Volume 6, 2022, e9180
ISSN: 2594-5033
Section: Original article
http://periodicos2.uesb.br/index.php/geo
https://doi.org/10.22481/rg.v6.e2022.e9180

City science and urban planning: geoprocessing as an instrument for municipal strategic planning

Ciencia de la ciudad y urbanismo: el geoprocesamiento como instrumento para la planificación estratégica municipal

Ciência da cidade e planejamento urbano: geoprocessamento enquanto instrumento do planejamento estratégico municipal

Paulo Henrique Neves Santos [1] https://orcid.org/0000-0002-3115-469X
Marcelo Geovane da Cruz [2] https://orcid.org/0000-0003-3911-8236
Wallace Fernando da Silva Santos [3] https://orcid.org/0000-0002-2154-1119

[1] Federal University of Sergipe, São Cristóvão, Sergipe, Brazil, neves.santos.zero@gmail.com
[2] Federal University of Sergipe, São Cristóvão, Sergipe, Brazil, marcelogeovane1978@gmail.com
[3] Federal University of Sergipe, São Cristóvão, Sergipe, Brazil, wallacef93@gmail.com

Received on:30/11/2021
Accepted for publication on: 28/03/2022

Abstract

Urban spaces are characterized by ongoing complex and dynamic processes, which demand public management to develop a multiple and integrated perspective. This article aims to discuss municipal urban planning in public administration. Herein we adopt the Evidence-Based Planning (EBP) methodology, basing the analysis on government data geoprocessing. Given the above-mentioned objective, a bibliographic review and a cartographic production were carried out, which led to a compilation of the main EBP-based works undertaken in Aracaju-SE and their consequences to the city. We conclude the article by presenting a critical analysis of the methodology applicability at municipal level, highlighting positive aspects and main difficulties that might make its application unfeasible.

Keywords: Urban Planning; Thematic cartography; Geoprocessing; Big Data; Evidence-Based Planning.

Resumen

El espacio urbano se caracteriza por la complejidad y dinamismo de los procesos que en él se desarrollan, exigiendo desde la gestión pública una perspectiva a la vez múltiple e integrada. Este artículo tiene como objetivo discutir la planificación urbana municipal en la administración pública, donde aplicamos la metodología Evidence Based Planning (EBP), que se basa en geoprocesamiento y datos gubernamentales. Para la construcción de este expuesto se realizó una revisión bibliográfica y producción cartográfica, presentando los principales trabajos realizados en el municipio de Aracaju - SE a partir del PBE y sus consecuencias para el municipio. Concluimos el artículo realizando un análisis crítico de la aplicabilidad de esta metodología a nivel municipal, donde destacamos los puntos positivos y las principales dificultades que pueden hacer inviable su aplicación.
Palabras clave: Planificación urbana; Cartografía temática; Geoprocesamiento; Big data; Planificación basada en evidencia.

Resumo

O espaço urbano é caracterizado pela complexidade e pela dinamicidade dos processos que nele acontecem, demandando da gestão pública uma perspectiva ao mesmo tempo múltipla e integrada. O presente artigo tem o objetivo de discutir sobre o planejamento urbano municipal na administração pública, em que aplicamos procedimentos metodológicos fundamentados no geoprocessamento de dados governamentais. Para a construção desse exposto, foram realizadas revisão bibliográfica e produção cartográfica, apresentando os procedimentos metodológicos realizados no município de Aracaju – SE baseados em PPBE e os seus reflexos para o município. Concluímos o artigo realizando uma análise crítica sobre à aplicabilidade dessa metodologia no âmbito municipal, na qual destacamos os pontos positivos e as principais dificuldades que possam inviabilizar sua aplicação.

Palavras-chave: Planejamento urbano; Cartografia temática; Geoprocessamento; Big Data; Planejamento baseado em evidência.

Introduction

The need to solve social problems in cities requires effective actions from the public administration within the shortest time period possible. Despite current technological and scientific development, methods and techniques fastened to antiquated procedures that do not meet citizens’ real needs are still dominant.

The growing discussion on smarts cities encourages us to look for new understandings of decision making in public administration, so efficient data management can result in information that will underpin public policies.

> The concept of the smart city emerged during the last decade as a fusion of ideas about how information and communications technologies might improve the functioning of cities, enhancing their efficiency, improving their competitiveness, and providing new ways in which problems of poverty, social deprivation, and poor environment might be addressed (BATTY, et al, 2012, p. 483).

Given the great volume of municipal data available, the need for a new management model emerges, so data can be transformed in high-value-added information in due time to solve issues. *Big data* is the term used to describe the group of these elements: Volume, Velocity, and Variety (RIBEIRO FILHO, 2016).

As a result of current technological advances, the virtual visualization of city spaces has become an essential instrument in geographic analyses because it enables quick associations among descriptive pieces of information about phenomena and their respective location.

Especially since the second half of the 20th century, informatization in cartography "has been revolutionizing ways of conceiving, creating, structuring, storing, manipulating, analyzing, and distributing maps" (RAMOS, 2005, p. 15, our translation).

Virtual cartography subsidizes space knowledge based on locations and representations (spatial data), as well as descriptions and attributes (non-spatial data), providing the reader with fast and simplified information on phenomena.

Mapping phenomena of social interest through the elaboration of thematic maps results in a summary of diverse pieces of information in a single visualization file, which makes understandings and correlations among different socioeconomic areas more dynamic. By applying it to municipal strategic planning, one can map phenomena related to health, public security, population's social profile, among others.

Integrating data represented virtually based on the overlap of layers enables the correlation of information and different themes, which provides municipal managers with intuitive data that can underlie urban planning and decision making.

Aracaju, with its Social Observatory, has been integrating geographic intelligence oriented by geoprocessing to strategic planning, which, in turn, is considered to direct decisions to priority focuses. Geographic knowledge underpins this management model that has been causing precise directed actions based on previous knowledge about the location of phenomena of interest.

This article aims to discuss results obtained in Aracaju from the application of methodologies that stem from discussions on Evidence-Based Policies (EBP), seeking to contribute to city science studies and to validate geographic intelligence as a resource upon which municipal public policies can be based.

The text is structured in three parts. The first one presents a bibliographic review on the evolution of thematic cartography, geoprocessing, as well as big data and urban planning interactions. The second, on the other hand, introduces data-based works undertaken in Aracaju. Finally, the third part submits critical notes on the use of geographic intelligence in city management, in addition to the main difficulties found and some perspectives.

Cartography and its effects on knowledge production: science and art as excellence in municipal planning and management.

Graphic representation is a fast and objective language that allows the observer to understand retracted information in a few instants. Martinelli (2009) states that it "has supremacy over the others because it requires just an instant of perception" (MARTINELLI, 2009, p. 13, our translation).

