IMPACTO CIENTÍFICO EDITORA

FROM ANCIENT CARTOGRAPHY TO MODERN GEOTECHNOLOGIES: ANALYSIS OF THE APPLICATION OF THESE TOOLS BY THE PUBLIC ADMINISTRATION OF THE MUNICIPALITY OF SOBRAL, CEARÁ

DA CARTOGRAFIA PRETÉRITA ÀS GEOTECNOLOGIAS MODERNAS: ANÁLISE DA APLICAÇÃO DESSAS FERRAMENTAS PELA GESTÃO PÚBLICA DO MUNICÍPIO DE SOBRAL, CEARÁ

DE LA CARTOGRAFÍA TRADICIONAL A LAS GEOTECNOLOGÍAS MODERNAS: ANÁLISIS DE LA APLICACIÓN DE ESTAS HERRAMIENTAS POR PARTE DE LA ADMINISTRACIÓN PÚBLICA DEL MUNICIPIO DE SOBRAL, CEARÁ

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ABSTRACT

Currently, there is a constant need for dialogue between geography and modern geotechnologies. This research project conducts a study ranging from historical cartography to contemporary geotechnologies to analyze how these tools can be used by public management in strategic decision-making in various sectors. The study focused on the

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municipality of Sobral, located in the northern region of the state of Ceará (3°41′10″ S; 40°20′59″ W). For this purpose, traditional cartography and its historical applications in urban administration and planning were explored, emphasizing the importance of maps as instruments of spatial representation and analysis and the transition to geotechnologies, which incorporate technologies such as geographic information systems (GIS), satellite imagery, and remote sensing, providing a new level of precision and dynamics in the management and monitoring of territories. In addition, we investigated how geotechnologies are employed in the public management of Sobral for strategic decision-making, for efficiency in resource administration, and for promoting the sustainable development of the city. The study noted that integrating these technologies into the management process can increase the effectiveness of public services and provide a basis for developing targeted public policies. In the case of public management in Sobral, the use of geotechnologies represents a significant advance over past cartographic practices, contributing to the modernization of administrative processes and the development of smarter and more participatory urban planning.

Keywords: Cartography. Geotechnologies. Public Management. Urban Planning. Sobral.

RESUMO

Atualmente, há uma necessidade constante de diálogo entre a geografia e as geotecnologias modernas. O presente trabalho de pesquisa realiza um estudo desde as cartografias pretéritas às geotecnologias contemporâneas para analisar como essas ferramentas podem ser utilizadas pela gestão pública na tomada de decisão estratégicas em diversos setores. O estudo foi direcionado ao município de Sobral, situado na região norte do estado do Ceará (3°41′10″ S; 40°20′59″ O). Para esse propósito, explorou-se a cartografia tradicional e suas aplicações históricas na administração e no planejamento urbano, ressaltando-se a importância dos mapas como instrumentos de representação e análise espacial e a transição para as geotecnologias, as quais incorporam tecnologias como sistemas de informações geográficas (SIG), imagens de satélite e sensoriamento remoto, proporcionando um novo nível de precisão e dinâmica no manejo e monitoramento de territórios. Além disso, investigou-se como as geotecnologias são empregadas na gestão pública de Sobral para a tomada de decisões estratégicas, para a eficiência na administração de recursos e promoção do desenvolvimento sustentável da cidade. O estudo observou que a integração dessas tecnologias no processo de gestão pode aumentar a eficácia dos serviços públicos, bem como oferecer bases para a elaboração de políticas públicas direcionadas. No caso, da gestão pública de Sobral, a utilização das geotecnologias representa um avanço significativo em relação às práticas cartográficas do passado, contribuindo para a modernização dos processos administrativos e para a construção de um planejamento urbano mais inteligente e participativo.

Palavras-chave: Cartografia. Geotecnologias. Gestão Pública. Planejamento Urbano. Sobral.

RESUMEN

Actualmente, existe una necesidad constante de diálogo entre la geografía y las geotecnologías modernas. El presente trabajo de investigación realiza un estudio desde las cartografías antiguas hasta las geotecnologías contemporáneas para analizar cómo estas herramientas pueden ser utilizadas por la gestión pública en la toma de decisiones estratégicas en diversos sectores. El estudio se centró en el municipio de Sobral, situado en la región norte del estado de Ceará (3°41′10″ S; 40°20′59″ O). Para ello, se exploró la

cartografía tradicional y sus aplicaciones históricas en la administración y la planificación urbana, destacando la importancia de los mapas como instrumentos de representación y análisis espacial y la transición a las geotecnologías, que incorporan tecnologías como los sistemas de información geográfica (SIG), imágenes satelitales y teledetección, que proporcionan un nuevo nivel de precisión y dinamismo en la gestión y el monitoreo de territorios. Además, se investigó cómo se emplean las geotecnologías en la gestión pública de Sobral para la toma de decisiones estratégicas, la eficiencia en la administración de recursos y la promoción del desarrollo sostenible de la ciudad. El estudio observó que la integración de estas tecnologías en el proceso de gestión puede aumentar la eficacia de los servicios públicos, así como ofrecer bases para la elaboración de políticas públicas específicas. En el caso de la gestión pública de Sobral, el uso de las geotecnologías representa un avance significativo en relación con las prácticas cartográficas del pasado, contribuyendo a la modernización de los procesos administrativos y a la construcción de una planificación urbana más inteligente y participativa.

Palabras clave: Cartografía. Geotecnologías. Gestión Pública. Planificación Urbana. Sobral.

