

Chapter 6

Mapping by remote sensing of sources in the municipality of Piumhi – Minas Gerais

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ABSTRACT

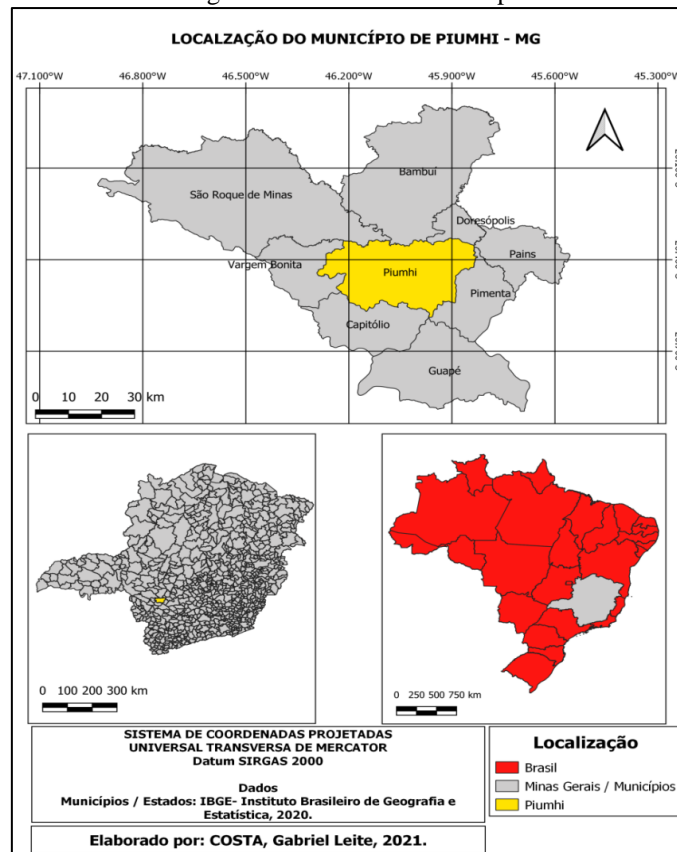
The municipality of Piumhi, located in the center-west of the state of Minas Gerais, receives a significant number of tourists due to the natural landscapes in its area and neighboring cities, such as waterfalls, canyons, among others, also for its production of cheese and dairy products, which are national highlights. With this, the city's springs will be studied, to obtain information from as many watercourses as possible and with that to prepare maps of the place with the information contained in these springs. The maps obtained will be able to help residents, researchers, tourists, students, and anyone interested in contributing to the place, adding a greater socioeconomic value to the municipality and its region, consequently causing the arrival of more tourists to this area, as well. contributing to future studies in the environmental area, serving as a location for preventing water courses and cleaning streams, having various public, scientific, social, and even tourist purposes, contributing to everyone around it, and also to environmental sustainability.

Keywords: Remote sensing, Geoprocessing, Hydrographic basin, Springs, Conservation.

1 INTRODUCTION

The municipality of Piumhi, located in the Midwest region of the state of Minas Gerais, as shown in Figure 1, is 256 kilometers from Belo Horizonte and 265 kilometers from Ribeirão Preto. Its economy is historically focused on agriculture and livestock, being a producer of Canasta cheese and highlighted as a coffee center (IBGE, 2010).

Figure 1: Piumhi location map.

