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Spatial statistics

The role of the spatial dimension in official statistics in Mexico

Note by the National Institute of Statistics and Geography of Mexico

Summary

The paper gives an overview of the development of Geographic Information Systems linked with the technological innovations, and the concept of geomatics as a systemic operation of processes for integration, systematizing and application of geospatial information through the use of information technologies. The paper presents a case study of a geomatic solution implemented by the National Institute of Statistics and Geography of Mexico to design a scheme for providing electricity via solar energy.

I. Introduction

1. Historically, mankind has needed to locate places, define routes, measure distances and establish positions and times. To meet these needs, he designed maps as tools to locate the required information; these maps are Geographic Information Systems (GIS) in their most basic expression. Below are examples of the oldest known maps found so far: Figure 1 shows the first, found in Ankara in 1963, dating from 6200 b.c.; Figure 2 shows the Babylonian cuneiform stone from around 1400 b.c.

Figure 1
Ankara

Figure 2
Babylonian cuneiform stone

2. The situation in our world today has not changed that much: decision-making is oriented to satisfy needs based on the application of Information Systems, with today's technology using systems which allow the processing of large volumes of information generated from aerial photographs, satellite navigation systems and satellites for earth observation.

II. The development and use of Geographic Information Systems and geomatic solutions

3. Information technology can make the processes related to Geographic Information Systems[1] more efficient, as well as those in many other fields of knowledge and human activity. The computer has not made us smarter, it has simply increased our capacity for processing data.

4. Given this wide availability of information through technological innovation, the competitive advantage of today's organizations lies in their ability to collect, organize, systematize and interpret information in order to make timely and supported decisions. Geo-referencing information is a vital part of the technical support for decision making in today's world.

1 A group of people, processes and geographical objects that, based on information technology, ease the management, analysis and representation of the spatially and temporally referenced data for the gestation of geographic knowledge and the construction of geomatic solutions. INEGI, 1997.

5. The evolution of society, understood as a series of transformations, depends on social conditions and circumstances at a given time. Evolution defines, in turn, new conditions which influence the next stage. Thus, it is important that decision-makers have, at each moment of change, the necessary and sufficient information to enable them to effectively plan the activities that consume resources and influence the course of human endeavor.

6. The constant evolution of today's society produces information that can be quantified and related to facts or events inherent to these changes. This information can be explained in a complementary way, by studying its geographical conditions through its flora, fauna, hydrography, topography, soil, and so on. It is important to note that the current geographical science studies physical, social and biological phenomena through analysis of their distribution and behavior, relationships and interactions.

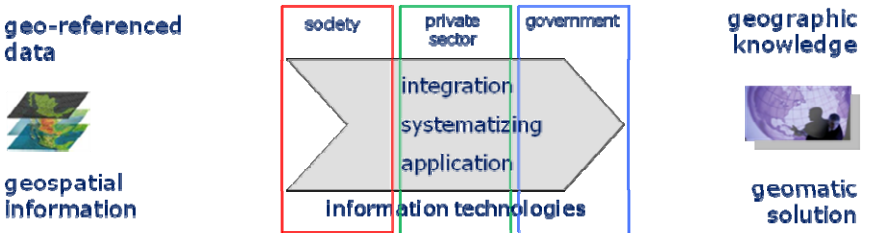
7. In this context, society requires instruments consistent with technological development that enable efficient study of the available information so that the results can positively and directly influence smart decision-making. From a systemic point of view, the consideration of the space-time nature — geospatial nature — of information is important because data and graphics, while providing necessary elements, are not sufficient to analyse the spatial and temporal relationships and interactions between elements of study. Therefore, it became necessary to adopt an integrative concept: geomatics, understood as a conjunction and systemic operation of processes for the integration, systematizing and application of geospatial information through the use of information technologies, notably Informatics and Telecommunication.

8. The emerging science of geomatics has encouraged the development of disciplines such as spatial statistics, also known as geostatistics, aimed at setting trends of statistical observations from the space-time reference, in addition to the trends established by traditional numerical analysis.

9. In this geomatic context, decision-makers involved in this age of information and knowledge are part of a broad spectrum, ranging from the student who wants to plan an ecotourism trip as a vacation exercise, to the executive in charge of land use of a country, via those that require the location of a single site of interest, such as those responsible for planning the distribution of goods and services. From this perspective, Geomatics adds value to numeric data, linking them to the geographic location in a given time, making them "visible" and therefore subject to space-time analysis. Thus, geomatics complement the numerical abstraction by giving an identity to the data that makes it different from the rest of the observations of the same species, thus allowing study and analysis of phenomena whose distribution in time and space is critical for their understanding.