1 INTRODUCTION

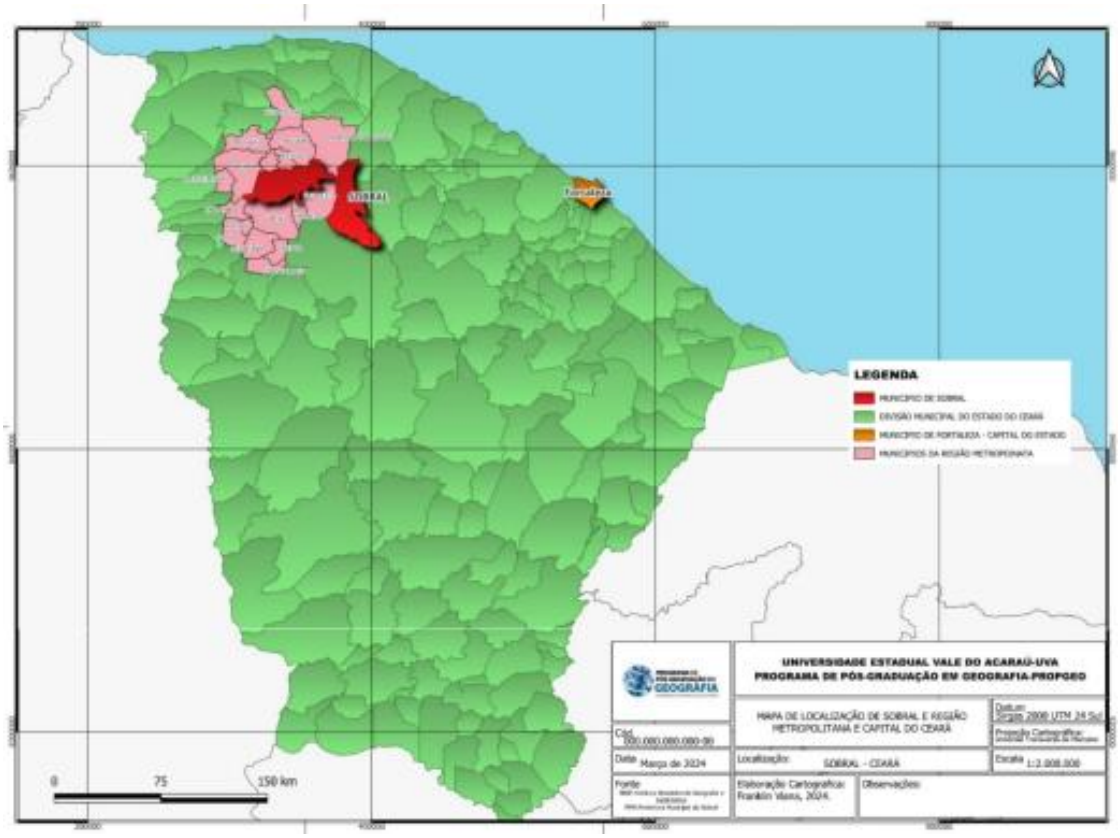
Geographical science, with its different areas of research, enables the study, understanding and analysis of society and nature. To this end, scholars interested in themes related to Geography have written theses, dissertations, books, monographs and scientific articles on the most diverse environmental, social, economic, cultural, educational and agrarian phenomena and problems on a local, regional, national and/or global scale. Among such researches, those related to geotechnologies and their multiple applicabilities have stood out in contemporary times.

Several scholars, such as Santos (2014), Fitz (2008) and Rosa (2005), understand geotechnologies as a set of technologies that enable the collection, processing, analysis and provision of geographically referenced information, such as: geoprocessing, Geographic Information System (GIS), Global Positioning System (GPS), remote sensing, aerial photogrammetry. These tools can be applied in the most varied studies of environmental and urban phenomena, as well as in different sciences, such as: Engineering, Agronomy, Geology, Geography, for example, enabling better management of the territory, urban planning and public management. The various applicabilities of geotechnologies in different areas of knowledge were possible due to the evolution of technologies that intensified, especially from the 1960s onwards, parallel to the globalization process.

Advances in geotechnologies have enabled many Brazilian municipalities to start using these technologies in urban and regional planning, environmental management, monitoring of natural disasters, sanitation and energy works, the provision of health equipment and services, municipal and rural registration, among several other possible applicabilities with these tools (Carmo et al., 2025; Rafael et al., 2025; Ximenes et al., 2025). Among the Brazilian municipalities that have adopted geotechnologies as a resource to manage, organize and direct municipal management, the municipality of Sobral has implemented the use of these technologies as a support to assist strategic segments of public management. The municipality of Sobral is located in the northern region of the state of Ceará, 230 km from the capital, Fortaleza and occupies a strategic geographical position that connects the coast and the hinterland of the state, configuring itself as one of the main urban and economic centers.

Figure 1

Location of the municipality of Sobral and metropolitan region



Source: Authors, 2024.

In addition, it stands out as one of the main industrial and commercial centers in Ceará, having in its territory a diversified base of industries, including sectors such as textiles, footwear manufacturing and metallurgy, generating jobs and income for a portion of the local and regional population.

The present research work carried out a systematic study on the insertion of geotechnologies in the planning and management sectors of the urban space of Sobral, Ceará. In addition, it addresses the modifications, advances and applicability of geotechnologies over time, the evolution of the use of cartographic tools and geotechnologies in the Master Plans of Sobral, from the 1960s to the most recent legislation, evidencing the transition from CAD systems to GIS in municipal public management and the multiple applicability of geotechnologies in the secretaries of the Municipality of Sobral.

2 THEORETICAL FRAMEWORK

2.1 EVOLUTION OF CARTOGRAPHY, DIFFERENT GEOTECHNOLOGIES AND APPLICATIONS IN URBAN PLANNING

Cartographic science has great relevance in the spatialization and understanding of spatial phenomena by using information technologies, software and equipment that provide high precision in the acquisition and analysis of spatial data aimed at various areas of knowledge, such as territorial and urban planning.

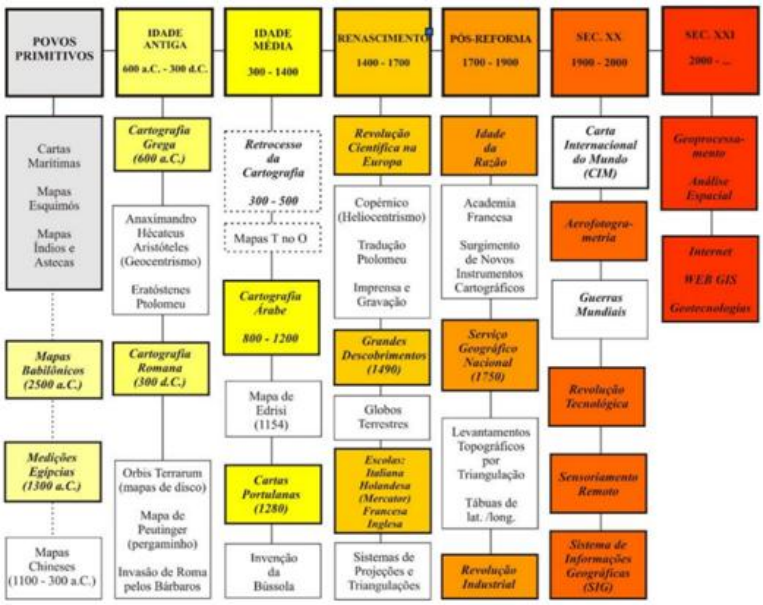
2.1.1 From cartography to geotechnologies