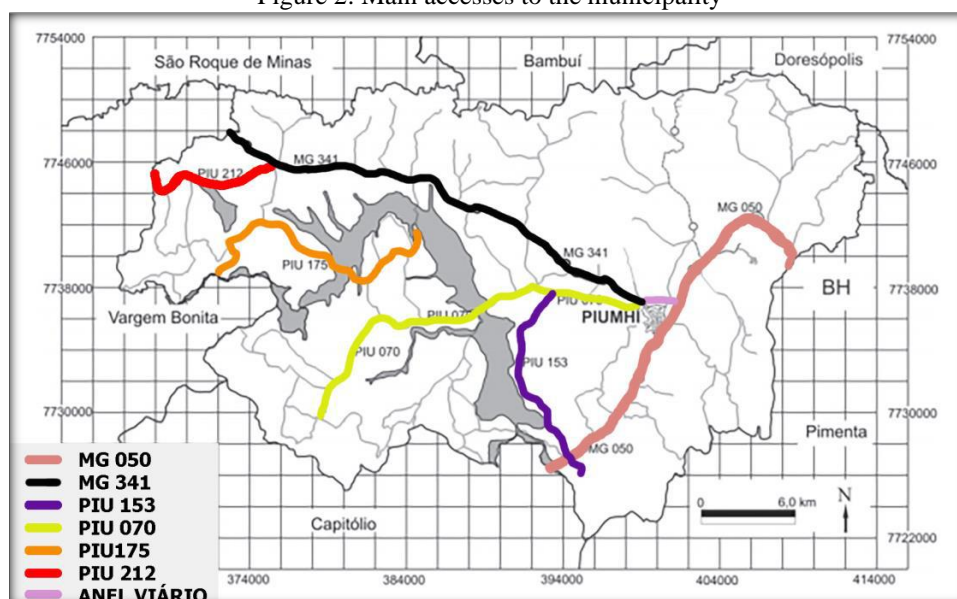


Source: Drafted by authors, 2021.

It borders the municipalities: of São Roque de Minas, Bambuí, Dorcasópolis, Pains, Pimenta, Capitólio, and Vargem Bonita. Due to its proximity to the Furnas Dam and the Serra da Canastra National Park, it receives many tourists.

The main accesses to Piumhi are the MG 050, and MG 341 and the municipal roads PIU 153, PIU 070, PIU175, and PIU 212 (Figure 2).

Figure 2: Main accesses to the municipality



Source: Modified by the authors based on REVISTA GEOCIÊNCIAS, 2007.

It has a territorial area of 902.468km² (IBGE, 2020), an estimated population of 35,137 people (IBGE, 2021), a population density of 35.33 inhabitants/km² (IBGE, 2010), and a GDP per capita of R\$ 25,148.18 (IBGE, 2018) and it is located at the geographic coordinates: Latitude: 20° 27' 42" South, Longitude: 45° 56' 45" West.

Of all the existing households in the city, 92.7% have adequate sanitary sewage, 62% of those located in urban areas are on public roads with trees and 30% of these are on public roads with the presence of a culvert, sidewalk, paving, and means. wire. Compared to other municipalities in the state, it ranks 47th out of 853, 444th out of 853, and 331st out of 853, and in federative comparison, its position is 312th out of 5570, 3581st out of 5570 and 1228th out of 5570, respectively (IBGE, 2010).

According to Professor, historian, and lawyer Luís Augusto Júnio Melo,

"The origin of the village of Piumhi was built on the standards of Minas Gerais in the 18th century, that is, a strong connection between mining, agriculture, livestock, and religiosity. During the first three decades of the 18th century, the hinterland of Piauí was a dense virgin forest inhabited by hostile indigenous people and black people from the Quilombate, although it was already a land coveted by the Bandeirantes, as they believed that there was a lot of gold here."

"Many adventurers thought of taking this trip to the sources of the São Francisco River, but no one had the courage or the necessary capital to make the dream come true. Some came but were unsuccessful in mining.

In 1731, João Batista Maciel from São Paulo, based in Pitangui, decided to seek the necessary support to undertake the adventure. He made a preliminary expedition and found sparklers in the region. Upon returning to Pitangui, he spread rumors that there was a lot of gold in the Sertão do Piauí. Thus, a formal entourage was organized with the presence of Father Luís Damião and the City Attorney João Veloso Falcão."

"When we arrived in the region, the gold was not found in the magnitude that was expected. (..) Despite the confusion, some miners decided to stay here to better explore the terrain" (MELO, 2021)

According to Melo (2021), as a result of signs of depletion and decline in other mining regions, a new mining boom appeared in Piauí in 1752, significantly increasing the number of inhabitants. The miner priest Marcos Freire de Carvalho, takes possession of the "Novos Descobertos do Piauí" for the Bishopric of Mariana and, two years later, the camp was already so developed that the representatives of the Chamber of São José Del Rei, took possession of the region of Piauí, and the Bishop of Mariana Dom Frei da Santíssima Trindade, by decree, decided to subordinate the Hermitage of São Roque to the Parish of Piauí, becoming the "Parish of Nossa Senhora do Livramento do Piauí" in 1754.

