

REVIEW ARTICLE

Geographic information systems and their application in the social sciences: A literature review

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ABSTRACT

This article presents a bibliographic review on the evolution of Geographic Information Systems (GIS) and their integration in the social sciences, which is important because the interrelation of these areas contributes to the knowledge of the people. In this sense, the objective was to contribute to the university academic knowledge, through the compilation, classification, analysis and synthesis of scientific works according to the subject treated. For this purpose, the historical, synthetic, dialectical, and analytical methods were used, with a descriptive and documentary type of research, obtaining as a result that the GIS are very useful in different fields of social sciences, ranging from archeology to sociology, including specific topics such as economics and criminology.

Keywords: Geographic Information Systems; Social Sciences; Information and Communication Technologies

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1. Introduction

Since ancient time, the human being has felt the need to discover new horizons and to capture these discoveries in different ways, thus the man of Cro-Magnon (European homo sapiens) made cave paintings on the routes of the animals hunted 13,000 years before Christ (BC). Much later, in the 18th century, a devastating outbreak of cholera in London led the physician John Snow, with the help of cartography, to draw up a map of an area of the city^[1], by means of which he detected the problem and was able to find the solution. In the nineteenth century, specifically in 1962, Roger Tomlinson created the first GIS in Canada^[2], which is why he is considered the father of GIS, and it is based on this study that in the same year the Environmental Systems Research Institute (ESRI) appeared, which currently develops GIS applications^[3]. At present, the progress of GIS has been vertiginous, especially with the use of the Internet as a large platform for communication and management of geographic data. For decades, GIS have been applied among other things for:

- (i) solving problems of land and natural resource management and environmental issues;
- (ii) military logistics;
- (iii) earth sciences (geology, geography, etc.);
- (iv) navigation;
- (v) architecture, among others.

“It is only recently that the use of the potential of GIS for other relatively unpublished fields and disciplines and in particular in Human and Social

Sciences research has begun to be considered”^[4].

In this sense, a GIS is nothing more than the

grouping of data, procedures, hardware, software and human resources^[5], which are used to work with geographic data, and which are generally applied to computer systems that are used among other things for research in earth sciences^[6]. Thus, it is important to mention that a GIS is not only a database, although it uses the computer to store the information obtained.

A clear example can be found in the study presented by Maldonado^[7], who proposes the use of GIS to teach social sciences to young people studying at the secondary level, with the aim of motivating research and taking advantage of the potential of geographic systems.

Under these precedents, the objective of this study is to contribute to university academic knowledge through the compilation, classification, analysis and synthesis of relevant scientific works on the application of GIS in different areas of social sciences. It is important to mention that this research was carried out due to the growing use of GIS in different academic disciplines, where of course those related to social studies are not the exception, in addition to the fact that it can be useful for those professionals who are looking for new areas of work for the application of GIS. However, in spite of the above, research on social aspects using GIS as a support tool, is not very well known, which is why the article in question was written.

2. Methodology

The article presented corresponds to a bibliographic review. In order to define the application of GIS in the social sciences, the following methods were used:

(1) Historical, because in the first place the evolution of GIS was defined;

(2) Synthetic, since the elements of GIS that could be used for application in the social sciences were identified;

(3) Dialectical, due to the consideration of the historical phenomena involved in the development of GIS;

(4) Analytical, because each element of GIS was distinguished and ordered to be applied to social sciences.

This article details, prior to a review of the published literature on the subject, the benefits of the application of GIS in the social sciences. To this effect, firstly, documentation on information systems in general and GIS in particular was reviewed to determine their evolution over time. We then reviewed the applications to which GIS have contributed.

3. Results and discussion

The application of GIS in the social sciences serves an important reference in the work developed by the Center for Spatially Integrated Social Sciences (CSISS), where through the use of information and communication technologies (ICT) related to geospatial and georeferencing techniques, GIS have been used in social sciences as the following.

- Archaeology, from the management of archaeological resources to the conception of landscape archaeology. In this sense, there are some basic studies about the use of GIS in archaeology such as the one proposed by Figuerero and Izeta^[8], which analyzes how prevalent is the use of these systems in South American archaeology, and where it was found that there is a tendency of greater autonomy on the part of archaeologists in terms of the use of GIS.
- Likewise, the study proposed by Pastor, Murrieta and García^[9] on the use of GIS in Spanish-speaking archaeology analyzes the current situation of archaeology in Ibero-America, obtaining as a result that the development of GIS as well as the methods and techniques for spatial archaeological analysis has been quite variable.
- There is also the study presented by Rodríguez-Pérez^[10] regarding the use of databases and Geographic Information Systems for the archaeological study of a specific type of architecture such as vernacular architecture. Even in this field there is suggestion of the use of GIS in

archaeofaunistic analysis as a support tool to examine space and resources^[11], and there is undoubtedly a strong correlation between archaeology and GIS, because the latter is used as a tool for analysis and interpretation of the archaeological record, which can be evidenced in Figuerero^[12] through his study on technology and ideas used for spatial analysis of archaeological landscapes in Argentina, or in the study proposed by Ibarra^[13] regarding the applications of geo-referenced information system in Ecuador, where he concludes that this type of systems are used in archaeological scientific research.