Cartography, over time, has received different definitions, with the International Cartographic Association (ICA) being the most accepted in the literature, considering it as scientific, technical and artistic studies and operations, resulting from direct observations or analysis of documents, aiming to elaborate maps and charts representing elements, phenomena and physical and socioeconomic environments, as well as their use (Favrin, 2009; Duarte, 2006; Villaça, 1999). Thus, cartography is understood as a set of scientific or artistic studies and techniques that seek the elaboration of cartographic products, representing natural and social phenomena.

Figure 2 shows the evolution of cartographic science by a periodization, as proposed by Castro (2023). It is noted that cartographic science has evolved together with technological evolution, under the social, political and economic conditions of each historical period.

Figure 2

Periodization of cartography



Source: Castro, 2023.

According to Castro (2023), cartography has its history marked by the passage from a technical-scientific context with a slow pace to a dynamic context in the collection, storage, and processing of spatial information, which has enabled accurate, fast, and increasingly efficient spatial analyses. In this way, the history of cartography is associated with historical events and technological advances and has been undergoing theoretical, conceptual, methodological and technical transformations, especially since the 1960s, evidencing two distinct but complementary phases related to the production of maps before and after computational tools (Castro, 2023; Moura, 2014; Trivisan, 2009).

Rosa (2013) reports that until the 1950s of the twentieth century, documents, charts and maps were prepared in an analog way, which did not allow for more precise and detailed analyses. In the 1970s, with the advances in information technologies and remote sensing techniques, it allowed the obtaining, storage and representation of spatial information in a computational environment. At the same time, mathematical and statistical methods for the treatment of geographic information emerged, resulting in thematic mapping of the most varied areas of the earth's surface. From the 1990s onwards, these technologies were consolidated as a support for decision-making in public management, leaving academia and reaching the market in general. Government institutions and large companies start to invest in applications and software development for spatial analysis, digital image processing, modeling, geostatistics, etc.

At the beginning of the twenty-first century, with the consolidation of the internet, these technologies become part of the web environment, in which applications become simpler and easier to handle, and there is no need for professionals in the area to use them. Systems such as Google Maps, Google Earth, among others, emerge (Rosa, 2013). In Brazil, the use of these technologies began in the 1980s, with the Canadian Dr. Roger Tomlinson, responsible for the development of the first GIS, the Canadian Geographical Information System (CGIS), in 1982, a milestone for the emergence of groups focused on the development of geographic information technologies.

In 1984, the National Institute for Space Research (INPE) created a research group for the development of geoinformation and remote sensing technologies, developing the Image Processing System (SITIM) and the Geographic Information System (SGI) and, in 1991, the Geographic Information Processing System (SPRING) and TerraVIEW. All the technologies mentioned above have in their essence the collection, storage, analysis, representation and distribution of georeferenced information, that is, they correspond to geotechnologies. According to Fitz (2008), geotechnologies are new technologies with the

most diverse purposes, providing an expressive and powerful technical instrument aimed at cartographic production.

In this way, in the current scenario, cartography, developed through geotechnologies, becomes a tool of great relevance to analyze, diagnose and plan different environments, landscapes and regions.

2.1.2 Main geotechnologies

Information and communication technologies have been undergoing significant transformations due to technological advances, influencing the most varied branches of science. In geographical science, which focuses on understanding the development and organization of societies and the dynamics and evolution of landscapes on the earth's surface, new technologies have provided greater precision in the analysis of natural resources, installed infrastructures, distribution of populations, etc. (Lima et al., 2023; Costa et al., 2022; Rosa, 2013). Thus, geotechnologies refer to new technologies related to geosciences, which bring significant advances in the development of research, in planning actions, in management and management processes, and in many other areas, and the applications of geotechnologies in the most different fields of knowledge have obtained significant growth.

Geotechnologies are formed by hardware, software and peopleware solutions, aimed at data collection, editing of complex maps and the crossing of spatial information in a fast and effective way, which allows users of geotechnologies convenience in their research, providing greater reliability and accuracy of information (Silva, 2017; Ribeiro et al., 2015; Milk; Rosa, 2006). Among the main geotechnologies, we can highlight the Global Positioning System (GPS), Topography, Digital Cartography, Remote Sensing, and Geographic Information Systems (GIS). GPS is a system of global scope and has facilitated all activities that require positioning. This global positioning system involves a constellation of satellites orbiting around the Earth, which allow receivers to know their position anywhere on the Earth's surface with remarkable precision (Monico, 2002; Bernardi; Landim, 2002).

Digital Cartography is the dynamic representation of the real world, which has enabled the user to change the perspective, projection and level of detail of the information, giving more interactivity, that is, it allows its users to digitally navigate over geospatial information, contributing to a new relationship between the reader and the geographic space and plays a fundamental and indispensable role for a good performance in the area of the so-called geotechnologies (Godoy; Moura; Menezes, 2010; Fitz, 2008).

Remote Sensing can be defined as a way of obtaining information from an object or target, without physical contact with it. In general, it refers to the act of obtaining information about a given territory, using satellite images as a means of data acquisition (Leite; Rosa, 2006). Remote Sensing basically involves two stages: the acquisition of information and the other of use. In the first stage, the information is acquired through the electromagnetic radiation captured by the sensor systems and the spectral behavior of each target. The second stage refers to the applicability in different areas of knowledge, such as Geography, Civil Engineering, Agronomy, etc. (Pereira; Silva, 2001; Nogueira, 2009; Miranda, 2005; Holanda et al., 2023; Hamada; Gonçalves, 2007; Cavalcanti, 2008).

The applications of geotechnologies, as well as free access to georeferenced information in databases and free software, have made the use of geoinformation increasingly popular. In public management, especially in urban planning, geotechnology techniques have been widely disseminated, being applied in the preparation of master plans, environmental zoning, sectoral plans, that is, in all urban planning instruments.

