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# CARTOGRAPHY OF SURFACE WATER RESOURCES AS A PLANNING AND MANAGEMENT TOOL IN THE SEMIARID REGION: CODE SC.24-X-A-IV (CARTA FLORESTA)

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**RESUMO**
Em regiões secas como o semiárido brasileiro, a escassez de recursos hídricos frente à demanda por água é um dos maiores desafios a ser enfrentado pelas autoridades e órgãos gestores. A manutenção de dados hidrográficos atualizados, por sua vez, pode ser um instrumento de subsídio às ações de gerenciamento da água, especialmente nos períodos de estiagem. Dessa forma, o objetivo deste trabalho é atualizar os dados hidrográficos de um setor do semiárido Nordestino, correspondente a Folha SC.24- X-A-IV (Carta Floresta). Foram utilizados arquivos vetoriais das cartas topográfica e geológica, imagens orbitais do satélite LandSat 5, LandSat 8 e Google, cujas feições foram mapeadas no QGIS 3.10. Assim, foram reconhecidos e quantificados canais de drenagem, início e confluência de drenagens e corpos de água, subdivididos em lagos/lagoas, açudes, barreiros e tanques. A partir da atualização, verificou-se o aumento dessas feições entre 1985 e 2020, principalmente dos açudes. Acredita-se que a atualização dos dados hidrográficos é imprescindível, no sentido de se conhecer a distribuição espacial dos recursos hídricos de maneira precisa, e o que pode facilitar o planejamento e a tomada de decisões durante as secas habituais e as estiagens de longa duração.
**Palavras-Chave:** Mapeamento; Feições hidrográficas; SIG; Seca.

**ABSTRACT**

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In dry regions such as the Brazilian semiarid region, the scarcity of water resources in relation to the demand for water is one of the biggest challenges to be faced by authorities and management bodies. The maintenance of up-to-date hydrographic data, in turn, can be an instrument to support water management actions, especially in dry periods. Thus, the objective of this work is to update the hydrographic data of a sector of the Northeastern semiarid region, corresponding to Code SC.24-X-A-IV (Carta Floresta). Vector files of topographic and geological maps, orbital images from the LandSat 5, LandSat 8 and Google satellites were used, whose features were mapped in QGIS 3.10. Thus, drainage channels, beginning and confluence of drainages and water bodies were recognized and quantified, subdivided into lakes/ponds, weirs, barriers and tanks. From the update, there was an increase in these features between 1985 and 2020, mainly in the dams. It is believed that the updating of hydrographic data is essential, in order to know the spatial distribution of water resources in a precise way, and which can facilitate planning and decision-making during usual droughts and long-term droughts.



**Keywords:** Mapping; Hydrographic features; GIS; Dry.

## INTRODUCTION

In the Brazilian semiarid region, the growing demand for water resources for human supply and for the development of productive activities has generated the need to store increasing volumes of water (VIEIRA, 2002), due to the usual and exceptional droughts that generate water stress situations (MARTINS et al., 2017). Added to the growing demands, the degradation of water resources is also an aggravating factor for this context (SOUZA FILHO, 2011).

Historically, it was considered that the natural scarcity of water constitutes the main challenge to be faced by the region, in view of its greater economic development. However, it is pointed out that the lack or inadequate planning, by the different spheres of public power in water management, has compromised the access and use of resources by the population (SUASSUNA, 2002; PEREIRA, 2019), in such a way as to ensure the regional supply in its diverse needs and to promote its social development.

In several contexts in the semiarid region, inadequate planning and management of water resources, corroborate inefficient actions in this perspective (VIEIRA, 2003; GONDIM et al., 2017), as they permeate aspects that begin with issues such as: [i] the identification of currently existing water resources; [ii] the understanding of their spatial distribution in the planning unit; [iii] the analysis of their scalar and temporal variability; [iv] understanding the multiple uses of resources, as well as their management; among others.

In this sense, it is considered that cartography and Geographic Information Systems (GIS) can be used as instruments capable of supporting these issues, where strategic actions aimed at water planning and management can be developed from the availability of information spatial and thematic maps on water resources. To this end it becomes strategic to keep cartographic data regarding hydrographic aspects up to date, as a way of managing water properly and efficiently (PRUSKI; PRUSKI, 2011).