Considering the need to represent space in an expansionist colonial context based on the great navigations, cartography was consolidated as the science that represents physical and social elements of thus far unknown territories. The intensification of trade between the West and the East demanded detailed cartographic bases, in addition to new instruments to help mapping and navigating the world.

> Undoubtedly the great advance of cartography took place in Europe, being related to the Renaissance (15th and 16th centuries), when capitalist relations began to be stablished. With the intensification of trade between the West and the East, which required the development of navigation, there was a strong impetus in relation to the need for maps, as well as the creation of means of orientation – the compass (MARTINELLI, 2009, p. 8, our translation).

In spite of the understanding of cartographic representation as both science and art (DUARTE, 1991), it cannot be subjected to multiple interpretations that reflect the author's state of mind. Cartography is a technical work that must represent an idea or phenomenon harmonically, with no room for contradictory interpretations. Therefore, it should provide coherent and reliable information.

Among the main cartographic instruments, the map is culturally linked to geography, given that cartography enables the representations and analysis of geographic spaces – the main category of geographic analysis. Regarding this discussion, Fitz (2008) infers that "[...] the association between Cartography and Geography is quite direct; the first is an essential tool to geographic studies" (FITZ, 2008, p. 107, our translation).

To critically reflect on geographic spaces, the map allows the integration of spatialized elements, enabling integrated analyses of cause-and-effect relations of physical and/or social phenomena.

> The map should never result in an illustration of a geographic text, rather, it should be an instrument capable of revealing the content of information. Therefore, it ought to provide the understanding that will guide scientific discourses, offering the reader the opportunity to critically reflect on the topic, promoting knowledge (MARTINELLI, 2009, p. 12, our translation).

Cartographic innovation has expanded possibilities to represent reality. In a historical context of "[…] flourishing and systematization of different fields of study operated with the division of the scientific work […]" (MARTINELLI, 2015, p. 914, our translation), a cartographical succession entitled thematic cartography was developed.

By definition, a thematic map "would report a certain number of spatial sets resultant from the classification of phenomena that integrate the object of study of a specific field, product of scientific work division" (LACOSTE, 1976 *apud* MARTINELLI, 2009, p. 22, our translation).

Thematic cartography exceeds the limits of depicting only what is visible. It rather "represents 'known' properties of facts and phenomena from reality of interest to spatial manifestation" (MARTINELLI, 2015, p. 914, our translation). Therefore, the integration of the territorial base with the spatialization of social or environmental phenomena became viable, enabling fast, efficient, and objective analyses.

Virtual technological advances, especially in the second half of the 20th century, allowed map elaboration, new possibilities, and exponential gain of production speed. The specialized software entitled Geographic Information System (GIS) led to the gain of new methodological parameters to the integration of multidisciplinary data, making production more dynamic and facilitating observation.

This method termed geoprocessing "represents the area of knowledge that uses mathematical and computational techniques provided by Geographic Information Systems (GIS) to deal with the processes that take place in geographic spaces" (D'ALGE, 2001, p. 61, our translation). However, this facilitation is linked to the trivialization of specialized scientific knowledge, which in turn reproduces a distorted cartographic knowledge.

The absence of specialized cartographic knowledge results in 'cartographic errors', as Filho and Martinelli (2007) have entitled it. What one could consider as unnecessary details actually have effects on the trustworthiness level of the study conducted, as well as on the guarantee of the professional's technical and scientific knowledge.

Filho and Martinelli (2007) highlight the confusion between analysis cartography and synthesis cartography among the most common errors currently. The first one consists on the reasoning directed to spatial analysis, allowing the intersection of complementary and interrelated data to the formulation of hypotheses about a given phenomenon. In analysis cartography, data or spatial phenomena overlap, so the graphic representation allows readers to identify factors and findings. In this sense, the causality of phenomena becomes discussable, and it is possible to verify how they are linked.

On the other hand, synthesis cartography refers to the synthetization of information. Herein the overlap of elements or layers in a map is unusual, rather, the correlation of phenomena based on their fusion is represented, therefore creating specific taxonomic unities (FILHO; MARTINELLI, 2007). Given that, the main point of a synthesis map is to condense distinct and correlated information, so it can be represented systemically to allow a quick concise reading.

The geographer must consider that cartography works as an instrument par excellence in representations of essential information to public administration. This means that clarity in visual reading should be one of the pivotal concerns in cartographic development, along with reliable information presentation.

Therefore, thematic cartography emerges and gains space as a method par excellence for graphical representation of phenomena in the geographic space. Its use as a tool in city management becomes necessary when managers seek to implement measures and/or actions to deal more effectively with citywide socio-environmental issues.

Big data and urban planning: towards a smart public administration.

One can initially regard the great volume of data in public administration as a barrier to socio-spatial analysis. However, their effective management expands the possibilities of correlations between phenomena and geographic spaces.

The understanding of data as "the natural resources of the new industrial revolution" (TAURION, 2013, p. 20, our translation) is current. Considering that we live in the Information Age, historical period marked by the world's greatest demographic number, the volume of data available requires new professional skills, especially specialization in storage, management, and analysis within a short time span. Big data is the term used to refer to this management model that processes gigantic amounts of data.

The concept of big data is linked to the professional who uses it due to its applicability in diverse fields of science and economy. Given that, we will limit our perspective to big data applied to public management.

Taurion (2013) claims that this concept is not restricted only to the handling of a great volume of data. Upon such consideration, the author lists several variables inherent to big data, namely: 1) data variety, the possibility of obtaining data from diverse sources; 2) velocity, the time required to develop analyses based on information generated, with the note that one needs an adequate time frame to conduct the examination; 3) data veracity; 4) added value, the highlight of data relevance; and 5) privacy.

All the above-mentioned varieties are relevant when one works with big data; particularly those related to privacy because in public management data come from citizens, which requires the complete confidentiality of information.

Historically, public management and urban planning take a long time to solve structural problems in city territory, above all when they are associated to economically vulnerable groups. Additionally, some managing measures present little or no effectiveness, either due to a delay in taken actions or to the failure to identify the real causes of problems.

> In the history of urban studies and planning, most theory and applications have focussed on the long term – on what happens in cities measured over months and years, certainly not over minutes and hours (BATTY, 2013, p. 277).

A new model of data management can make “a new understanding on the functioning of cities possible within a short time horizon, allowing the development of new theories” (RIBEIRO FILHO, 2016, p. 3, our translation).

> My interest in them [data set] is primarily for developing a new understanding of how cities function, albeit on much shorter time horizons than has traditionally been the focus in urban geography. (BATTY, 2013, p. 276).