The parish gained the status of Colada Parish only in 1803, when the State, under the command of the Portuguese King Dom João VI, assumed the expenses and the right to collect the tithes.

From that moment on, mining was left in the background and they had access to agriculture and livestock, which remain the main source of income for the city until the present day, with an emphasis on coffee production. The creation of Vila do Piumhi dates back to April 1, 1841, led by the local parish priest, Vigário José Severino Ribeiro, with a campaign to raise funds to organize the installation of the Municipality of Piumhi, which was consolidated on April 7, 1842 – date of political and administrative emancipation of the municipality, dismembered from Vila Nova de Formiga. Already on July 20, 1868, by law no. 1510, Vila do Piumhi becomes a city (MELO, 2021).

Catholic temples are a historical landmark in the city, such as the Igreja Matriz de Nossa Senhora do Livramento, built in the 1940s; the Sanctuary of Nossa Senhora do Rosário de Fátima, completed in 1956, replacing the old Chapel of the Rosary; and the Chapel of Nossa Senhora da Abadia da Cruz do Monte, the main postcard of the city (MELO, 2021).

The name of the city also has history, due to the dozens of different ways of writing the name of the city. When it was still a village, the spelling "Piumhy" was used. With the presidency of Getúlio Vargas, the letters "K", "y", and "w", from the Brazilian alphabet were extinguished and, in this way, it started to be written as "Piumhi". The same president also commissioned a study in which he concluded that it should be spelled Piuí, by federal institutions, but state and municipal departments used the spelling "Piumhi". Mayor João Batista Soares, through the Legislative Assembly of Minas Gerais, approved a law that made the spelling "Piumhi" official.

For some scholars, the meaning of the toponym is “river of many fish” (piu= fish, i= water/river) and for others, (pium= mosquito, i= water/river). Both versions are considered correct, as there is an abundance of fish and blackflies in the region (MELO, 2021).

As for the potential of the city of Piumhi, Melo (2021) describes it as being very special and privileged, with flat topography, although it is surrounded by a mountain range that provides indescribable natural beauty, to be explored by tourists. The city forms a kind of gateway to the greatest tourist riches in the region, Serra da Canastra and Lago de Furnas, with waterfalls, mountains, caves, century-old farms, and lookouts in its surroundings.

Water resources are sources of surface or underground water that can be obtained and available for human use, such as rivers, lakes, streams, groundwater, etc. (COSTA, et al., 2012).

Its importance can be measured by hydroelectric power plants, the most important and most used source of energy in Brazil, and by the growing supply crisis and the constant degradation suffered by freshwater ecosystems on our planet (COSTA, et al., 2012).

The increase of agricultural frontiers, the irregular use of pesticides, the irregular occupation of the soil, the irregular sanitary treatment of garbage, and the lack of awareness, are among the main causes of the increasing degradation of water resources (COSTA, et al., 2012).

The minimization of these causes is achieved by raising awareness of the importance of water, knowledge of projective legislation and the appropriate forms of use, responsibilities, and primary use, water resources being indispensable for life on earth, as it is the element most used by human beings. humans, both for power generation, irrigation, basin management, drainage, supply, fish farming, and leisure, among others (COSTA, et al., 2012).

2 OBJECTIVES

2.1 GENERAL PURPOSE

This research project aims to investigate and map the existing watersheds in the municipality of Piumhi and, through the identification and classification of each one of them, show the importance of these maps for society to have the possibility of analyzing them for future actions.

2.2 SPECIFIC OBJECTIVES

- Collect data on existing watercourses in Piumhi through government websites, municipal institutions, sanitation companies, and help from the population;
- Name new beds found;

Formulate maps with the help of QGIS software with the available data.

3 THEORETICAL REFERENCE

3.1 CERRADO

The Cerrado is the second largest biome in South America, occupying approximately 2 million km², around 22% of the national territory, behind only the Amazon (Ministério do Meio Ambiente - MMA, 2020).