Thus, the objective of this work is to carry out the cartographic resources of a data set from a survey of the Northeast, the aim of this work by Carta Floresta, SC.20-X-A-1. The aim is to provide updated hydrographics from updates that make it possible in different areas of knowledge, as well as water resources planning and management actions, presented significant research dissociated in hydrographic features in recent decades, The diversity of levels of resources available to desertification (SE, 202) that allows the development of quality resources and the quantity of available water resources, in addition, the choice for this work.

## METHODOLOGY

### *Characteristics of the study area*



The cover area of Carta Floresta is located between the states of Pernambuco and Bahia (Figure 1). This is a sector that has an advanced stage of soil desertification, located in the Cabrobó Desertification Nucleus - PE (BARBOSA NETO et al., 2020) and in the Jeremoabo Regional Hub - BA (OLIVEIRA JÚNIOR, 2019). Regionally, the semiarid climate has an average annual rainfall of 400 mm, an average annual temperature of 24°C and an aridity index of 0.31, resulting in high annual evapotranspiration rates. In addition, droughts are frequent, contributing to the widespread scarcity of water resources for long periods (ASFORA et al., 2017).

From a systemic point of view, other environmental variables, in addition to climate, constitute limiting factors for the storage and permanence of water in the region. The geological substrate is predominantly composed of Pre-Cambrian rocks that make up the crystalline shield that, from the interaction with the semi-arid climate, favors the development of shallow soils, such as Planosols (Alfisols/Planosols), Luvissols (Alfisols/Luvisols) and Neosols (Entisols/Arenosols), highly susceptible to erosive processes (BARBOSA NETO et al., 2020). These soils cover the surface of regional planing, inserted in the Sertaneja Depression, whose slopes are predominantly between 2 and 5%. Under these conditions, water resources stored in water courses and reservoirs during the rainy season (January to April) have high salinity, high levels of turbidity and silting (XAVIER, 2014), compromising their quality for human use.