Time, in matters related to urban planning, is seen from a new perspective when one uses technology-based big data methods, for they generate information based on aggregated data within a shorter time scale; consequently, the application time of possible solutions is reduced.

Currently, the main differentiating feature of the new data input generated is a spatial reference, a *geolocation*, which directs the eyes of public management to the spots where a given phenomenon is happening. This model is part of the latest tendency of smart cities, which has been promoting methodological reformulations in land management in order to find faster and more efficient methods.

> [...] Smart cities initiatives would be an example of the use of many of these data in an attempt to manage city life more efficiently [...] (SENDRA, 2015, p. 168, our translation).

By incorporating geolocation to a great volume of municipal data on social phenomena, new possibilities of interpretation, association, and correlation among data emerge; as a result, the attention of geographers and managers is directed to pressing issues.

Methodology

The study included a bibliographic search on cartography, thematic cartography, and geoprocessing. The theoretical background about thematic cartography and its effects on geography as per Martinelli (2009) guided a critical understanding of the cartographic evolutionary process and its implications for the geographical science.

Data gathered to produce information come from several management bodies, including those from the city, the state, and the federal government. The set comprises data obtained in the form of micro-data, which were processed in statistical software, as well as those in KML and shapefile. Before the elaboration of the maps, we organized and filtered data to select only the ones truly necessary for the final production – the thematic map.

The initial part of procedures consisted on the organization of data in matrix model through software, namely Excel 2016 and SPSS. In this phase, columns which contained data of interested to public management were analyzed and selected.

Data types and sources used in the thematic maps are presented below:

1- Location map: data the municipal government of Aracaju provided;
2- Aracaju poverty map: per capita income, number of households;
3- Heat map (kernel) with reported occurrences of self-inflicted child injuries from 2011 to 2019 in Aracaju: denounced episodes of self-mutilation, fall, bullying, child suicide attempts from 2011 to 2019;
4- Correlation map between sanitary exhaustion and child mortality: percentage of sanitary exhaustion per neighborhood with data from the 2010 demographic census and number of infant deaths from 2016 to 2019;
5- Occurrences map of Aracaju City Guard (kernel): number of cases reported to the guard in 2019;
6- Occurrences map of Aracaju City Guard: number of episodes denounced to the guard from January to June 2019;
7- Irregular waste disposal map: number of cases reported to the Environment Secretariat (SEMA) of irregular waste disposal from 2018 to 2019.

After the matrix organization, georeferencing was the next step. In this phase, the coordinates of occurrences were captured through the software Google Earth Pro with the described locations.

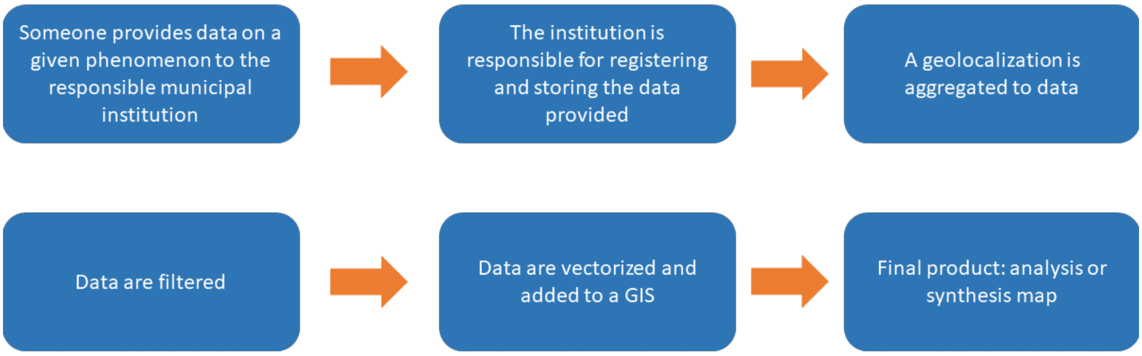
Subsequently, captured locations were exported to the software QGis 3.4, so the symbology could be stored, manipulated, and edited to enable the reading of phenomena.

Regarding the heat maps (kernel), the procedures included the use of the function (plugin) available at toolbox > interpolate > heat map. In this case, color edition in the symbology sector happened through the selection of the option false color in two patterns: I) blue for minimum values and red for maximum values; II) light yellow for minimum values and red for maximum values.

As for the third map, the steps taken involved the use of graded symbology to represent the number of child deaths from 2016 to 2019 in Aracaju. Here yellow refers to minimum values and brown to maximum ones; in addition, there is the employment of the diagram function in bars with the variable "number of households with inadequate sanitary exhaustion in 2010," retrieved from the database of the 2010 demographic census.

Data required to vector development come from information citizens themselves provided, including spatial (geolocation) and non-spatial (attributes and additional information) data. The production of the thematic maps, in turn, can be illustrated in a flowchart (Diagram 1). The process comprehended the utilization of databases from municipal institutions.

Diagram 1: Flowchart of thematic maps production



Source: Authors, 2020.

The population provides information on a given socioenvironmental phenomenon via report cards or denouncements to the responsible institutions (for instance about robberies, irregular waste disposal, among others), which should register the occurrence in great details, especially concerning variables about addresses.

Pairs of coordinates (latitude and longitude) were attributed to data that could be geolocalized, hence enabling the vectorization of spatial and non-spatial data provided. It is valid to highlight the need for knowledge about cartography and basic geoprocessing because the geographic elements related to the Coordinate Reference System (CRS) underlie the whole procedure under discussion.

Afterwards, data were filtered with the aim to identify possible spelling and numeric errors that would otherwise result in operational difficulties in the following steps. In this phase, it is important to standardize spelling throughout the process, or else information can be lost.

Upon data quality verification, they were vectorized on QGis 3.4, in order to manipulate the symbology of geolocalized data. Consequently, it became possible to highlight areas of interest and to grade data, so the most recurrent phenomena could present brighter colors or greater symbology, among other options.

Finally, after analyses on the best way to represent data, the procedure was completed. As a result, two types of products could be created: analysis map(s), contributing to the interpretation of phenomena emphasized; or synthesis map(s), submitting a summary of data transformed into information.

Considering data origin, one can claim this is an indirect collaborative cartography, in which the population is the main responsible for providing data on the phenomena that affect them. The indirect feature is justified because the population is unaware that the data provided might underlie representations which will inform public policies.

Such way of using city science in favor of public policies is still being developed towards a more refined model of urban planning. Nonetheless, its application in municipal management fosters the identification of the main social problems in each city.

This methodological procedure is part of discussions within Evidence-Based Policies (EBP). However, EBPs are marked by a conceptual multiplicity due to the comprehensiveness of the term, given that "there are differences relating to diverse public policies areas [...] and distinctiveness referring to the use of evidences by those involved in public policies processes" (PINHEIRO, 2020, p. 8, our translation).