- Anthropology, due to studies such as the one proposed by Carrera^[14] in which he explains how ethnographic cartography is used as a methodological technical tool in anthropological research; or the one defined by Rivas and Perera^[15], in which they allude to the use of ethnocartography for the care of the environment; or the one proposed by Malo^[16], in which he analyzes the use of GIS for the adequate planning of the territory, in order to obtain a sustainable development of its inhabitants, and he concludes that a good way to achieve such development is, among other things, through the construction of territorial models through the generation of maps.
- In Ecuador, there is the work by Enríquez *et al.*^[17] entitled *Archaeology and anthropology in Ecuador: Scenarios, challenges and perspectives*, which analyzes various scenarios in which GIS and other technological tools can be used in order to propose new studies in archaeology and anthropology in the country.
- On the other hand, there are studies that relate engineering with anthropology to establish, for example, a system of indicators on public transport and mobility^[18], which explains the importance of GIS in the analysis of the territory for the design

and implementation of efficient transport services. In fact, this concept is not new. Garcia^[19] talked about the anthropology of the territory and the effect exerted on society by various factors such as biodiversity, cultural heritage, knowledge, among others^[20]. Economics, since it is related to research on economic growth, environmental economics, land use, and others such as studies on population distribution, fertility, family planning, and other topics related to demography. Here we can find studies such as that of Saldarriaga^[21], on the use of GIS for environmental conservation, or that of Haro-Martínez and Taddei-Bringas^[22], which explains through the use of GIS, how sustainable an economy can be according to its environmental valuation.

- There is also the study by Goerlich and Cantarino^[23], who use GIS to carry out the distribution of the population over a given territory, with the aim of studying the relationship between economy and environment in a unified system. Similarly, there is a study by Fagandini and Villanueva^[24] on the use of GIS as a tool to facilitate territorial decision making in terms of planning, development and integrated management.
- In Ecuador, there is a study published by the United Nations Development Program (UNDP), where a situational analysis of food sovereignty in the context of climate change adaptation is carried out, using GIS to obtain production data in certain productive sectors, with the aim of “reducing the vulnerability of the most important crops for the Ecuadorian economy”^[25].
- Human geography, due to the relationship between human beings and the world around them. It also focuses on the migratory movement, climate change, territorial planning, geopolitics, among others. Clear examples can be seen in the study

of GIS as a tool for the analysis of migrations, the example of the Catalan exodus of 1936 proposed by Burel, Rubióy Sitjar^[26], where the paths taken by migrants through the Pyrenees are analyzed through the use of cartography, with which the cartographic representation assisted by GIS is key to demonstrate the incidence of population displacement.

- In this context, there is also the study by Alonso^[27], who talks about the application of GIS for climate risk analysis through the use of cartography; as well as the research of Gezan-Matus^[28], who analyzes the use of GIS in civil protection, which is a contribution to risk management not only in the prevention stage, but also in disaster mitigation.
- In this sense, there is a proposal for a risk map of immovable heritage assets exposed to natural hazards, proposed by Rueda^[29], where the Model Builder tool of ArcGis was used to analyze and evaluate the state of conservation of Ecuador's immovable heritage assets. In addition to the aforementioned studies, Chuvieco *et al.*^[30] defined a new term that makes use of GIS in the geographic field and called it Geographic Information Technologies (GIT), which is applied in areas such as teaching, research or professional practice.
- Criminology, where concepts such as spatial modeling and analysis of patterns that interrelate social, economic or environmental phenomena with crime occurrences are studied. Examples of studies on these topics can be found in the research by Vozmediano and San Juan^[31], referring to the use of GIS in the study of fear of crime, through which crime maps were constructed in urban contexts.
- In the study on environmental criminology and GIS applied in a Spanish city, proposed by Martínez^[32], where the analysis of crime data and the space where

they occur was carried out, facilitating the study of the environment and its characteristics in order to base police actions on the analysis of these elements. In this sense, there is also the study proposed by Salafranca and Rodríguez^[33] regarding GIS applied to police investigation, or the study by Alcívar and Calderón^[34], regarding the spatial analysis and distribution of crime in the city of Guayaquil, where thanks to geostatistical methods, estimation and variance maps were obtained, through which it can be known that which areas has more crimes. However, these types of studies are not completely new, since Stageland and Garrido^[35] talked about the geographic analysis of urban crime, where they used computerized means to organize information on the crime problem.

- Sociology, because it studies the behavior of individuals and groups living in a given place. Thus, the study by Barrera^[36] on participatory GIS and social cartography can be highlighted, where aspects of formal (Euclidean) and social (not necessarily Euclidean) cartography and their relationship are analyzed, with the aim of complementing these two forms of spatial representation of territories.
- In this same context we can cite Linares^[37] with his study on the application of GIS in urban socio-spatial segregation, where working with databases linked to georeferenced geographic entities, allows adjustments of the information from points to lines, and from these to polygons, which overcomes the limitations in relation to the way in which the data is originally stored.
- On the other hand, there is the study by Chasco^[38]. In reference to the application of geomarketing and commercial distribution, a geographic analysis of the economic-social reality is carried out through GIS, which can find those locations with

the greatest potential for the establishment of a business.