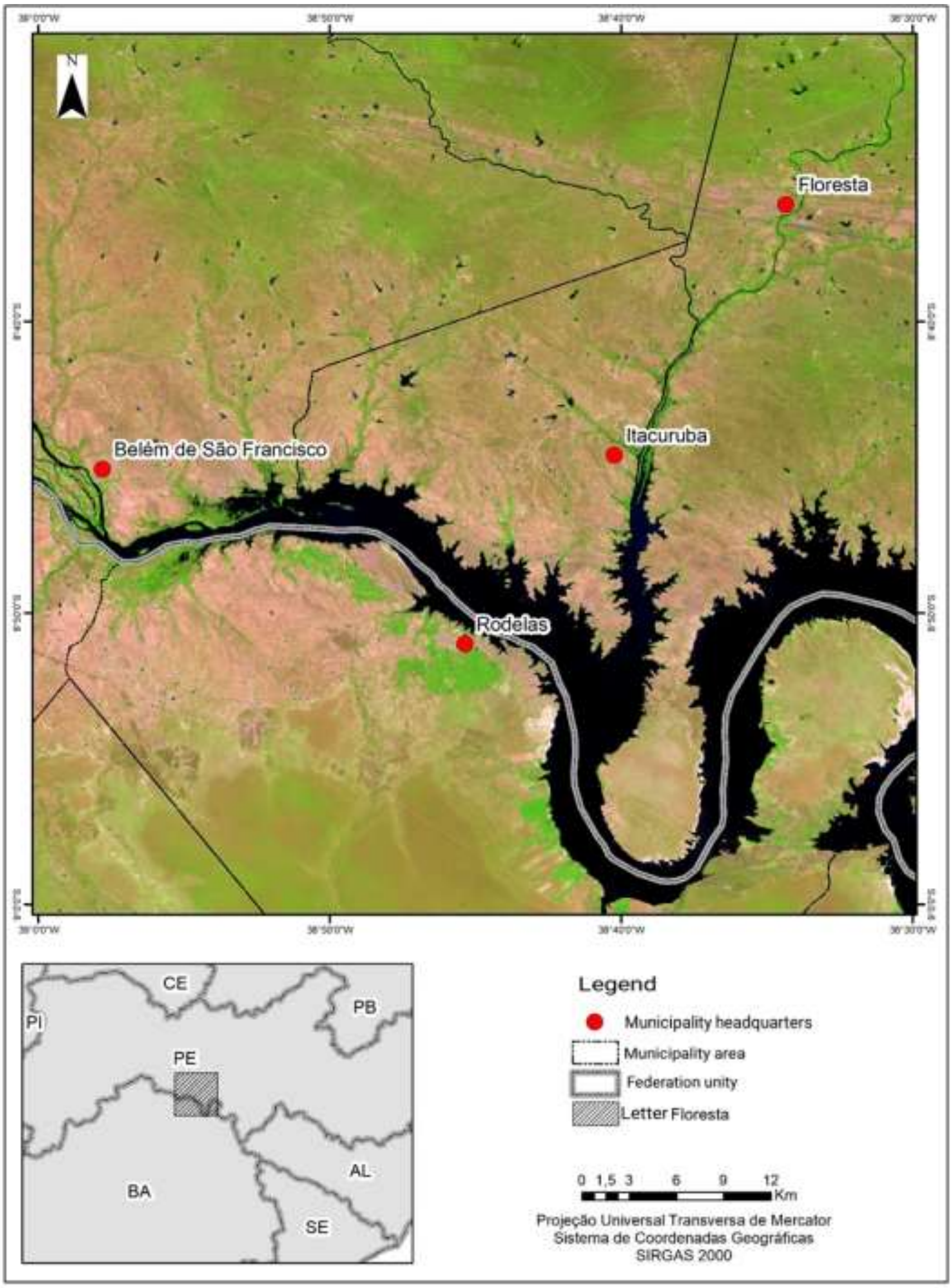


**Figure 1:** Location of the SC.24-X-A-IV joint (Carta Floresta), between Bahia and Pernambuco. Source: Own authorship.

### *Technical and operational procedures*

As a reference, files in shapefile format of the topographic (SUDENE-1985) and geological-geophysical (CPRM-2018) maps were used, both at a scale of 1:100,000, corresponding to the SC.24-X-A-IV articulation (Figure 2). Hydrographic elements used from the topographic map were the drainage channels, the beginning and the drainage confluences and the bodies of water. In the geological-geophysical map, the hydrographic data used were drainages and water bodies. The data were superimposed and compared, in order to verify the quantitative evolution of each feature between the years 1985 and 2018.

