*Article*

# Utilization of geoprocessing for environmental studies

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**Abstract**

The geoprocessing is a computerized processing of georeferenced data, which has grown since the last 50 years and has been applied in several areas of study, including the environmental field. This innovative technology made possible the integration of data from different origins that can be processed through GIS into relevant information for society. Furthermore, geoprocessing is an essential tool for environmental professionals to apply on specific projects, which will require on the future more research in alternatives for reliable forecasting. Given that, this report describes the applications of geoprocessing for environmental studies and examines the advantages and disadvantages of its implementation. It also aims to discuss the utilisation and efficiency of this tool for environmental purposes.

**Keywords** GIS; acquisition of data; innovative technologies; geographical information; software

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## 1 Introduction

### 1.1 Definition

Obtaining information on the geographical distribution of natural resources, property and biodiversity has always been an essential segment of the activities of organized societies. Until now, however, this was done only for documents and paper maps; this prevented an analysis that combined several maps and data. With the simultaneous development in the second half of last century, computer technology, it became possible to store and represent such information in computing environment, making room for the appearance of geoprocessing (Ribeiro, 2008)

The term geoprocessing is defined as computerized processing of georeferenced data that uses computer software which enable the use of cartographic information and information that can be associated with the coordinates of these maps, charts or plans (Goodchild, 1990, p. 5). The term 'geoprocessing' denotes the use of mathematical and computational techniques for the treatment of Geographic Information Systems (GIS), and it has increasingly influenced the areas of Cartography, Analysis of Natural Resources, Transport,

Communications, Energy, and Urban and Regional Planning. For Francelino (2003), geoprocessing is a set of techniques and storage procedures, processing, automation and use of images for decision making.

According to Dias et al. (2011), geoprocessing activities involve several phases that might consist of storage, recovery and manipulation of spatial information and their combination, spatial analysis, and the production generation and visualization of already processed information, such as generation of maps and cartographic bases

**1.2 Historical background**

The art of drawing maps started in Greece in the sixth century BC, due to their navigation and military expeditions, Greeks stablished the main geographical knowledge center of the Western world. The oldest map ever found was made in Sumer, in a small clay tablet, and represents a state (Ribeiro, 2008). In the 1950's, in England and the United States, there were the first attempts to automate the processing of data with spatial features, with the main objective of reducing the costs of production and maintenance of maps.

In the 60's, came the first Geographic Information Systems as part of a government program in Canada to create an inventory of natural resources (Coppock and Rhind, 1991, p. 22). These systems, however, were difficult to use and the storage capacity and processing speed were very low.

In the 70's, new and more affordable hardware resources were developed. It was when that the term Geographic Information System (GIS) arose. Around the same time the commercial Computer Aided Design (CAD) systems arised, which served as the basis for the first automated mapping systems emerged (Coppock and Rhind, 1991, p. 23).

Finally, in the 80's, the technology of GIS started an accelerated growth period. In the USA, the creation of research centers that form the NCGIA (National Centre for Geographical Information and Analysis) marks the establishment of GIS as an independent scientific discipline (Coppock and Rhind, 1991, p. 33). With the popularity and cheapness of printing and the development of personal computers workstations there was a wide spread of use of GIS.

This innovative technology made possible the integration of data from different origins, which can be processed through GIS into relevant information for society. Therefore, this report describes the different applications of geoprocessing tools for environmental studies and then examines the advantages and disadvantages of its implementation. It aims to discuss the utilisation and efficiency of this tool for environmental purposes.

**2 Process**

Firstly, the acquisition of data enables the process of identification and collection of the necessary data (Maguire, 1991, p. 15-17). Subsequently, the pre-processing involves the treatment of captured data in its different shapes to be properly stored in digital format inside the computational database (Maguire, 1991, p. 15-17).

Afterwards, a database manager regulates the creation and access to database information. Through this, it is possible to enter, update, delete and recover the stored data (Maguire, 1991, p. 15-17). Then, manipulation and analysis is required. When working with analytical operators upon the database components, it is possible to generate new information. This analytical capacity is one of the great advantages of the system, since the coherence of information can lead to observation of facts that could not be easily noticed if the data is analysed separately. The interaction with mathematical models is also present at this stage (Maguire, 1991, p. 15-17).

Lastly, the generation of products is a phase in which the final products generated by GIS are created, for instance: reports, graphics and thematic maps (Maguire, 1991, p. 15-17).

According to Pina (2000) a GIS work can be divided into the following implementation phases:

**Problem specification:** clear definition of problems that are expected to solve the GIS, the reasons for development and what type of information needs to be generated through System.