2.1.3 Application of geotechnologies in urban planning

Geotechnologies can be defined as a set of technologies aimed at collecting, processing, analyzing, and offering information with geographical references. In addition, the applications of geotechnologies in the various fields of science have shown great potential, especially in geographic science, both in the environmental and social areas, as well as in urban planning and management (Rosa, 2005; Florenzano, 2011).

Urban planning, according to Vilaça (1999), is the act of organizing urban spaces in a specific way. For Hoffmann et al. (2011), urban planning aims to improve the quality of life of the inhabitants, in addition to providing structures for organized urban space.

The urban planning instrument available to the municipal government is Law 10.257/2001 (City Statute), which regulates urban policy in Brazil, discipline of land use and occupation subdivision, environmental zoning, multi-year plan, budget guidelines and annual budget, participatory budget management, sectoral plans, programs and projects, economic and social development plans and the Master Plan.

Recently, municipal public administrations in Brazil have sought in geotechnologies technical alternatives to generate information on the most varied aspects of urban space for the implementation of their public policies. In this sense, geotechnologies, especially GIS, offer a range of tools to obtain geospatial data on infrastructure, land use, demography, and the environment, which can be mapped and analyzed to understand the dynamics of urban space and identify problems and opportunities. In this way, different development scenarios

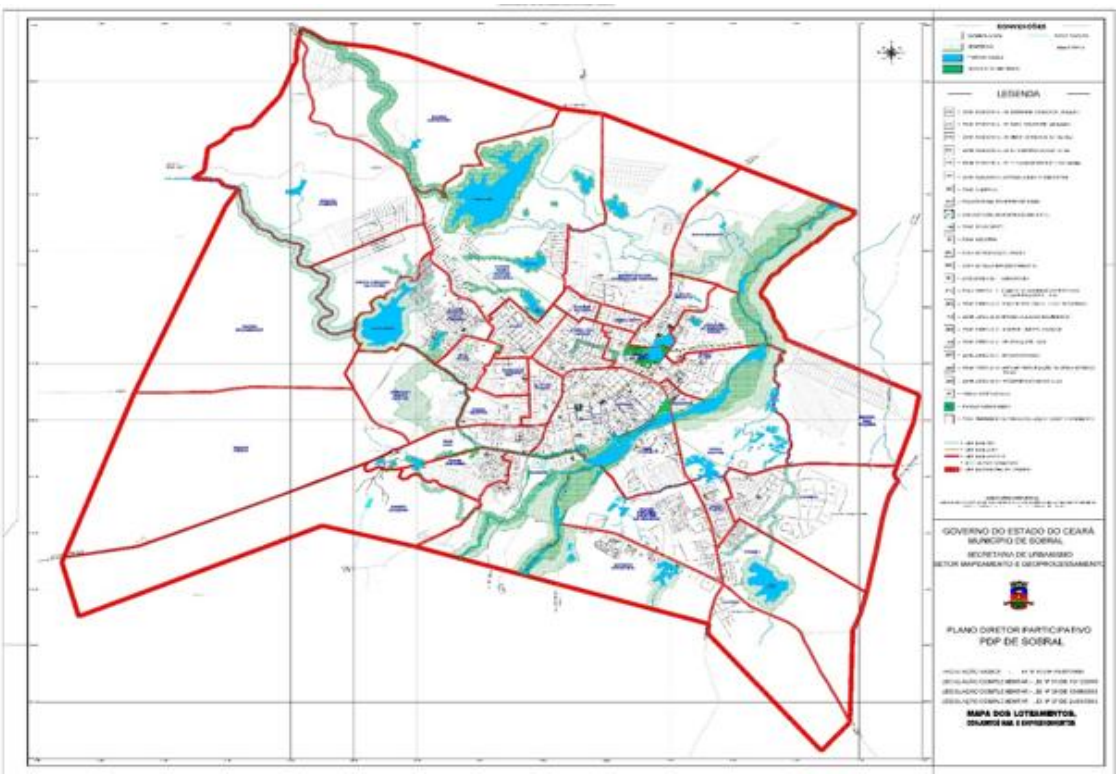
of cities can be modeled and simulated to assess their impacts, identify failures and adjust strategies (Ziegler et al., 2016).

Studies carried out on the urban planning of Sobral point to a rapid growth of the city and the need to improve development instruments as the main factors (Alves, 2009; Alves, 2017; Ziegler et al., 2016). The applications of geotechnologies for the urban planning of the city of Sobral have varied over time. It was observed that until 2008 there was the predominant use of *Computer-Aided Design* (CAD), from this period there was the implementation of other geotechnologies, such as GIS. This significant change in the landscape of the use of tools for cartographic production was marked by the gradual transition from the predominance of CAD to the growing adoption of GIS. This phenomenon reflects not only technological advances, but also a paradigm shift in the approach to the analysis and representation of geographic space.

Both CAD and GIS systems have the ability to manipulate spatial data. However, their conceptual and functional differences were fundamental to choose the use of GIS in the construction of urban and environmental planning in the municipality of Sobral. Figures 3 and 4 show the mapping of the neighborhoods of the seat of the municipality of Sobral, obtained by CAD and GIS, respectively.