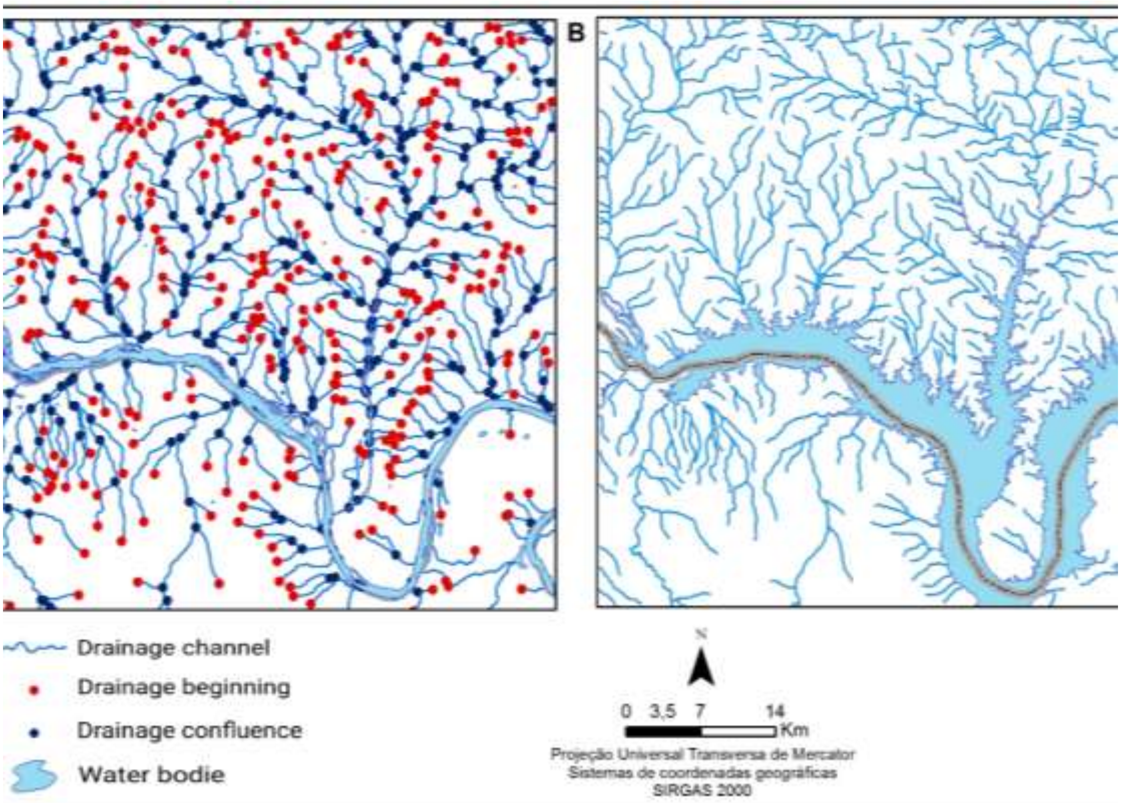


**Figure 2:** Hydrographic data from the topographic map (A) and from the geological-geophysical map (B).
Source: Own authorship.



As a way of updating the data and verifying possible features not represented in the previous cartographic bases, orbital images from the Landsat 5 satellite, from May 23, 2010 (wet period) were used; and Landsat 8, from April 8, 2020 (wet period). In a complementary way, images available on the Google basemap were used (LIMA; LUPINACCI, 2019a), through the Quick Map Services plugin in the QGIS 3.10 software. These images also served to confirm uncertainties regarding pre-existing vector files, in addition to allow the identification of features in the stretches covered by clouds and their shadows. In these images, the bodies of water identified in greater detail (1:50,000 and 1:25,000) were represented as a point, depending on the scale adopted, and considering their representativeness and economic and social importance in the regional context.

In order to standardize the nomenclatures used in the cartographic bases with the mapped features, the following terms were adopted: drainage channels (which include perennial, intermittent and ephemeral), beginning of drainage, drainage confluence and bodies of water (lake/pond, weir, stock ponds and tanks). The drainage channels were represented as a line and polygon (São Francisco river and lower Pajeú), the beginning and the confluences of the channels as points; and water bodies as a polygon (with an area ≥1,470 m²) and as a point (area <1,470 m²).

The term stock ponds, in this context, was used to name the open cavities in the ground for the accumulation of water from surface runoff, without necessarily having a connection with the drainage channels. The hydrographic features used for psiculture were those called tanks. The features called the beginning of drainage, in turn, corresponded to the points where the channels begin as an incision in the ground (LIMA; LUPINACCI, 2019b) or as springs. The latter, as a more restricted possibility for the context of the area under study.



## RESULTS AND DISCUSSIONS

The quantification of hydrographic features between the years 1985 and 2018 showed significant differences (Table 1), especially concerning the number of water bodies and drainage channels. It is possible to observe that the reduction of drainages was related to the damming of the São Francisco River and the subsequent formation of Lake Itaparica, which submerged small channels. This currently constitutes the main water resource in the area covered by the Carta Floresta, contributing to the development of diversified economic activities on its banks, such as psiculture and irrigated agriculture.

**Table 1:** Hydrographic features extracted from the cartographic bases corresponding to the SC.24-X-A-IV joint.

| Hydrographic features | Topographic chart (1985) | Geological-geophysical chart (2018) |
|---|---|---|
| Drainage channels | 437 | 418 |
| Beginning of drainage | 318 | - |
| Confluence | 360 | - |
| Water bodies | 63 | 15 |

Source: Own authorship.

