The Catatumbo geographical information system

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Abstract. The objective of this study was to develop a Geographic Information System (GIS) for 16 municipalities in the Catatumbo region, Ocaña province and in southern Cesar, located in Colombia, South America. For this, a joint investigation was carried out between three entities: the UFPSO, IGAC, and Asomunicipios, which permitted the collection and structuring of the information to be uploaded onto the GIS, following tool design. As a result, the implementation of said tool was performed via installation on university servers and is in a state of continuous operation, as municipal officials are regularly trained in the management thereof. Thus, the tool constitutes an important technological development that will allow municipalities to improve the quality of the cartographic inputs used for territorial planning processes, as well as provide the means necessary to publish and manage this information for various purposes.

1. Introduction
Geographic Information Systems (GIS) are sets of tools that integrate human resources, geographic data, technological resources, and procedures for the organization, integration, storage, manipulation, analysis, and publication of the information that is used as input for decision making, independent of the field of application for which a given GIS is constructed [1]. Thus, geographic information systems have diverse applications in different fields. These may include mobility, humanitarian issues, geomarketing, and meteorology, among other applications, which essentially require the management of large flows of geographic information for later use in decision making processes [2-4].

Today, GIS has evolved into a Geographic Information Technology concept, which LINKS other technological components, such as remote sensing and spatial data infrastructures, among others, and which allows for continuous improvement in the management of geographic information, independent of its applicability or articulation with global dynamics [5].

Spatial information and cartography should be considered public goods, as upon their addition to geography as a fundamental science for territorial understanding, they should be considered the platform for Colombian territorial development [6].

In the field of territorial planning, the GIS has acquired great relevance, since they permit territorial planning based upon a combination between the data flows offered by information systems offer and the capacity for analysis and evaluation provided by land use planning. This would enable the GIS to build a solid basis for said ordering process to be carried out, via the definition of the future of populations and places, in terms of the spatial distribution of the following: people, resources, the
layout of geographical areas, structures, and economic and political districts, among others. These would ultimately enable the creation of a structure for territorial occupation models [7].

The objective of the present study was to develop a geographic information system for the ordering of the Catatumbo region’s 16 municipalities, located in Colombia, South America. Said area was selected for study, in order that this tool would permit optimization of the territorial planning process, based upon the management of the quality geographic information that is constantly generated in the region.

2. Data description
The Catatumbo geographic information system is a kind of participatory GIS, which includes government entities, and which can be modified such that players in the territory, who have been excluded from many activities and from participation in decision-making spaces which surround territorial planning [8].

The data used for the advancement of this project were:
- Technological infrastructure inventory from the Universidad Francisco de Paula Santander Ocaña (UFPSEO).
- Cartographic information databases from 16 municipalities.
- Base cartography scale 1:100,000 for 16 municipalities.

3. Methodology
For the development of the Catatumbo geographic information system, a concurrence of wills was initially established between the UFPSEO, the Instituto Geográfico Agustín Codazzi, and the Association of Catatumbo Municipalities, Province of Ocaña and Sur del Cesar. In said agreement, 16 municipalities were specified to form part of the project’s spatial scope. These municipalities were: Abrego, Cachira, Convencion, El Carmen, El Tarra, Hacari, La Esperanza, Playa de Belén, Ocaña, San Calixto, Teorama, Sardinata, Villacaro, Tibú, in the department of Norte de Santander and Rio De Oro, and González in Cesar. Later, it was established that the UFPSEO entity would administer the system, therefore necessitating a diagnosis of its technological infrastructure. Following the diagnosis, it was decided that the GIS would be developed with free software, for the execution of the following stages and activities:

3.1. Planning
In this phase the Project Management Plan and detailed schedule will be elaborated.

3.2. Analysis
This phase of the project will allow obtaining the following products:
- A document containing the minimum requirements of geographic and alphanumeric information, to be supplied by the involved municipalities, and to be published in the Catatumbo GIS.
- An inventory and diagnosis document of the geographic and alphanumeric information defined for the Catatumbo GIS.
- Agreement minutes, in which the list of geographic information layers is determined. These may be published through geoservices.
- A document containing policy guidelines for the flow of information and the minimum conditions for delivery of geographic information.
- A Catatumbo GIS analysis document.
- An inventory document and diagnosis of the existing technological infrastructure for the Catatumbo GIS implementation.

3.3. Design
This phase of the project will allow obtaining the following products:
3.4. Development
This phase of the project will allow obtaining the following products:
- Source code developed and documented inline, for the Catatumbo GIS functionalities, established in the scope of the project.
- A copy of the Catatumbo GIS database, with operation in the IGAC test environment.
- Metadata regarding the geographic web services published in the Catatumbo GIS, in accordance with the ISO 19119 standard.