Figure 3

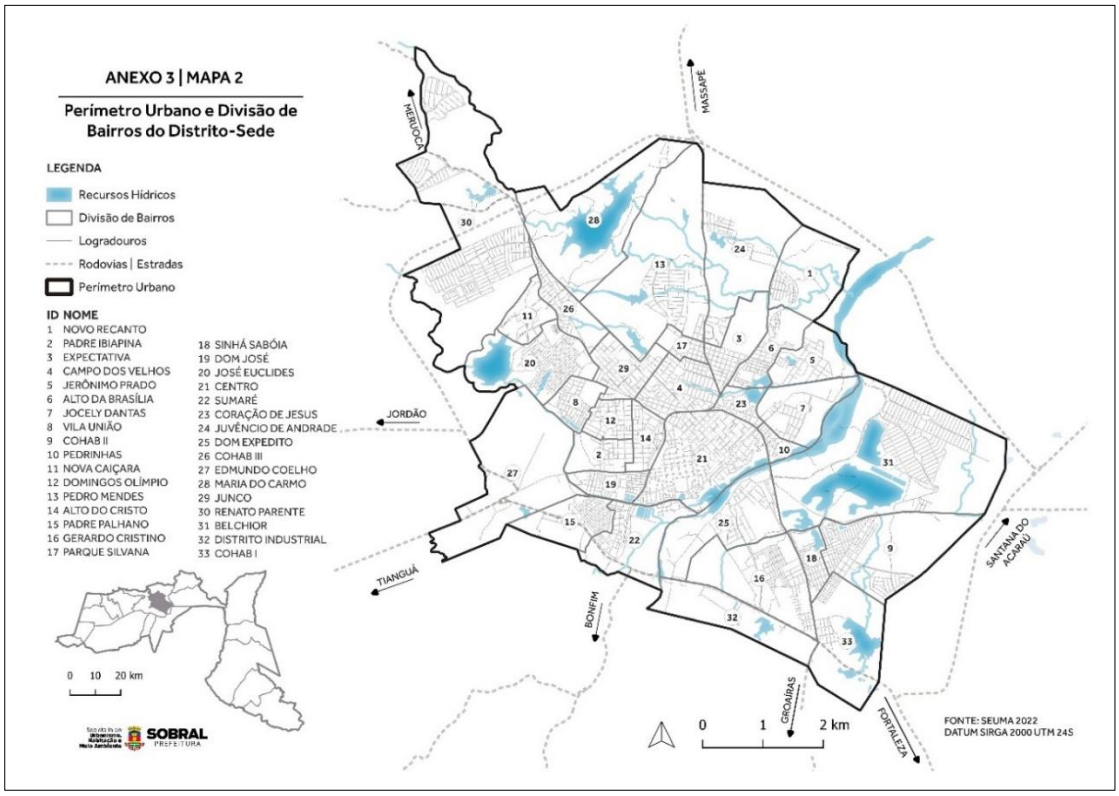
Division of neighborhoods of the seat of the municipality of Sobral using CAD (dated 2013)



Source: Secretariat of Urbanism – Sobral City Hall (2023).

Figure 4

Division of neighborhoods of the seat of the municipality of Sobral using GIS (dated 2023)



Source: Secretariat of Urbanism – Sobral City Hall (2023).

It can be seen in Figure 3 that the application of the CAD tool in the elaboration of the map of the municipal division of Sobral, in the year 2013, there is a difficulty in producing cartographic products adequate to the demands of urban planning. On the other hand, the mapping produced in a GIS environment (Figure 4) shows higher quality and better understanding of the information, enabling the integration of various information. Therefore, it is essential to use geotechnologies as tools for urban planning, especially in decision-making by public agencies and their agents.

3 METHODOLOGY

The development of the research work encompasses bibliographic, documentary and field research. The bibliographic research includes works reported in the literature such as theses, dissertations, monographs, scientific articles and books related to the theme. The documentary research was based on the consultation of documents in the public domain, official websites (Brazilian Institute of Geography and Statistics – IBGE) and companies, industries or journalists, reports, recordings and photographic records. The field research involved the collection of data obtained by geotechnologies in the different secretariats of the

municipal government of Sobral, as well as the knowledge of these tools and their applicability in specific segments.

The field research was carried out in the period 2023 and 2024, both in the city of Sobral and in districts (such as Taperuaba), where a conservation unit is located (Pedra da Andorinha). The field research was strengthened with notes, photographic records and images generated by drones.

4 RESULTS AND DISCUSSIONS

4.1 GEOTECHNOLOGIES AND DATA COLLECTION BY THE PUBLIC MANAGEMENT OF THE MUNICIPALITY OF SOBRAL

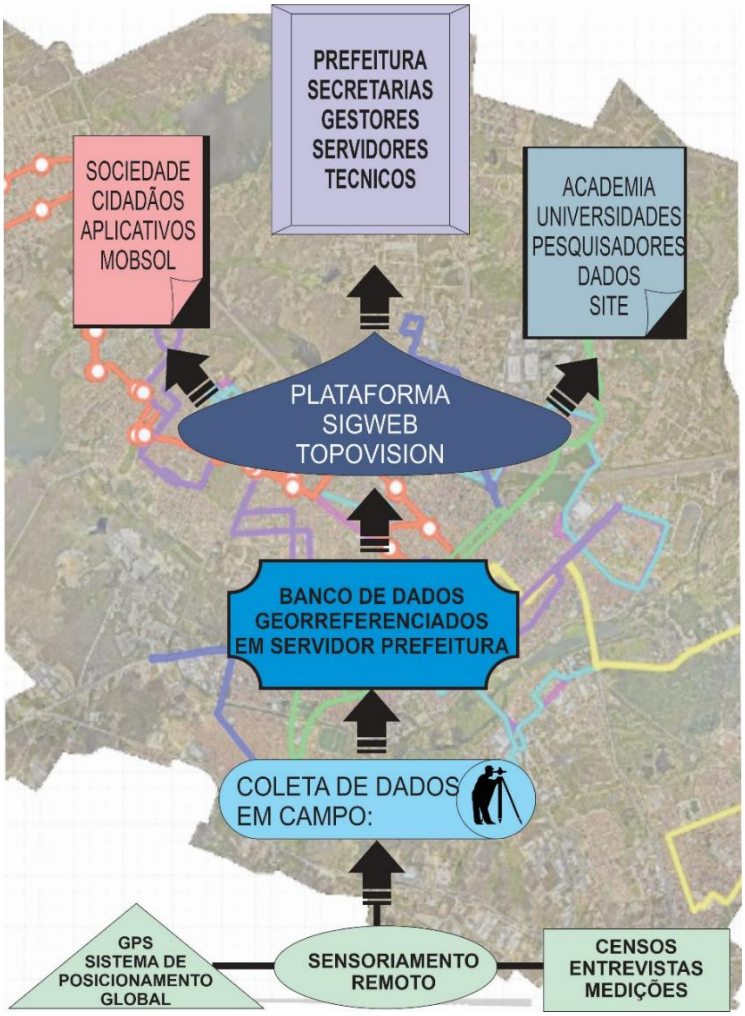
Geotechnologies encompass a set of knowledge from different areas, aimed at understanding the territory, such as, for example, remote sensing, topography, GPS, application to digital cartography, geodesy, *hardware*, *software*, GIS, etc., capable of providing accurate territorial information, which help to think about the city and the environment and contribute directly to the urban territorial reorganization and the emergence of sustainable buildings and cities.