Despite conceptual multiplicity, methodological applications in several areas of public organization (e.g. education, health, justice, economy) are valid, considering that they are based on data and information from reality.

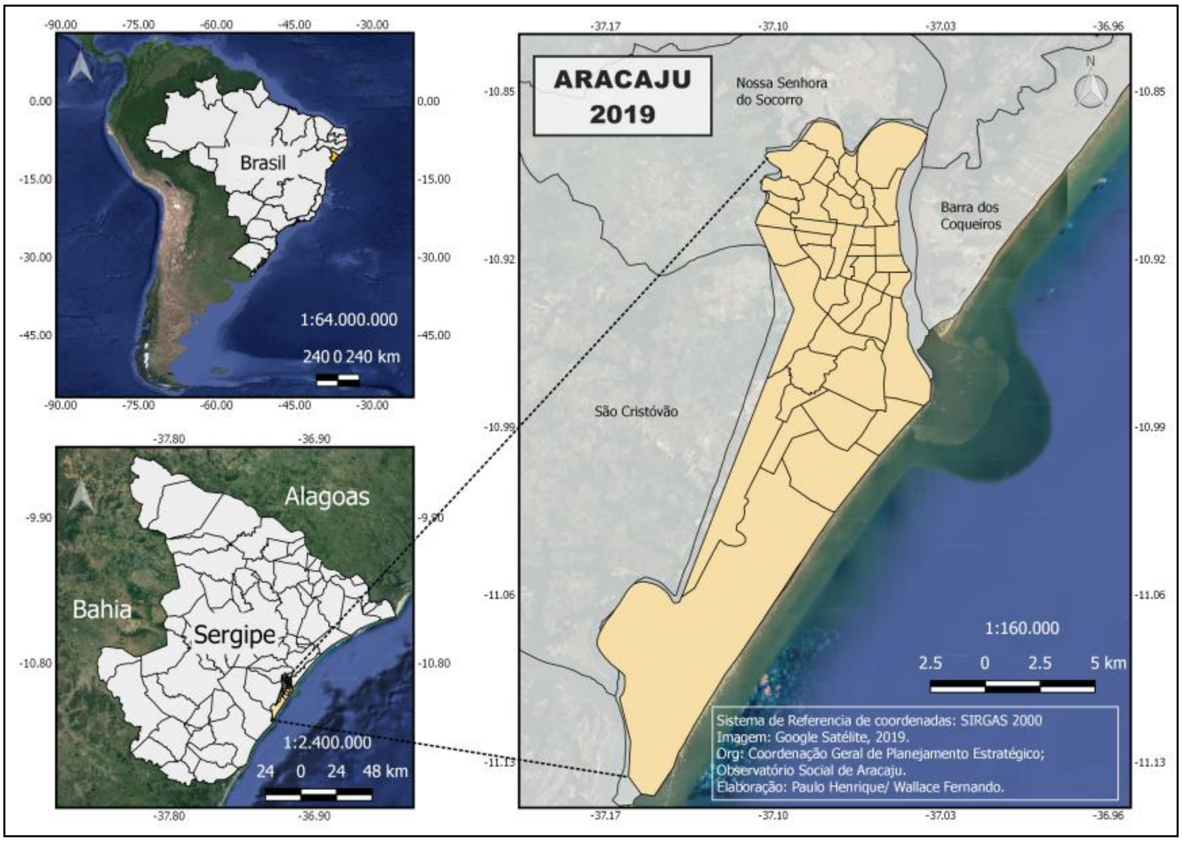
Pinheiro (2020) explains that procedures from evidence-based policies have been a point of interest of "research funding agencies and many professional segments, with regard to the use of information and knowledge as elements in decision making" (PINHEIRO, 2020, p. 16, our translation).

The EBP perspective has been gaining momentum in the last few years due to the growing demand for improved scientific methods to deal with data available to underlie precise government actions. In other words, "producing an evidence-based public policy implies using science as a transformation agent" (FERNANDES, et al. 2022, p. 60, our translation).

Main social effects of evidence-based planning and geotechnologies use.

Aracaju (Map 1), capital city of Sergipe, has been implementing management methods based on geoprocessing to inform fast, precise, and systemic decision making.

Map 1 – Location of Aracaju – SE.[3]



Source: Authors, 2019.

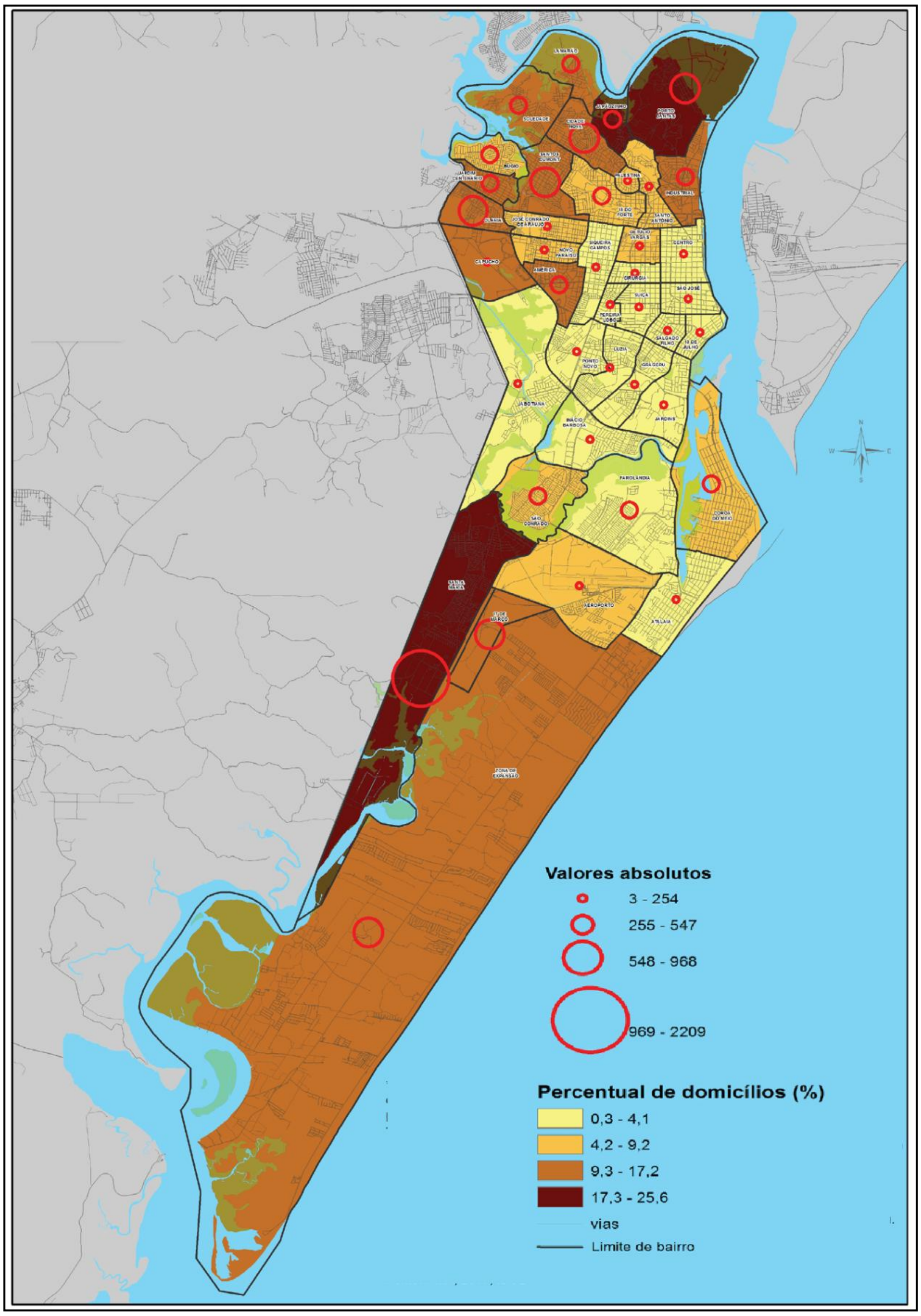
Adopting an EBP methodology is an innovative action in Sergipe, which the Social Observatory and the General Coordination of Strategic Planning (CGPE) of Aracaju have been leading. They have been developing several projects in social areas, approaching themes such as poverty, work, income, health, education, public security, environmental monitoring, demography, among others. Considering the main aim to minimize socioenvironmental problems in the city, geoprocessing becomes a monitoring instrument that allows the spatial analysis of phenomena.