The Cerrado has great natural wealth and great biodiversity, but is threatened with extinction; therefore, it is extremely important for the conservation of the world's biodiversity. It has the richest flora among the savannas in the world (>7,000 species), with a high level of endemism. Its species richness of birds, fish, reptiles, amphibians, and insects is equally vast (KLINK and MACHADO, 2005).

Klink and Machado (2005) point out that despite so much wealth, over the last 35 years, more than half of its original 2 million km² have been used as planted pastures and annual crops, that deforestation rates have historically been higher than those of the Amazon rainforest and the effort to conserve the biome is much lower. The authors also mention that only 2.2% of the Cerrado area is legally protected, and it is estimated that 20% of the various animal and plant species that are threatened with extinction are not protected in legally protected areas.

For Marouelli (2003), the Cerrado represents today, for the world, one of the last viable alternatives with high potential for agricultural production. However, its use as a mode of production requires a series of precautions and measures aimed at its sustainable development, without depleting natural resources.

Concerning biodiversity, the main threats are the invasion of soils, the degradation of the different types of vegetation present, and the biological invasion caused by grasses of African origin; and, although this biological community is adapted to fire, its use to clear virgin areas and to stimulate the regrowth of pastures is also harmful (KLINK and MACHADO, 2005).

With the wide changes that occurred in the Cerrado landscapes, conservation initiatives were created by the government, Non-Governmental Organizations (NGOs), researchers, and the private sector. Through

a network of NGOs called Rede Cerrado, practices for the sustainable use of natural resources were protected (Fundação Pró-Natureza, 2000 apud KLINK, and MACHADO, 2005).

According to Klink and Machado (2005), in 2004, the Ministry of the Environment (MMA), through a working group, proposed a conservation program called 'Sustainable Cerrado Program', based on the results and propositions of the seminar that defined the priorities for the conservation of the Cerrado, in 1998 (Fundação Pró-Natureza et al., 1999 apud Klink and Machado, 2005 apud). This proposal aimed at the integration of actions for conservation in regions of accentuated agricultural activities, harmful and widely disseminated.

Klink and Machado (2005), also talk about other works by these NGOs, which are the creation of state and federal conservation units in the region of the Jalapão complex (Tocantins), which is the largest continuous area of conservation in the Cerrado; the establishment of the Biosphere Reserve in the region of the Chapada dos Veadeiros National Park; support for indigenous communities in the development of management plans (in Mato Grosso and Goiás); acting in the management of aquatic ecosystems in the Federal District (WWF, 1994 apud KLINK and MACHADO, 2005); and the expansion (May 2004) – by 147,000ha – of the Grande Sertão Veredas National Park (KLINK and MACHADO, 2005).

3.2 WATERSHEDS

Based on the study by Porto and Porto (2008), Tucci (1997) says that a hydrographic basin can be defined as the natural catchment area of precipitation water that converges the flow towards a single exit point. It can be seen as a set of surface surfaces and a drainage network formed by watercourses that come together until they form a single bed at their outlet (TUCCI, 1997 apud PORTO, and PORTO, 2008). This is where the balances of input from rain and output of water through the outlet are highlighted, allowing basins and sub-basins to be traced, whose union is given by the water systems (PORTO and PORTO, 2008).

Porto and Porto (2008) say that the ideal size of a hydrographic basin incorporates an entire area of interest. You can analyze a small basin of 0.5 km² in an urban area or one in the São Francisco River basin, with more than 600,000 km² of area. This systemic concept adapts very well to water resources management systems.

The management of water resources based on the territorial outline of watersheds gained strength in the early 1990s when the Dublin Principles were agreed upon at the preparatory meeting for Rio-92. (WMO, 1992 apud PORTO and PORTO, 2008). Principle n.1 says that the management of water resources, to be effective, must be constructed and consider all physical, social, and psychological aspects; it is suggested that management be based on watersheds (WMO, 1992 apud PORTO and PORTO, 2008).

Before the recognition and acceptance of the Principles, several initiatives in the area of management of these resources were based on the geographical outline of watersheds, having been documented treaties for the use of the Danube River dating from 1616, the Brazil-Peru treaty on the navigation of the Amazon River in 1851 and the treaty between Brazil and the Republic of the United

Provinces of Rio de la Plata in 1928 (GRANZIERA, 2001 apud PORTO and PORTO, 2008).