Geotechnologies such as geoprocessing and GIS are frequently used by the secretariats that make up the Municipality of Sobral, for example, in the Municipal Secretariat of Urbanism and Environment (SEUMA), in the Secretary of Traffic (SETRAN), in the Secretary of Security, which can use the database through the Topovision platform. Secretariats, such as SETRAN, have developed applications available on the *Play Store, Apple Store*, which help the population to follow the schedules and route of school transport.

Flowchart 1 shows how this platform and the different departments of the Municipality of Sobral are interrelated.

Figure 5

Interconnection of the process of collection and use of spatial data by the secretariats of the city of Sobral



Source: Authors, 2024.

Initially, data collection takes place in the field, usually with GPS, satellite images, aerial photographs and aerial survey with a drone to capture information from larger and hard-to-reach areas. This data is also collected by censuses, interviews and *on-site* visits. Then the collected data is integrated into a georeferenced database, stored on local municipal servers. This database centralizes spatial information, ensuring organized and secure access for analysis and planning.

Then, this information is made available to the SIGWEB *Topovision* platform, feeding the database and becoming available to municipal secretariats, managers and technicians, who use it to manage public policies and strategic actions in Sobral. Such information can also be accessed by researchers, in addition to feeding some applications, such as MOBSOL, whose population has access to information on stops, schedules and bus lines that run through the urban perimeter of the city.

The use of geotechnologies in Sobral permeates the platform *Topovison*, leaving, as stated in the previous chapter, the access and understanding of data by management easier to access, since geotechnologies encompass a set of areas.

4.2 GEOTECHNOLOGIES AND THEIR APPLICABILITY BY THE SECRETARIATS OF THE MUNICIPALITY OF SOBRAL

The Sobral City Hall is organized into 11 (eleven) departments: 1) Municipal Department of Education (SME); 2) Municipal Health Secretary (SMS); 3) Secretary of Infrastructure (SEINFRA); 4) Secretary of Urbanism (SEUMA); 5) Traffic Secretariat (SETRAN); 6) Secretariat of Conservation and Public Services (SCSP); 7) Secretariat of Human Rights, Habilitation and Social Assistance (SEDHAS); 8) Secretary of Labor and Economic Development (STDE); 9) Secretariat of Citizen Security (SESEC); 10) Secretariat of Culture and Tourism (SECULT); 11) Secretariat of Youth, Sports and Leisure (SECJEL) (Figure 5).

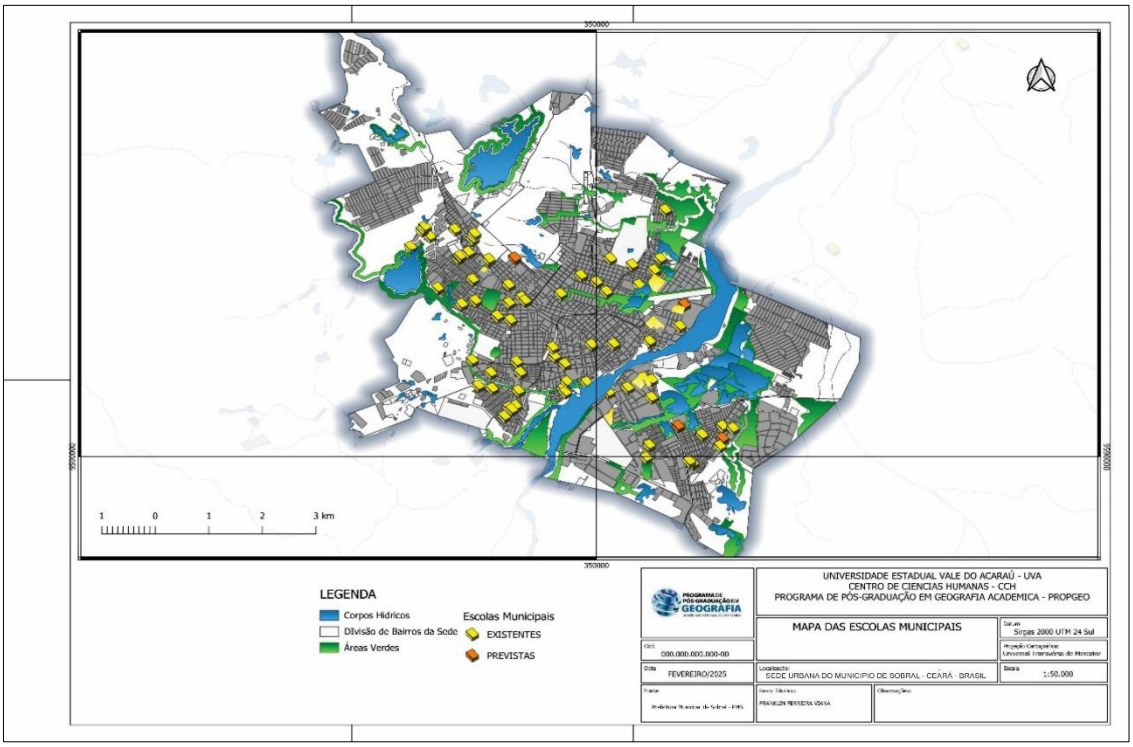
In addition to these departments, there are two autarchies, one responsible for a good part of the city's basic sanitation, especially for the supply of water and sewage treatment, called the Autonomous Water and Sewage Service of Sobral (SAAE), directly linked to SEINFRA and the Municipal Environment Agency (AMA), which develops a work of preservation and environmental awareness through inspection, licensing and environmental policies in Sobral.

4.2.1 Municipal Department of Education (SME)

The insertion of geotechnologies in educational planning has become a key element to ensure a more efficient and data-centric public management. For the Department of Education, these tools play a relevant role in locating new school units, monitoring works and analyzing enrollments. The use of geotechnologies by the Department of Education can directly assist in making decisions about the allocation of educational resources, such as the construction of new schools (Figure 6).

Figure 6

Distribution of municipal schools in Sobral



Source: Authors, 2025.