In 2017, the Observatory launched the *Poverty and social inequality map of Aracaju*, with the objective of identifying poverty zones in the city using geoprocessing. In this case, the study focused on income distribution and its relation to vulnerable environments, marked by processes of irregular occupation.

[3] Given that the maps presented here are originally in Portuguese, their respective translations will be presented in footnotes. Map 1 submits: "Coordinate Reference System: SIRGAS 2000; Image: Google Satellite, 2019; Organization: General Coordination of Strategic Planning and Social Observatory of Aracaju; Elaboration: Paulo Henrique/ Wallace Fernando."

The poverty map (Map 2) was one of the main guides to define actions within municipal strategic planning, which prioritized different interventions in the most vulnerable areas of the city, such as the neighborhoods *Santa Maria* and *17 de março* in the southern section, along with *Porto Dantas* and *Japãozinho* in the northern zone.

Map 2 – Poverty and social inequality of Aracaju.[4]



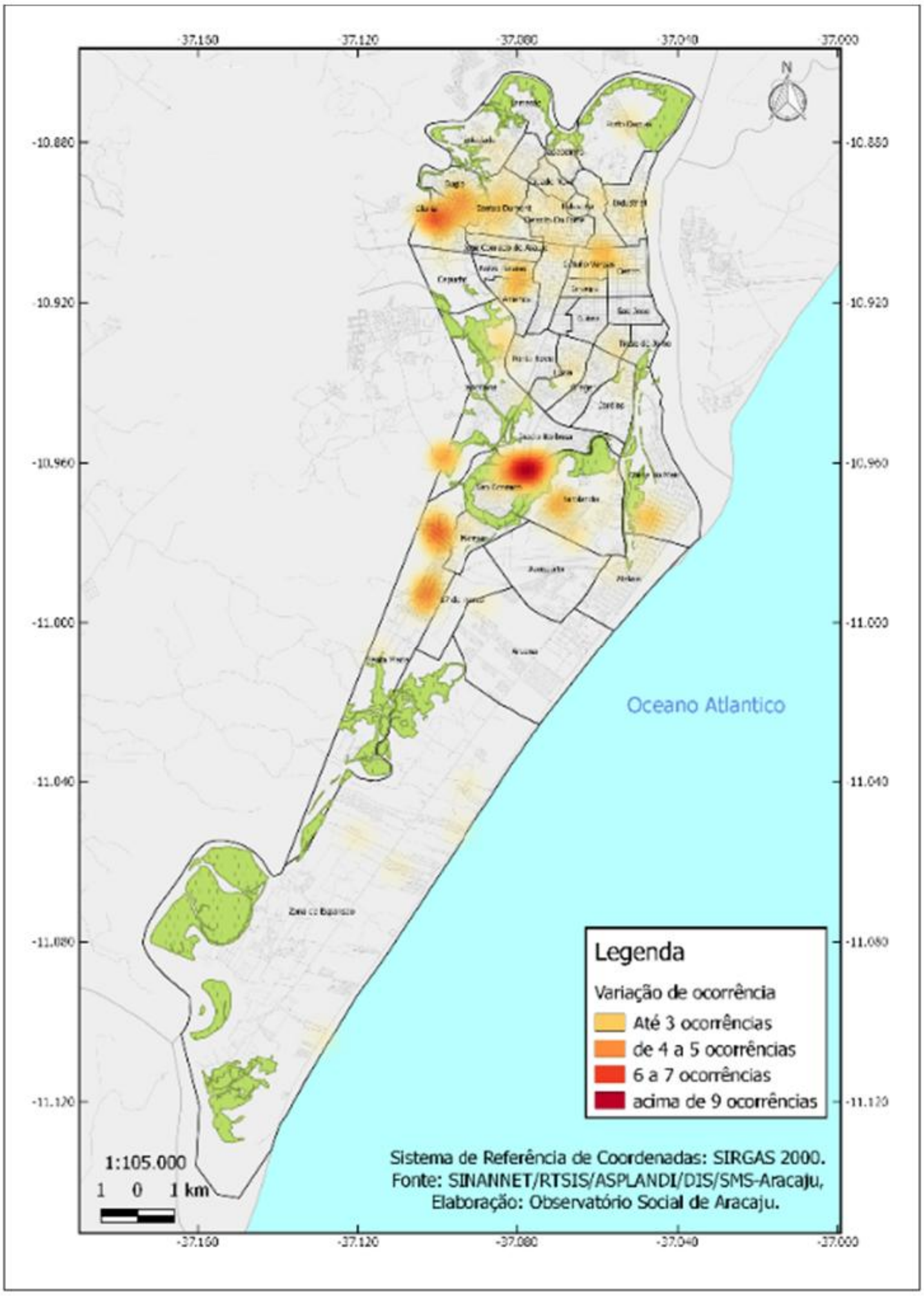
Source: Social Observatory of Aracaju, 2018.