The reduction in the number of water bodies in this time interval, in turn, may be associated with the technologies used as a basis for the mappings. However, this possibility is less justifiable, when in the 2010s, products derived from remote sensing of better quality were available than in the 1980s. Thus, it is believed that the smallest amount of water bodies in the 2018 scenario, was due to the objectives focused on geological and geophysical aspects of the chart, causing the omission of most of these features.

In the 2020 scenario, there was a significant increase in the number of hydrographic features (Table 2) compared to 2018. Drainage channels and water bodies were the features that showed a substantial increase. In this case, it is believed that the different objectives of the mapping carried out were responsible for the increase in the number of drainage channels that, in the 2020 scenario, artificial channels integrated into the natural drainage network, located in the irrigated perimeters, were also incorporated.

**Table 2:** Hydrographic features mapped in the area corresponding to the SC.24-X-A-IV joint.

<table>
<tr><th colspan="2">Features</th><th>Quantity</th></tr>
<tr><td colspan="2">Drainage channels</td><td>481</td></tr>
<tr><td colspan="2">Beginning of drainage</td><td>362</td></tr>
<tr><td colspan="2">Confluence</td><td>404</td></tr>
<tr><td rowspan="5">Water bodies</td><td>Lake/Pond</td><td>44</td></tr>
<tr><td>Weir</td><td>359</td></tr>
<tr><td>Stock pond</td><td>73</td></tr>
<tr><td>Tanks</td><td>9</td></tr>
<tr><td>Total</td><td>485</td></tr>
</table>

Source: Own authorship.

The water bodies (Figure 3) were the most frequent features in the area, mostly the weirs. The weirs are distributed over the entire area of the map, except for the Bahia section, concentrating in the vicinity of the São Francisco River (areas intended for irrigated crops). the increase in demand for water in rural areas, mainly due to the usual and exceptional long-term droughts, such as the one that occurred between 2011 and 2016 (MARTINS; MAGALHÃES; FONTENELE, 2017; ASFORA et al., 2017). In addition, the weirs, for the most part, do not have infrastructure that allows the distribution of stored water, allowing supply only to people and/or economic activities that are close to their banks.

In the regional context, as in the entire Brazilian semiarid region, the practice of weir is common (PEREIRA NETO, 2017), whose waters are used for multiple uses, such as animal watering, irrigation of small plantations and domestic purposes. The construction of weirs has been proposed as the solution for coping with drought since the first decades of the 20th century, fostered by clientelistic federal public policies (ANDRADE; NUNES, 2014). Currently, other actions aimed at capturing and storing water are being developed, mainly those aimed at the use of social technologies in rural communities (GNADLINGER, 2011; CAETANO et al., 2020).