Through the visualization of maps and territorial data, managers are able to analyze the distribution of students and ensure that schools are built in areas with high enrollment demand. These data also allow us to consider variables such as the proximity of students to school units, facilitating access to education and avoiding large commutes, which improves the efficiency of the educational system.

These technologies allow for a more detailed analysis of the available land, taking into account factors such as relief and accessibility, without the need for initial physical visits. This practice not only saves time, but also ensures that decisions are based on concrete and visual information, increasing the accuracy of the choices made by managers.

4.2.2 Municipal Health Department (SMS)

Studies have shown that geotechnologies can be widely used in the Unified Health System (SUS), in Health Departments, in health-related research through the availability of databases, monitoring and spatialization of different pathologies (Dengue, Leishmaniasis, Chikungunya, COVID, among others) with the making of maps. Thus, geotechnologies are essential tools to systematize public policies related to health, especially techniques involving geoprocessing, which is configured as a set of techniques that make it possible to collect, process, and expose information related to a given geographic space (Brasil, 2023).

Geotechnologies and geoprocessing can contribute to the planning of Health Services for the most varied purposes, whether in the monitoring of pathologies, epidemiologies, mapping the distribution of diseases, allowing the identification of spatial and temporal patterns. In spatial analysis, optimizing the implementation of hospitals, clinics and health centers based on the population quantity, also allowing to study the relationship between environmental factors (such as air and water pollution) and the health of the population, helping to identify risk areas.

4.2.3 Secretariat of Infrastructure (SEINFRA)

SEINFRA is responsible for carrying out the macrostructure of the city and the rural area, such as, for example, paving (asphalt, interlocked, rough stone), macrodrainage through the construction of rainwater galleries, manholes, manholes and gutters that make up a drainage system, responsible for removing excess water from both the urban perimeter and the countryside, in addition to supervising the execution of public works throughout the municipality, such as, for example, hospitals, health centers and schools. Thus, the use of geotechnologies by this department represents a qualitative leap in urban planning and in the management of public works in Sobral, given that its use allows a variety of analyses of the urban space through remote sensing which, by creating a georeferenced database through the GIS, contributes directly to the visualization and spatial organization of the city and to the mapping of problems related to infrastructure (the roads are not pavements, mapping of corrective maintenance, clearance and repairs of drainages).

An example of the application of geotechnology by SEINFRA is the use of the *Topovision* platform, in which managers have access to the mapping that shows some of these problems related to infrastructure. Figure 7 illustrates the mapping where there is a need for asphalt recovery.

Figure 6

Visualization on the Topovision platform of the areas where there is a need for asphalt recovery

With the help of the platform, it is possible to observe regions or critical points that need intervention by the secretariat, for example, asphalt recovery (yellow dotted lines), internalization of the electrical network (orange lines) and/or corrective maintenance (red lines).

Aerial photogrammetry with the use of drones has also been used by SEINFRA. This tool allows a better visualization of the entire intervened urban space of the city, within a radius of approximately three kilometers from where the drone and its operator are controlled, which facilitates visualization and planning in hard-to-reach spaces. Figure 8 shows the use of aerial photogrammetry to map regions of desilting and slope reconstruction.

Figure 8

Use of drone in the mapping of slope execution. Sumaré neighborhood, Sobral, Ceará.

Source: Authors, 2022.

As an example, SEINFRA uses aerial photogrammetry to carry out detailed aerial surveys with drones, which allows managers a complete view of the areas that will be impacted by new constructions, such as squares, daycare centers or new roads. This detailed view enables engineering and architecture teams to anticipate challenges and find solutions before construction begins, saving time and resources. Thus, geotechnologies at SEINFRA not only improve the planning and execution of works, but also contribute to transparency and efficiency in public administration.

4.2.4 Secretariat of Urbanism and Environment (SEUMA)

Urban planning has been one of the concerns of public management (municipal, state and federal). In the municipality of Sobral, this task is the responsibility of SEUMA, a secretariat responsible for thinking about actions, both for the city and for the environment, being composed of professionals from different areas, such as architects, engineers, geographers, lawyers and administrative technicians who, together, dialogue about the city and the environment. Environmental issues are directly linked to the Municipal Environment Agency (AMA), established by Law No. 411 of May 15, 2003.

The use of geotechnologies such as remote sensing, global positioning system, GIS web, geographic information system, the *Topovision* platform and the use of aerial photogrammetry, through the use of drones, is part of AMA's daily life. Geoprocessing, for example, is often used to map priority areas for reforestation, monitor conservation units, and

assess the environmental impact caused by fires for the planning of subsequent reforestation actions.

4.2.5 Secretariat of Traffic and Transport (SETRAN)

Geotechnologies are fundamental for decision-making about the flow of vehicles, changes in the direction of roads and optimization of public and school transport routes. The use of digital maps and georeferencing software allows the secretariat to trace the best routes. These technologies are essential to ensure traffic efficiency, optimize school and urban transportation, and ensure that decisions made are based on robust and accurate data.

One of the main applications of geotechnologies at SETRAN is related to the mapping and planning of school routes, given that the municipality has an extensive rural area and several districts far from the headquarters. Another application of geotechnologies by SETRAN is related to real-time traffic monitoring. To this end, he resorts to the use of drones and cameras scattered at strategic points throughout the city, which enables vehicle flow counts to make informed decisions about road changes (Figure 9).

Figure 9

Road monitoring system and public spaces

Source: Authors, 2024.

4.2.6 Secretariat of Conservation and Public Services (SESEP)

SESEP is the secretariat responsible for public cleaning, in general (collection, waste, sweeping of public roads) and public lighting in Sobral. In it, geotechnologies are used to locate irregular waste disposal points in general (hospital, construction, civil, commercial, industrial, household), popularly known as garbage points. The main geotechnologies used

to collect the data made available to SESEP are aerial photogrammetry, GIS, SIGWeb and GPS. SESEP collects geographic coordinates and passes them on to SEUMA's geoprocessing cell. This collected data is worked on by geotechnological tools, such as remote sensing and QGIS, transforming them into cartographic products made available on the *Topovision Platform* for consultation, in addition to assisting in the planning of actions aimed at reducing the production of solid waste and better management of collection points.