10. Today’s user demands sufficient, updated and timely geospatial information stored in a database and available through a web information system that can provide evidence for policy making: this is the aim of a geomatic solution. GIS application meets a specific requirement to allow systemic study of the distribution and behavior of physical, social and biological processes based on their relationships and interactions. The referred study is systemic because it takes into account the interdependence of phenomena, through a cause-effect relationship, in order to explain behavior through new paradigms. Thus the geomatic solution is a product of instrumentation of processes of integration, systematizing and application of geospatial information (Figure 3).

Figure 3
From geo-referenced data and information to geographic knowledge and solutions



11. A geomatic solution generates a model[2] — or a set of models — that offers a characterization to address specific requirements; provides quantitative and qualitative information; in short, provides users with the necessary and adequate elements for effective decision-making about outlined requirement. For this, the process of building the geomatic solution requires resources such as concepts, models, structures, rules, geo-referenced data, geospatial information and geographic knowledge; meanwhile, the result consists of alphanumeric tables, text files, images, graphics , maps, videos and vector files. Geographic Information System plays a major role in building the solution through the application of its statistical and spatial analysis tools, as well as in the presentation of results.

12. Regarding its construction, from the early stages of a geomatics solution, requires the participation of all stakeholders: users, customers, information producers, analysts, integrators and decision makers, which at its formation may belong to different areas of knowledge; the selection will depend on the defined requirements which must be addressed in a timely manner to ensure that the geomatic solution meets its goal.

13. A geomatics solution is the result of an evolutionary process that begins with the identification of real events through their properties, which are modeled as entities using a predetermined taxonomic classification; this results in their modeling in the form of objects, following an oriented methodology, which serves as a logical structure upon the design and construction of the corresponding database, in which geo-referenced data are shaped, and whose main characteristic is its location based on a space-time reference frame.

14. The next stage is determined by the definition of geo-referenced data relationships, which makes them geospatial information. Subsequently, the identification of interactions promotes the gestation of geographic knowledge, whose application leads ultimately to the construction of geomatic solutions.

15. Global advances in GIS have been as dizzying as the evolution of Information Technology and Communication (ICT), such that in the near future, thanks to their close relationship, they will become integrators schemes in collaborative systems, tending to form systems of systems.

16. The National Institute of Statistics and Geography (INEGI) of Mexico, as promoter of the concept of geomatic solutions, has designed and built solutions at expressed request of various organizations, such as: the Ministry of Communications and Transport, the Ministry of Tourism, the Ministry of Energy, the National Center for Disaster Prevention and the Federal Electoral Institute, among others.

2 Abstraction of reality which facilitates its understanding, showing its important aspects in a simplified way, is a representation of an idealized structure similar to that of a real system; displays relations between variables of the phenomena that attempts to explain and assert that these formal relations are similar to those existing in reality. (INEGI, 2002).

III. Ministry of Energy: case study

17. For supporting poor rural communities, the Ministry of Energy designed schemes for providing electricity to these communities through the utilization of solar energy. For this purpose, INEGI supported the secretariat in identifying geospatially localities in the country that fulfill the following conditions:

(a) Situated in municipalities of high and very high deprivation (Figure 4);

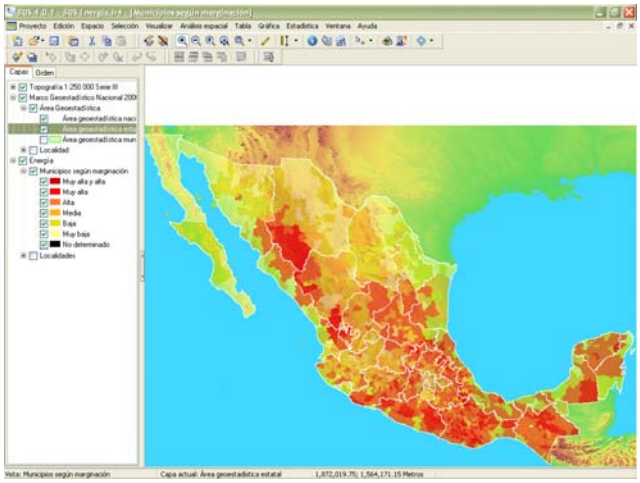
(b) Include 40% or more speakers of indigenous language;

(c) Have a population equal or greater than 100 inhabitants; and

(d) Have electricity in less than 10% of households.