**Definition of Databases:** it is important to list the type of data necessary to meet the stated purposes and manners to achieve them.

**System Specification:** it is necessary to stablish which equipment and programs will be needed to achieve the objectives.

**Acquisition System and early implementation:** the system is obtained and installed, and then it starts the generation of databases and begins the development of the GIS procedures.

**Data acquisition:** the generation of databases is usually the most expensive part of the implementation process. It is required special attention at this point to ensure the quality of data collection. In other words, it is fundamental that, the data will be sufficient to develop the analysis that the system proposes. It is also crucial to think about procedures that update the data involved.

**Preprocessing of data:** it is important to notice that data from different origins at different scales and different projection systems need a pre-processing in order to make them compatible.

**Data analysis:** after cleaning and making data compatible it is possible to perform the analysis, through which the data becomes useful information.

**Data Management:** It is essential to organize the updating of existing bases and the incorporate new bases and strategies. The extent to which new information is obtained, new questions arise, being common the need to deepen the analysis and expand access to new information.

**Graphics outputs:** the obtained data can be represented through various forms such as: maps, reports and tables

**Evaluation of Errors:** It is fundamental to verify the results to make sure they make sense. A computer program performs tasks, but the critical analysis of the results, assessing the consistency and quality of the data depends on the technical team.

**Operational phase:** it is important to establish procedures to ensure the system upgrade, keeping the satisfaction of information needs.

**Decision-making:** after completion of the above phases, the generated information becomes an important tool to aid decision making.

## 3 Advantages

- Classification and evaluation of the area: the land cover can be estimated in its degradation or protection levels (Pons *et al*., 2007, p. 727-728), and classified if it is an urban area, a crop field, a forest, a grassland, a pristine water area, a coastal area, etc. (Burrough and McDonnell, 1998, p. 30). Noise can also be analysed if it is affecting the area (see work of Costa and Lourenço, 2011). This classification can provide several information about the status of the surrounding biodiversity as well as the physical features, which will determine how significant is a certain area.
- Presentation of details of territorial occupation and vegetation cover: the area can be analysed to present details about the effects of human occupation, the percentage of them, to present which type of vegetation cover it has (floristical composition, type of species, etc) and estimate its percentage (Pons et al., 2007, p. 737-738). A particular type of vegetation cover can influence the occurrence of phenomena such as erosion, infertility, deserting, and other factors that affect soil structure, which reveal the importance of these details.

- Historical comparison between areas: it is possible to observe the local's past situation and compare the changes and its origins (Burrough and McDonnell, 1998, p. 31-32). This allows that geographical studies take place for mitigation and future ecological studies.
- Future projections: through the historical comparison, it is possible to foretell what the environment's conditions will be if a certain factor continues to degrade or improve the area, which is essential for decision-making.
- Powerful tool for decision-making: decision-making is always crucial in environmental studies (Dunn, 2007, p. 620-621), because it will influence the future of a particular area which is composed by a community that depends on its resources. Since geoprocessing contributes to the generation of all these information, it can be a good resource for decision-makers to rely on.

The use of geoprocessing can contribute to survey the forest situations occurred in the past, due to the dynamics of the use and occupation of the area, and thus determine which tools can be used for a complete analysis of the spatial dynamics. Consequently, reflections would be raised about what environmental conditions associated with the need for protection could be created, using the GIS technology and methodology, through satellite images that can contribute to the creation of new proposals for protection.

## 4 Disadvantages

- Cost-effectiveness: GIS can be expensive, especially for big projects, such as governmental studies which require a greater scale of data and specific programs to store them (see work of Arend, 1990).
- Acquisition of data: This stage is slow and expensive, which will depend on the accuracy of the first data and consequently the reliability of the resulting products (Maguire, 1991, p. 15-17).
- Estimations and predictions can be uncertain: spatial data can suffer some degree of uncertainty due to error-laden data (Krivoruchko and Crawford, 2005, p. 20), which can give a few dubious results.

## 5 Conclusions

Several works have been studying environmental issues using geoprocessing lately, for instance, da Silva, da Silva and Chagas (2014) show that geo techniques can be used to monitor areas where fishing is developed and Furlan, Bonotto and Gumiere (2011) used GIS for developing maps and analyses regards to environmental vulnerability in Brazil. In other words, geoprocessing is definitely an innovation that provides several advantages for the environment. However, at the same time, disadvantages are also a threat and need to be monitored for better outcomes. In conclusion, geoprocessing is an essential tool for environmental professionals to apply on specific projects, which will require on the future more research in alternatives for reliable forecasting.

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