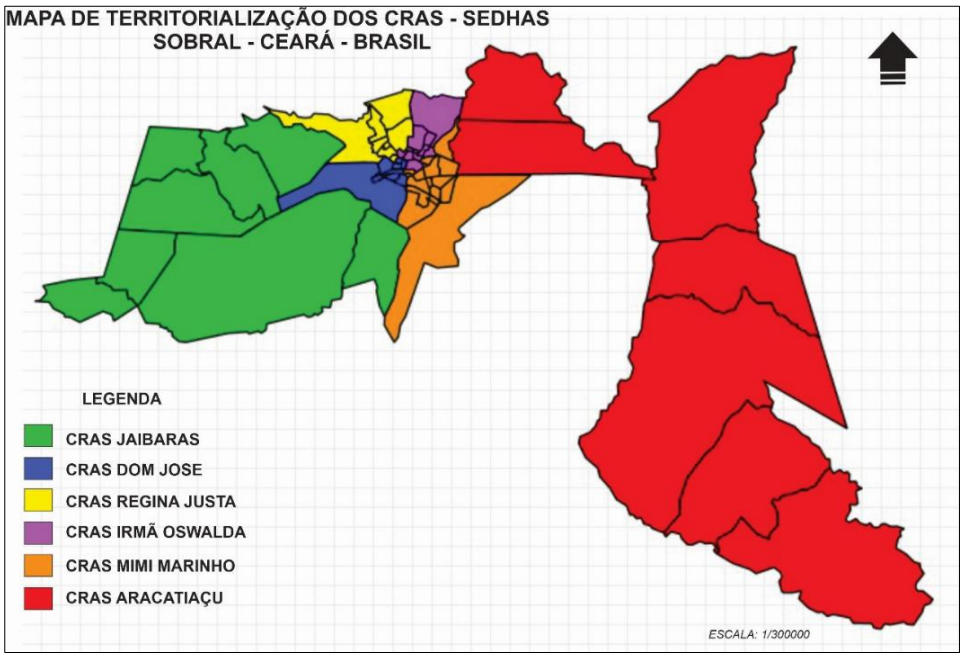
4.2.7 Secretariat of Human Rights and Social Assistance (SEDHAS)

The use of geotechnologies in SEDHAS can directly contribute to understanding and proposing actions in the territory, especially those related to the most vulnerable populations, using GIS through QGIS to map and manage their social assistance programs. This information is essential for the territorial organization of the Social Assistance Reference Centers (CRAS).

Therefore, one of the main applications of geotechnologies in SEDHAS is related to the distribution of CRAS in the municipal territory. The municipality has 6 (six) CRAS units, 4 in the headquarters and 2 in the districts. Figure 10 shows the mapping of the CRAS units in the municipality.

Figure 10

Territorialization of the CRAS-SEDHAS of the municipality of Sobral



Source: Authors, 2025.

Using cartography and georeferencing data, the secretariat is able to identify the areas of greatest vulnerability and allocate its services according to these needs. This territorial strategy is essential to ensure that families in poverty have easy access to assistance services, optimizing the application of public resources and promoting equity in access to social services.

4.2.8 Secretariat of Labor and Economic Development (STDE)

STDE is a secretariat that develops economic activities in Sobral such as offering administrative improvement courses and the concession of public spaces. The latter occurs through projects to donate land for enterprises and job creation, such as the installation of companies and industries with 250 employees or more. An example is the donation of land for the implementation of the company GRENDENE, donated by the municipal public management in the 1990s.

The secretariat receives the demands of the private sector, studies the potential locations with the use of remote sensing, aerial photogrammetry and GIS. This information is passed on to SEUMA, which prepares the projects, which together with the Attorney General's Office of the municipality, forward the donations and concessions for the implementation of these companies in the search for the generation of employment and income for citizens and the municipality. Furthermore, through the use of geotechnologies, such as remote sensing with the use of QGIS, STDE is able to have access and visualization to a better spatialization of companies, industries, commercial points and economic problems in the municipality of Sobralense.

4.2.9 Secretariat of Citizen Security (SESEC)

SESEC is a secretariat responsible for the security and monitoring of public buildings and equipment in Sobral, such as squares, city hall, schools, hospitals, among others. In this secretariat, the geotechnologies used include aerial photogrammetry, geospatial data, remote sensing cameras, as well as a radio communication channel by security agents. The GIS is also used in this secretariat, especially to cross-check security data, such as assaults, occurrences, thefts, robberies, domestic violence, etc.

4.2.10 Secretariat of Culture and Tourism (SECULT)

SECULT is a secretariat responsible for organizing cultural events, for the city's tourism and for the administration of public administration equipment, such as theater and museums. The use of drones by this department contributes directly to the monitoring of events (Figure

11), such as races, carnival, the city's anniversary, gangs and other parties, identifying cases of violence or emergency care.

Figure 11

Event monitoring system

Source: Sobral City Hall, 2025.

5 CONCLUSION

The research work addresses the implementation of geotechnologies in the planning and management sectors of urban and rural space in the municipality of Sobral, Ceará. In addition, it reports the modifications, advances and applicability of geotechnologies over time, as well as the evolution of the use of cartographic tools and geotechnologies in the Master Plans of the municipality of Sobral, Ceará, from the 1960s to the most recent administrations. It also highlights the transition from CAD to GIS systems in municipal public management and the multiple applicability of geotechnologies in the secretaries of the Sobral City Hall.

The research addresses the main geotechnological tools used by public management, as well as the way of use by the various secretariats and autarchies as an auxiliary tool in decision-making by public managers. It was observed that the use of geotechnologies shows great potential to boost decision-making and planning of future actions by municipal management in various segments of society. The insertion of geotechnologies in the municipal secretariats of Sobral transforms not only the internal management of each portfolio, but also the municipal governance structure itself. As geospatial data is incorporated into decision-making processes, Sobral builds and becomes part of a small group of municipalities that develop shared geospatial data in a more robust, inclusive, and resilient

public management, capable of responding to contemporary challenges in a planned and sustainable way.

The study also highlights the need for continuous investments for the training of professionals and updating the use of geotechnologies, consolidating the role of applied geography as a vector of development and efficiency for public administration . The integration and sharing of data between the various secretariats must also be continuously improved for joint decision-making and the creation of more robust databases. Therefore, the use of geotechnologies proved to be a valuable tool in decision-making and by managers of various municipal segments.

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