Based on the study entitled *Social Mapping of Aracaju*, managers became aware of vulnerable areas and defined actions to be undertaken to deal with infrastructure

[4] Map 2 presents: "Absolute values: 3-254; 255-547; 548-968; 969-2209."; "Percentage of households (%): 0,3-4,1; 4,2-9,2; 9,3-17,2; 17,3-25,6; routes and neighborhood limits."

issues in the above-mentioned neighborhoods, which were prioritized. These endeavors encompass sanitation, drainage, paving, in addition to the construction of full-time schools, reform of schools and multi-sports court, afforestation efforts, environmental education, and ecological points implementation.

Map 3 – Reports of self-inflicted child injuries from 2011 to 2019 in Aracaju.[5]



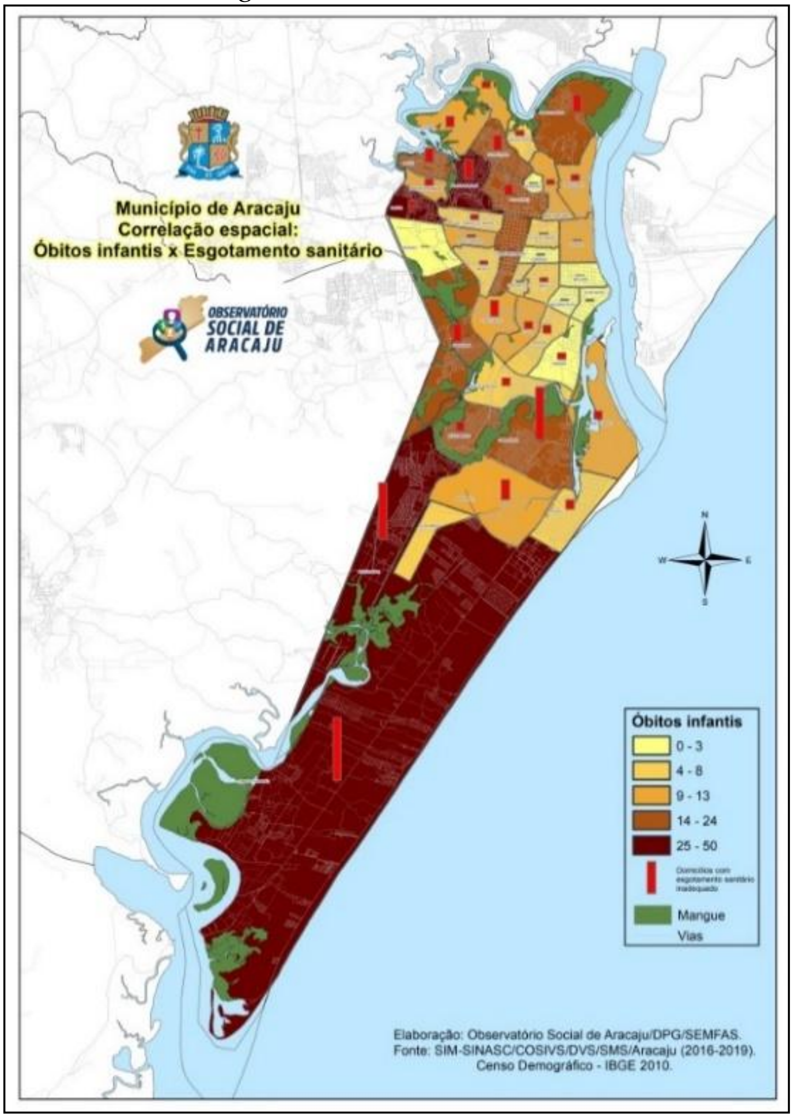
Source: Social Observatory of Aracaju, 2019.

[5] Map 3 includes: "Caption – occurrence variation: until 3 occurrences; from 4 to 5 occurrences; 6 to 7 occurrences; more than 9 occurrences."; "Coordinate Reference System: SIRGAS 2000; Source: SINANNET/RTSIS/ASPLANDI/DIS/SMS-Aracaju; Elaboration: Social Observatory of Aracaju."

Concerning the health area, thermal spots indicated the places where child injuries took place within the city from 2011 to 2019 (Map 3). The map indicates that the greatest number of cases were concentrated in the northern region of the city, which corresponds to *Olaria, Jardim Centenário, Bugio, Santos Dumont, Cidade Nova, Porto Dantas, Japãozinho, 18 do Forte, Santa Maria* and *17 de março*.

Informed by this methodology, the Social Observatory along with CGPE, consultants, and health practitioners discussed hypotheses to identify the central causes of problems.

Map 4 – Correlation between child death cases (2016 to June 2019) and the sanitary exhaustion coverage.[6]



Source: Social Observatory of Aracaju, 2019.