3.5. Implementation
This phase of the project will allow obtaining the following products:
- Verification of technological infrastructure (production environment) prepared for the Catatumbo GIS.
- Installers and/or deployment files for the Catatumbo GIS.
- Catatumbo GIS, installed and stable, in the production environment, with the technological infrastructure available.
- An act of installation and start-up for the Catatumbo GIS.
- A copy of the Catatumbo GIS database.
- A Catatumbo GIS installation manual.
- A Catatumbo GIS user manual.
- Catatumbo GIS geoservice construction manual.
- Support material, in digital and print format, for training sessions.
- A training session minutes at the user and administration levels, for the Catatumbo GIS.

3.6. Dissemination and training
This phase of the project will allow obtaining the following products:
- A technical article on the Catatumbo GIS.
- Workshops in the Catatumbo region, in order to socialize the GIS.
- Execution of two short courses at the IGAC headquarters.

3.7. Monitoring and control
This phase of the project will allow obtaining the following products:
- Reports of monthly project progress.
- Reports of quarterly project progress.
- A final project reports.
• Meeting minutes and attendance records.
• Acts of approval for those products resulting from each stage of the project.
• Final delivery certificate.

3.8. Support
• This phase of the project will allow obtaining the following products:
  • Service Level Agreement document - SLA.
  • A log of faults detected, and solutions implemented, in accordance with IGAC provisions.
  • Installation and use manuals for the Catatumbo GIS.
  • Installer and / or deployment files contained in the Catatumbo GIS.
  • A copy of the Catatumbo GIS database.

It is important to highlight that, in the analysis and design stages, an inventory of municipality geographic information was carried out, an activity performed by the UFPSO and Asomunicipios, in order to structure 50 regional layers.

The GIS was thus developed in the IGAC CIAF offices, employing postgresQL + postgis for database management, and the geoserver software for geoservice management, metadata and other purposes. The use of free software in a web geographic information system contributes greatly to the massive diffusion of cartographic information, which may be consulted by any user with an internet connection [9-10].

Following development, the GIS was installed on the servers arranged by the UFPSO, and the administration chief was trained. GIS management training sessions were carried out simultaneously for municipal officials.

4. Results and discussion
The main result of the project was the development of the Catatumbo GIS web platform, which is available at the following website: http://sigcatatumbo.ufpso.edu.co/SIGCATATUMBO/.

The tool works from four servers: a web server, map server, application server, and a database server, and contains 79 layers of geographic information, structured in accordance with the catalogue of objects for land use planning from the Instituto Geográfico Agustín Codazzi [11]. Said layers are organized into five themes: agrology, base cartography, structures, and determinants, as shown in the table of contents for the application1.

On the other hand, the system has several tools which allow for not only the display of information, but also the performance of basic analysis. Within the navigation and visualization menus are the pane, zoom, zoom out, total view, refresh layers, previous view, and rear-view tools (Figure 1). In the following menu, titled application tools, are those tools used to measure, locate by coordinates, draw, add WMS, for and graphic output (Figure 2). In the penultimate menu are the query tools that are Spatial Selection, Identify, Simple Query, Advanced Query, Intersection Query, Influence Area (Buffer), Clean Spatial Selection (Figure 3).

Finally, there is a help module integrated into the system, which contains a manual that explains all necessary considerations for the use of the GIS [12] (Figure 4).

When implementing the GIS, after its installation on university servers, several tests were carried out, in order to verify the correct functioning of each tool. This evaluation revealed that all tools were working correctly. However, the platform was a bit slow to load, therefore the university systems division performed tests, so as to optimize server response speed. The tool is operational 24 hours a day, and municipalities are continuously trained for its use, and so there is already a certain level of system ownership present within the municipal administrations.

It is expected that, in the short term, this tool may be integrated with regional spatial data infrastructure, which will improve the quality of the geographic information generated in the region.
for territorial management in these 16 municipalities. The above will allow for the dissemination of quality public information for both territorial management and decision making.

**Figure 1.** Navigation and display panel display.  **Figure 2.** Display of the application tools panel.

**Figure 3.** View of the queries panel.  **Figure 4.** View of the help module.

**5. Conclusions**
The development of the Catatumbo GIS constitutes an important regional advancement for the construction of a network platform that fosters the culture of geographic information as an input for decision-making on crucial issues, such as land-use planning, and which will allow officials from territorial entities to publish and access information, in addition to permitting other types of users to access the information in a responsible manner for academic, scientific, or other purposes, with the
aim of generating new knowledge or providing timely solutions problems that affect the sustainable regional development of Catatumbo, especially considering that this region has been affected by the armed conflict for many years.

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