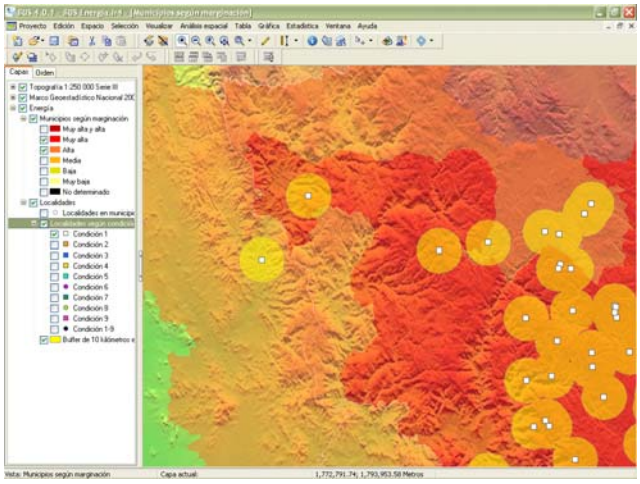
18. The first condition was treated based on data from the National Population Council, while for the remaining three was used information derived from the II Count of Population and Housing, 2005 (INEGI, Mexico, 2005).

Figure 4
Municipalities with high and very high deprivation



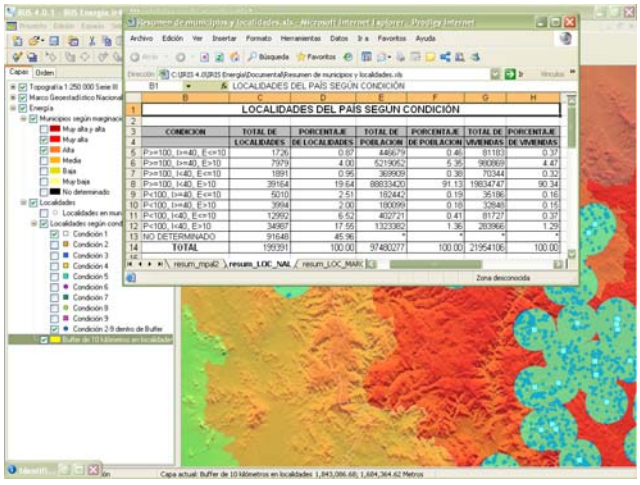
19. As result of spatial and statistical analysis, it was found that of among almost 200 thousand localities in the country, according to the II Count of Population and Housing, 2005, only 763 met the four conditions simultaneously (Figure 5).

Figure 5
Identifying target communities for providing electricity through solar energy



20. In addition to the initial requirement, it was sought to identify those communities that were in a radius of 10 kilometers from those already identified, although that did not meet predefined conditions. The aim was to evaluate the energy redistribution through wiring from these 763 communities to others also in need. As a result, we obtained a total of 15,910 communities that could benefit with the project undertaken by the Ministry of Energy (Figure 6).

Figure 6
Communities that could benefit from the project



21. Of course, all results obtained are geospatial in nature, so that one can see, using software-oriented GIS, the distribution and behavior of the communities involved. This can be viewed in both national and regional, state and municipal contexts and in its relationship and interaction with natural, cultural and social elements. When combining these elements with additional geographic information, decisions can be made about choice of routes for distribution of materials, location of solar collectors, choice of supply centers, identification of available natural resources, studies of temperature, calculation of electrical wiring and electrical capacity, among others.

22. This geomatic solution was given to the Ministry of Energy through a Geographic Information System known as IRIS.[3]

IV. Conclusion

23. We can say that today, the construction of geomatic solutions has a diverse character, in accordance with social, natural, cultural, economic and political conditions. So while some regions of the world aim at the conservation of resources, others are geared towards their exploitation, but in both cases with the same goal: making timely and evidence-based decisions.

24. Moreover, as already mentioned, the development of Geographic Information Systems has been so dizzying that now we are able to not only provide elements of study and understanding of social, biological and physical facts that occur somewhere in the world, but can also show their distribution and behavior in space and time. This suggests that, in the near future, the construction of geomatic solutions will allow the design of scenarios as a tool to prevent actions around natural disasters, for monitoring global climate change, for management of resources, and overall planning for sustainable development.

3 Software system developed by INEGI whose objective is to promote and facilitate the use, analysis, interpretation and integration of national geographic and statistical information to contribute to the knowledge and study of the characteristics of the territory, oriented to technically supported decisions.