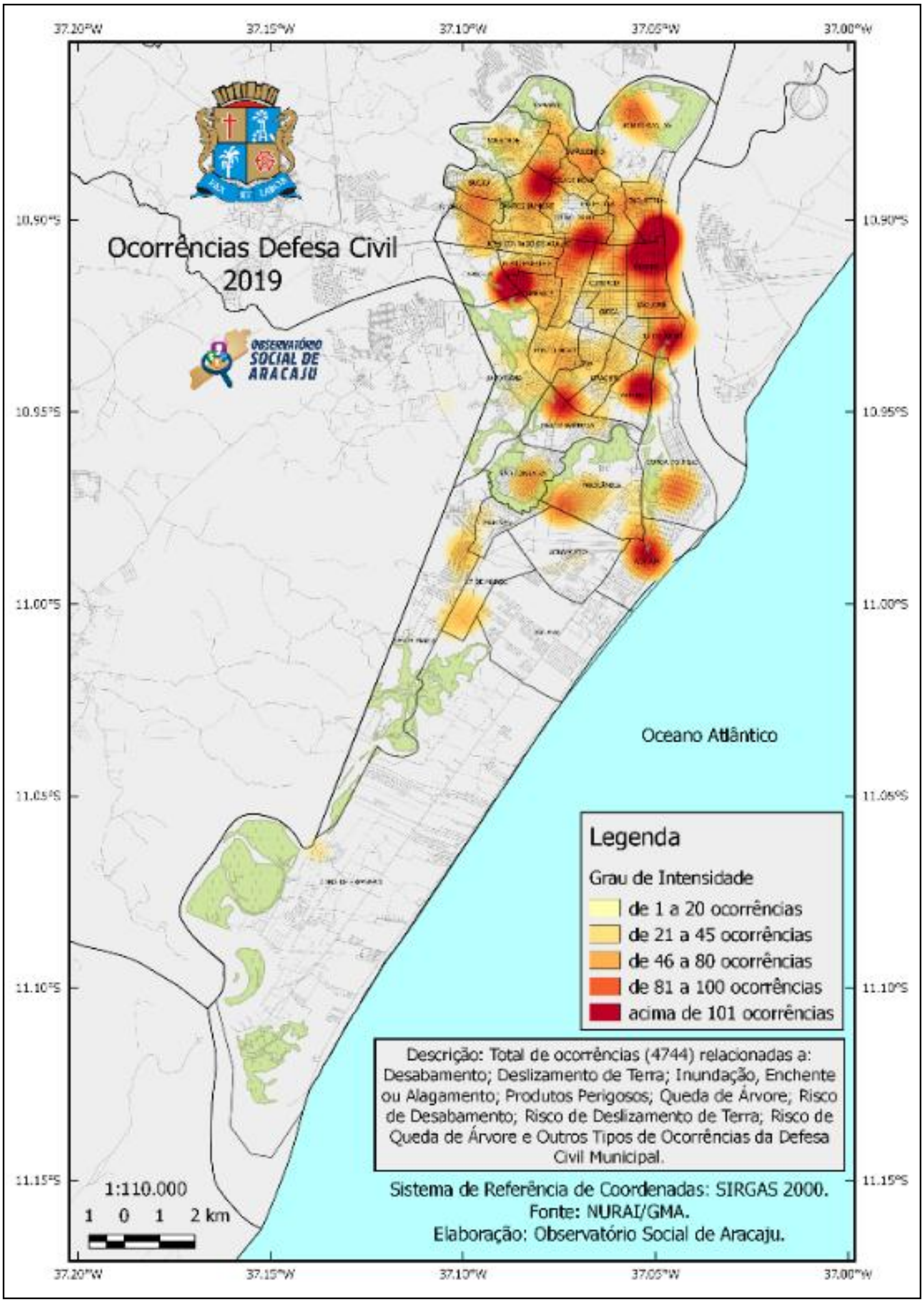
[6] Map 4 submits: "Child deaths: 0-3; 4-8; 9-13; 14-24; 25-50; households with inadequate sanitary exhaustion; mangrove routes."; "Elaboration: Social Observatory of Aracaju/DPG/SEMFAS; Source: SIM-SINASC/COSIVS/DVS/SMS/Aracaju (2016-2019); Demographic Census: IBGE 2010."

As an example of this work proposal, one can highlight the map of spatial correlation between sanitary exhaustion and the number of child deaths per neighborhood (Map 4).

This mapping process allowed the ratification of the hypothesis that phenomena are linked. Based on this conclusion, the Health Secretariat undertook specific actions to deal with the reality of the above-mentioned locations. The endeavor focused on improvements in the infrastructure of the most affected neighborhoods; consequently, child death rates dropped from 20,09 in 2018 to 17,28 in October 2019, according to data from the Ministry of Health's Mortality and Live Birth Information Systems in Aracaju (SIM/SINASC/SMS/Aracaju).

Regarding the management of information, the Civil Guard created an integrated system of information and, along with the Social Observatory, included georeferencing to process data, which contributed to mapping and monitoring occurrences (Map 5).

Map 5 – Occurrences registered by the Municipal Guard of Aracaju.[7]

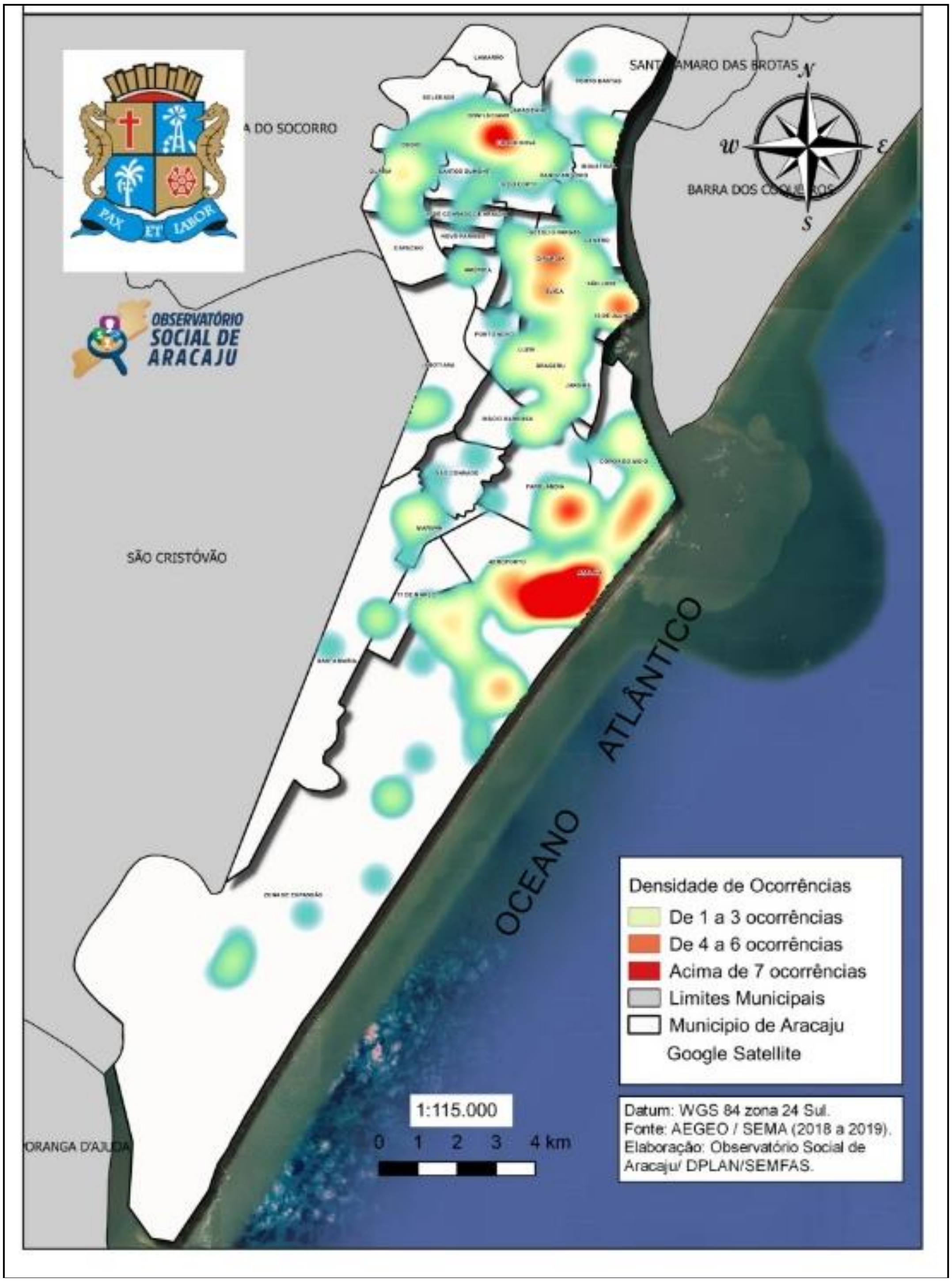


Source: Social Observatory of Aracaju, 2019.