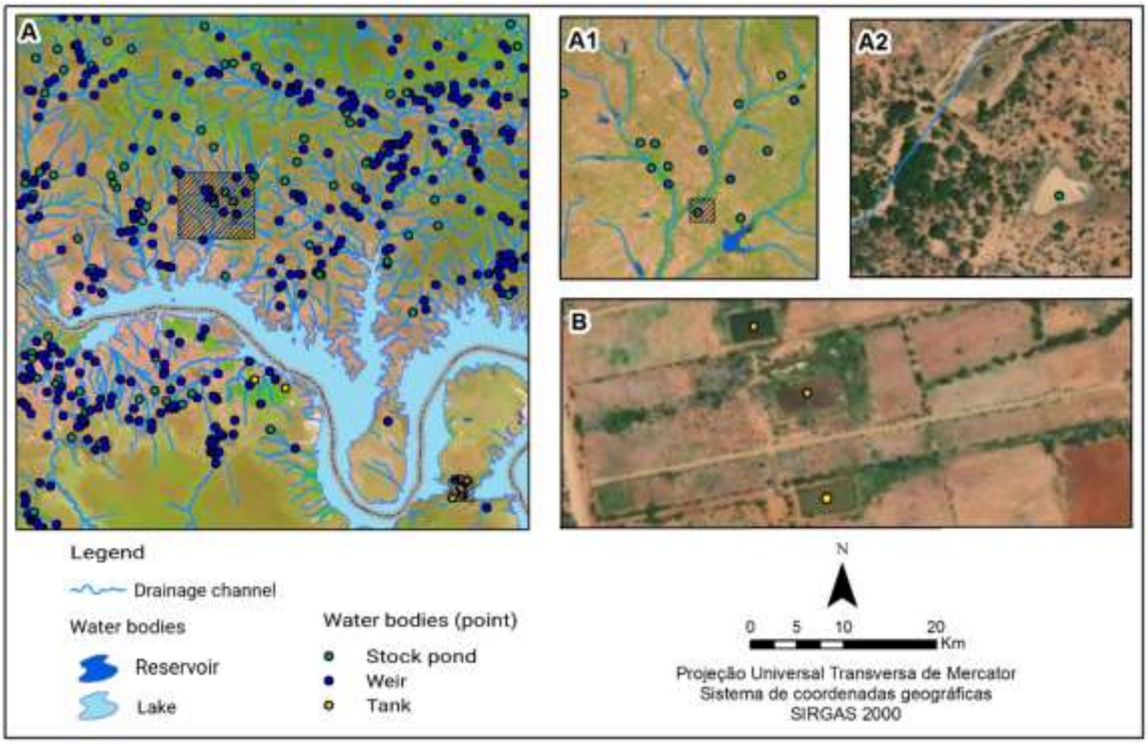


**Figure 3:** Hydrographic data corresponding to the SC.24-X-A-IV joint on the 2020 LandSat 8 image (A), with emphasis on weirs represented as a point and polygon (A1). On Google images, *stock ponds* (A2) and ponds in irrigated agriculture areas (B), represented as a point.
Source: Own authorship.

The features called the beginning of drainage were compared between the years 1985 and 2020, as they were not represented in the geological-geophysical map of 2018, as well as the drainage confluences. It should be noted that mapping the places where drainage begins is of paramount importance for dry regions due to its hydrological, geomorphological and ecological significance (BOULTON et al., 2017). The confluences, in turn, constitute a data that allows the understanding of the morphodynamics in the channels, when significant water flows occur. It can also subsidize projects for the implementation of rainwater harvesting technologies, such as trench *stock ponds* or "*barraginhas*" (LIMA, 2013).

From an environmental point of view, the area covered by the Carta Floresta corresponds to one of the sectors with the most severe degree of soil desertification (SEMAS, 2020). In this sector, the exposed soils provide significant amounts of sediment that cause the silting of the reservoirs during the rains, compromising the quality of the water stored in these reservoirs. In addition, they can reduce their useful life (LOPES, 2016), since increasingly higher levels of salts are concentrated in water and restrict their use.

## FINAL REMARKS

In view of the objective and proposed methodology, it is stated that the topographical and geological-geophysical maps provide important hydrographic data and information, however, they must be updated, in order to meet purposes aimed at the management of water resources on a regional analysis scale. Thus, it is believed that the mapping of surface water resources at 1:250,000 and 1:100,000 scales should be developed with technical procedures specifically aimed at this purpose, in order to provide consistent data and avoid problems such as omission and underquantification of features hydrographic.

Considering the regional limitations in terms of surface water resources, there is a need to update hydrographic data, in order to have knowledge of their spatial distribution, which can facilitate decision-making by public managers, especially in periods of drought. In view of National Law No. 9,433 (BRASIL, 1997) and the state laws of Pernambuco - Law No. 12,984 (PERNAMBUCO, 2005) and Bahia - Law No. 11,612 (BAHIA, 2009), on public policies aimed at water resources, as well as their respective information systems on water resources, this work can contribute with legal aspects related to the updated maintenance of the thematic database, the provision of subsidies for planning and management, access to data for the population as a whole, among others.



For the semiarid context, the updating of these data must be carried out constantly, although the region, in general, still presents problems regarding the availability of higher quality remote sensing products (spatial resolution, for example), with wide temporal coverage. Especially in periods of drought, hydrographic maps can also guide the location of future works to cope with the drought, aimed at minimizing its effects, especially in small rural communities. Finally, it is also pointed out the need to develop spatial databases in Geographic Information Systems with an emphasis on water resources, as a way of grouping as much information as possible on the quantity and quality of this resource.

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