- There are also studies on the use of GIS for the optimization of public administration^[39] in order to include spatial and thematic information to carry out different types of queries, as well as to execute dynamic cartographic models.
- In addition to the aforementioned, there are specific studies such as the one by Jiménez, Romeu, Pámies and Guasch^[40] on how to effectively manage noise through the representation of sound levels using such information systems, or the one by Becerra, Paichard, Sturma and Maurice^[41], who talk about the social perceptions of health risk due to oil pollution in Ecuador, and how geographical circumstances could limit the possibilities of action.

In this sense, the application of GIS in the social sciences covers various fields of study from archeology to sociology, including specific topics such as economics and criminology, which indicates that computational sciences and social sciences complement each other perfectly to contribute to science and to the knowledge of the people. There is no doubt that the use of these information systems is a growing trend^[42] due to the facilities it provides in various fields of study as demonstrated in the aforementioned literature review.

Thus, it can be noted that in each of the social sciences considered for this research, there are studies and publications of great interest in the regional context (South America), as well as in the Ibero-American context and, why not say it, in the global context.

According to the authors, the discovery and progress of many archaeological investigations has been thanks to the use of GIS by professionals who carry out this type of studies, which in turn has allowed the diversification of the methods and techniques used when carrying out archaeological explorations, with which the analysis of a given territory could be done in less time and with less use of resources.

In the same way, when we refer to the physical

aspect and the social and/or cultural expressions of a given population, we find the use of cartographies to determine anthropological elements and their interrelation with the habitat of the people, even considering their flora and fauna as resources that can be monitored and managed in a better way through the use of GIS, which is of supreme importance due to the fact that nowadays the cultural aspect has been taken up and is widely used to achieve the longed-for *Sumak Kawsay*, a Kichwa expression, which means Good Living^[43].

Thus, the realization of the so-called ethnographic cartography would allow, for example, to effectively detect the cultural, social, economic and even ethnic manifestations of a given population^[44]. It is also important to mention territorial planning in order to relate factors such as care for the environment, the preservation of biodiversity and cultural heritage, as well as to promote the sustainable development of the inhabitants of a given place.

At this point, we can also mention that since we are using a technological tool, the contribution of engineering professionals in various fields such as the development of computer systems, telecommunications, architecture, civil engineering, agro-industrial, environmental and others is unquestionable.

Regarding topics such as economics or human geography, the studies found are useful for making decisions regarding the management of a given territory or of a particular population group, or how the population could be distributed in a territory in such a way as to take more efficient advantage of the natural resources of the sector, for example, to know how sustainable an economy can or cannot be in accordance with the existing environment.

In this sense, studies related to the aforementioned areas are aimed at preserving the habitat in order to prevent extreme climate changes, such as the one we are unfortunately already experiencing and which is related to global warming due to the increase in greenhouse gases such as carbon dioxide, which causes, among other things, the depletion of the ozone layer^[45].

But it can also cover such important issues as food security, as reflected in a United Nations study

for Ecuador, or the use of GIS to prevent and mitigate disasters, in order to protect the population.

In the specific case of sciences such as criminology, the use of GIS makes it possible to detect patterns of behavior in a given region, which, in the opinion of the authors of this article, could increase the effectiveness of police investigation. But in addition to studying social behavior, GIS are used to know the precise locations where most criminal acts take place, which could undoubtedly serve to prevent risk situations as detailed in Vázquez and Soto^[46], through the development of maps and the use of methods and techniques related to geostatistics.

In sociology, we believe that the study of human behavior, supported by GIS, has revolutionized the conception and use of these sciences, for example, by coining terms such as participatory geographic information systems and social mapping, which according to some authors such as Sastre, Dorado and Ríos^[47], promote sustainable development by working with geo-referenced data.

We can also mention the management of noise in urban areas, the study of socio-spatial segregation, the optimization of public administration, the application of geo-marketing, or as in the case of Ecuador, social perceptions of pollution. All of these are good examples of how the use of GIS can optimally contribute to improving the quality of life of human beings.

4. Conclusions

The contribution to university knowledge proposed as an objective for the development of this review article has been effective, because relevant works in the area of social sciences were collected, classified, analyzed and synthesized, which were supported through the use of GIS.

As can be inferred from the results and discussion of this article, the use of GIS in the area of social sciences has grown significantly, due to the great diversification of studies in this area, which use geographic information as a support for the development of their sciences.

The application of GIS in the social sciences is not only useful in the academic field, but also in different sectors such as the social, produc-

tive, business, and even commercial sectors have benefited from the use of this important tool of technology, information and communication, as demonstrated in this article.

GIS-based research applied to the social sciences still has a long way to go, so the benefits that can be obtained from the use of such information systems is infinite, which will allow the interrelationship between engineering, social sciences and education in general to become stronger.

Conflict of interest

The authors declare no conflict of interest.

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