[7] Map 5 presents: "Caption - level of intensity: from 1 to 20 occurrences; from 21 to 45 occurrences; from 46 to 80 occurrences; from 81 to 100 occurrences; more than 101 occurrences."; Description: Total number of occurrences (4744) related to: collapse; landslide; inundation; flood or flooding; dangerous products; falling trees; collapse risk; landslide risk; falling tree risk; and other types of occurrences reported to the Municipal Civil Defense."; "Coordinate Reference System: SIRGAS 2000; Source: NURAI/GMA; Elaboration: Social Observatory of Aracaju."

Concerning environmental monitoring, it was possible to map the main spots of irregular waste disposal in the city (Map 6) using data from the Municipal Environment Secretariat (SEMA).

Map 6 – Spots of irregular waste disposal from 2018 to June 2019.[8]



Source: Social Observatory of Aracaju, 2019.

[8] Map 6 reports: "Density of occurrences: from 1 to 3 occurrences; from 4 to 6 occurrences; more than 7 occurrences; municipal limits; City of Aracaju; Google Satellite."; "Datum: WGS 84 zone 24 South; Source: AEGEO/SEMA (2018 to 2019); Elaboration: Social Observatory of Aracaju/DPLAN/SEMFAS."

The map shows that the southern area, which encompasses the city's main tourist attractions, concentrates more cases of irregular waste disposal, especially in *Atalaia* and *Aruana* neighborhoods.

Picture 1- A) New recreational areas where irregular waste disposal spots used to be located; B) Ecological point.

Source: Municipal government of Aracaju, 2019.

Bearing this information in mind, managers defined strategies, such as strengthening surveillance in former spots of irregular waste disposal, where recreational devices made of recyclable materials (Picture 1 - A) were implemented, and installing 18 ecological points in strategic locations to collect construction waste (Picture 1 - B). These actions helped reducing irregular waste disposal in 95% within the capital.

Further considerations

Spatialized knowledge of social phenomena is consolidated as an essential instrument to strategic planning and decision making. In Aracaju, since the implementation of geotechnologies to inform social actions, government endeavors have been more objective and faster, given that precise knowledge on social phenomena and their location is available.

The association between different thematic maps allows one to understand, with the support of specialist technicians, phenomena that occur simultaneously within a given space-time. This link is the main differentiator in geotechnology use for strategic planning due to the speed of data processing to generate information.

However, the application of this management model is still under development in the city, where improvements are required. The main difficulty is the lack of a georeferenced database because it is the pillar for thematic maps production. Therefore, if the city does not have such a database, especially one structed based on the matrix model, there will likely be a delay in mapping and thereupon in social actions.

Another obstacle identified is the absence of specialist technicians in geoprocessing and in spatial city and social functions comprehension. The negligence in this matter results in lack of understanding about produced information, originating erroneous, incomplete or inconclusive reports, which will turn geoprocessing into an obsolete and imprecise tool. Ergo, the thorough utilization of this management methodology demands the incorporation of specialized professionals who can make sense of space, urban processes, social actors, different scales (spatial and temporal), and correlation among elements from geographical space.

Integrating municipal offices and public management bodies is yet another difficulty. Considering that municipal public bodies share the same objective, i.e. improving the life of citizens, information produced individually should be combined, preferably in a single database. Upon that, intersectoral dialogue and actions unification will be possible, so the efforts can be directed to the same aim and the waste of human and financial resources can be avoided.

Therefore, the use of geotechnologies to underlie the municipal government's social actions is important to validate planning and decision making, provided it is applied correctly. The benefits of using this methodology exceed the organization and systematization of essential information, presenting direct effects on the life quality of the city's citizens.

References

BATTY, M. et al. Smart cities of the future. **The European Physical Journal Special Topics**, v. 214, n. 1, p. 481-518, 2012.

BATTY, M. Big data, smart cities and city planning. **Dialogues in human geography**, v. 3, n. 3, p. 274-279, 2013.

D'ALGE, J. C. L. **Cartografia Para Geoprocessamento**: Introdução à ciência da geoinformação. São José dos Campos: INPE, p. 32, 2001.

DUARTE, P.A. **Conceituação De Cartografia Temática**. Geosul, v. 6, n. 11, p. 133-138, 1991.

FERNANDES, I. F. et al. **Desafios metodológicos das políticas públicas baseadas em evidências**. Boa Vista. Editora IOLE, 2022.

FILHO, A. P. Q.; MARTINELLI, M. Cartografia de Análise e de Síntese na Geografia. **Boletim Paulista de Geografia**, n. 87, p. 7-44, 2007.

FITZ, P.R. **Cartografia Básica**. São Paulo. Oficina de Textos, 2008.

MARTINELLI, M. **Mapas Da Geografia E Cartografia Temática**. Editora Contexto. 5ª edição. – São Paulo. 2009.

MARTINELLI, M. GRAÇA, A.J.S. Cartografia Temática: Uma Breve História Repleta De Inovações. **Revista Brasileira de Cartografia**, Nº 67/4 - Edição de Cartografia Histórica: p. 913-928. Sociedade Brasileira de Cartografia, Geodésia, Fotogrametria e Sensoriamento Remoto. 2015.

PINHEIRO, Maurício Mota Saboya. **Políticas públicas baseadas em evidências** (PPBEs): delimitando o problema conceitual. Texto para Discussão, 2020.

RAMOS, C. da S.**Visualização Cartográfica E Cartografia Multimídia**. UNESP, 2005.

RIBEIRO FILHO, Nelson Rosas. **Big data e Geografia Humana: uma provocação**. Lisboa: IGOT-UL, 2016.

SENDRA, Joaquín Bosque. Neogeografía, Big Data y TIG: problemas y nuevas posibilidades. **Polígonos. Revista de Geografía**, n. 27, p. 165-173, 2015.

TAURION, Cezar. **Big data**. Brasport, 2013.

Authors' contribution:
Author 1: Idealization; Discussion elaboration; Collective cartographic production; Bibliographic research.
Author 2: General supervision, discussion review; Assistance in discussion production.
Author 3: Management of matrix files; Assistance in cartographic production.