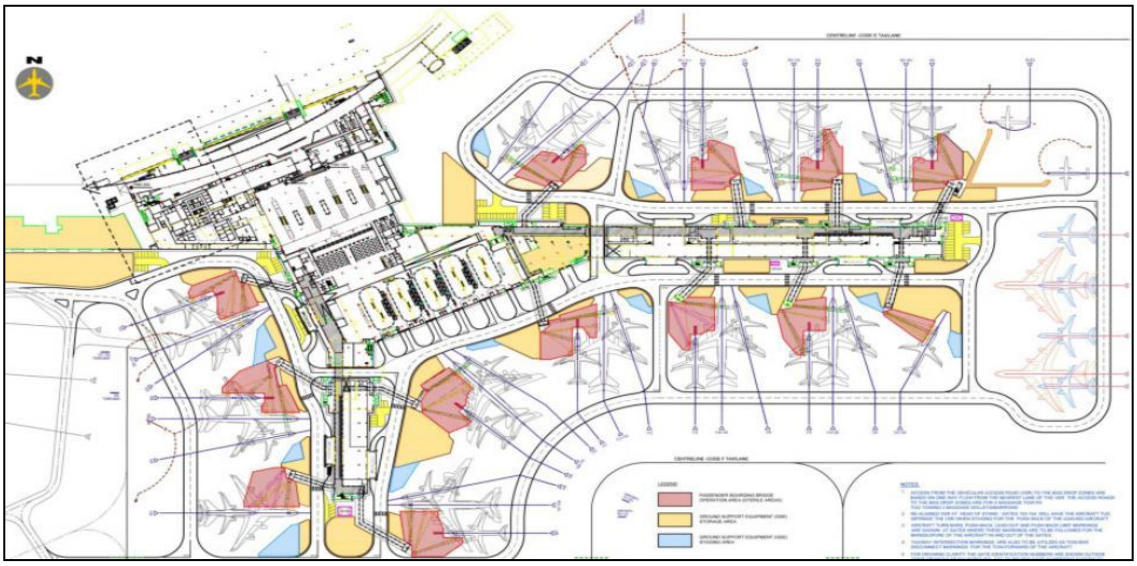
The difficulties associated with many spatial planning decisions can be firmly placed into Webbers (1984) classic characterization of "Wicked Problems" where the problems[9]:

- To influence the future distribution of activities in space;

[9] David R. Moore, 1998, GIS in a Knowledge Domain: Bringing GIS to operational integration in Spatial Planning? GIS in a Knowledge Domain, http://ais.gmd.de/MS/zeno/papers/schmidt-belz1998a.pdf, p2.

- To create a more rational territorial organization of land uses and the linkages between them;
- To balance demands for development with the need to protect the environment, and to achieve social and economic objectives;
- To c-ordinate the spatial impacts of the other sectorial policies;
- To achieve a more even distribution of economic development between region than would otherwise be created by market forces.

Figure 7. *Example of spatial plan*



GIS is used to access vital information on vulnerable populations and traffic patterns to assist emergency services to operate efficiently. By using specialized data provided by the GIS, administrative, strategic political and socio-economic space will no longer take place as pilot in sight yet less known disorder. This management is done daily by using the GIS tool because it provides:

- ✓ Thematic maps providing clear and accurate information on multivariate situations in the territory;
- ✓ Qualitative data and statistical learning about geospatial distribution of wealth, stocks, populations, rivers, basic infrastructure, existing multisectoral networks in the territory;
- ✓ Alphanumeric structured data in database and spatial data informing as many sectors as possible within a given territory.

This information system can play a fundamental role in the management of local in that it provides all of the local executive accurate locatable in space.

B.2. GIS and urban dynamics

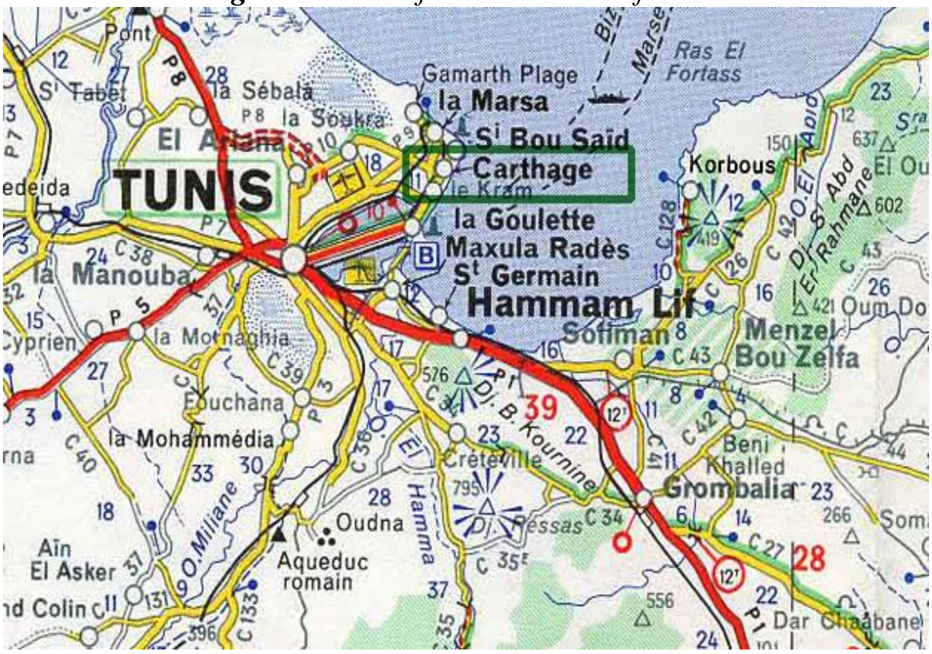
GIS can better understand all the information on one-way and becomes a guide for the best choice of urban traffic. It also allows to update the dynamic that know the ways in urban areas as new development will be done automatically updated in the information system, more specifically, it leads to:

- ✓ Mapping networks (urban transport, water, sanitation, electricity, etc.),

- ✓ Monitoring urban expansion, create zoning regulations to provide for the possible extension of the city, with services that must accompany it;
- ✓ Monitor extension possible nuisances (noise, pollution).

Although traffic safety is a concern to many urban residents, the role of urban design on crash incidence is typically not considered as part of the transportation planning and design process. To better account for the effects of urban design on crash incidence, the authors recently sought to develop a GIS. This technique will assist planners and urban designers in systematically evaluating the effects of community design on traffic safety. GIS have become increasingly important in the transport sector since the 1990s, so much so that a new acronym has been created: the GIS-T (Thill, 2000; Dueker et al., 2000a).

***Figure 8**. GIS-T for the suburbs of Tunis*



B.3. GIS and reorientation of environmental policies

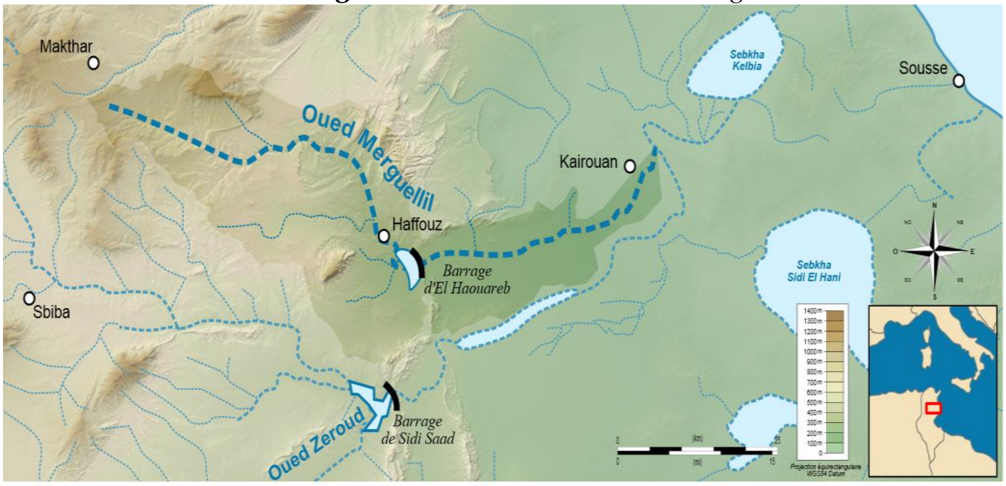
GIS is a readily available spatial analysis tool which gives unique and unparalleled insights into the natural and manmade environments due to its strength to link the "generic information" with its "location". GIS is a powerful tool which not only analyses the present environmental scenario but also helps in projecting the future, in other words, one can effectively use the GIS tool for past, present and future studies on environment and its protection for the generations to come in future.

The few examples where GIS can be effectively used are in Environmental planning, Ground water contamination, Fresh water and saltwater interface, Water quality, Solid waste and Waste water management, Air & Water pollution, Natural Hazards and their mitigation etc.

GIS can:

- ✓ Monitor land use;
- ✓ Cross the information collected with statements operators (political, agricultural and common);
- ✓ Diagnose the specific needs of certain operations and practice a less polluting agriculture (precision farming).

Figure 9. Water court Oued Merguellil



GIS can serve as the ultimate communication of environmental information to the public and policy makers since it is the technical basis for the multimedia approach in environmental decision-making. The evolution of spatial data standards, the Internet, and the next generation of GIS technology allow all types of users to access the environmental information in its proper spatial context. The environmental map is a decision support system that will allow mainly:

- ✓ Support and develop methods for monitoring and assessing the state of the environment;
- ✓ Provide a better design programs of various activities related to the improvement and protection of the environment.

To benefit the environmental map for all stakeholders concerned with the environment, it will be accessible via the Internet based on the techniques of web-GIS-Web.

Everywhere, they permit to prevent risks and study the effects of any natural or industrial disasters, as well as the means to implement to minimize the impact. They also provide the essential support to the knowledge of natural environments, inventory and protection of biodiversity, identification and protection of reservoirs of biodiversity and ecological corridors, the proper management of water resources and to the seas and oceans.

Conclusion

This paper has attempted to define GIS and its Features and identify how GIS plays a key role in delivering the information needed to support the local development program. Illustrative examples of GIS-intensive local development were presented to show how the use of GIS technology facilitates the process of presenting local development opportunities.

In summary, GIS technology will continue to play a vital role in spatial planning, in urban dynamics and in environmental system management. GIS is becoming more suitable for emergency operations and is integrating tools that allow real-time display of information. The GIS allows, in many respects, the enhancement of technical capacity and decision making in the territorial management.

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