In Brazil, in 1976, given the recognition of the difficulty in dealing with problems related to the use of water, an agreement was reached between the Ministry of Mines and Energy and the government of the State of São Paulo, to improve conditions of the Alto Tietê and Cubatão basins (PORTO and PORTO, 2008).

The high success rate of this experience led to the establishment, in 1978, of the Special Committee for Integrated Studies of Hydrographic Basins (CEEIBH), and the subsequent creation of executive committees in several hydrographic basins, such as in Paraíba do Sul, São Francisco and the Ribeira de Iguapé (PORTO and PORTO, 2008).

These committees had only government bodies as members and the duty to advise, without the obligation to implement their decisions, becoming important experiences and a starting point for the future evolution of management by river basin in the country (PORTO and PORTO, 2008).

In the 1980s, several experiences emerged based on the management of watersheds. In Espírito Santo, the first Santa Maria/Jucu Intermunicipal Consortium was constituted to facilitate negotiation between users in the dry period that occurred in that State (PORTO and PORTO, 2008).

In 1988, the Sinos and Gravataí Basin Committees, affluents of the Guaíba in Rio Grande do Sul, were created. States (PORTO and PORTO, 2008).

With great repercussions in the technical field, the Brazilian Association of Water Resources (ABRH) mobilized and produced the Letters from Salvador in 1987 and from Foz do Iguaçu in 1989, electing the creation of an organized management system, and, in particular, the Charter of Foz do Iguaçu defines basic principles that should be followed in establishing the National Water Resources Policy, such as integrated management, basin as a management unit, recognition of the economic value of water, decentralized and participatory management (PORTO and PORTO, 2008).

Through a pioneering initiative, in 1989, some cities in the Piracicaba and Capivari river basins joined together to form the Intermunicipal Consortium of the Piracicaba and Capivari River Basins, intending to stimulate the environmental recovery of the rivers, regional integration and basin development planning, as it was born in the local administration and has a plenary of entities in which civil society is invited to participate in decisions, it becomes innovative (PORTO and PORTO, 2008).

Law no. 9,433, of 1997, gave Brazil a new water resources policy and organized the management system, implementing management by hydrographic basins throughout the national territory, whether these water bodies are owned by the Union or the States. The difficulty in dealing with this geographic area is the requirement for shared management with the public administration, sanitation bodies, institutions linked to agricultural activity, and environmental management, among others, with each of these sectors representing a different political vision of the hydrographic basin (PORTO and PORTO, 2008).

The 1988 Constitution played an important role in the management of water resources, as it defined water as goods for common use and changed the domain of water in the national territory, which was

previously considered Union property by the 1934 Water Code (Decreto n.24.63, of 7.10.1934).

In the Federal Constitution, within art. 26, item I is included among the assets of the States and the Federal District "surface or groundwater, flowing, emerging and in deposit, except, in this case, in the form of the law, those arising from works of the Union" (CONSTITUIÇÃO DA REPÚBLICA FEDERATIVA DO BRASIL, 1988).

These articles concern water bodies and not the hydrographic basin, as it constitutes a territory and, consequently, is subject to the exercise of the federative principle, which is the attribution and competence of the three federative entities (Union, States, and municipalities), and aims at the shared management of the common good, water (PORTO and PORTO, 2008).

Already art. 21, item XIX, aims to "establish a national water resources management system and define criteria for granting use rights". It gave rise to Law 9,433, dated 1.8.1997, which instituted the National Water Resources Policy and created the National Water Resources Management System. Soon, the country now has a legal instrument that aims to guarantee the availability of water resources in the future. The modernization of the sector is consolidated and Law n. 9,433, places Brazil among the countries with the most advanced legislation in the world in the water resources sector (PORTO and PORTO, 2008).

By the interpretation of Porto and Porto (2008) under the Constitution of the Federative Republic of Brazil (1988), this law has among its foundations, water as a public good, endowed with economic value, whose priority uses are human supply and the satiety of the animals and that the management must take the hydrographic basin as a territorial unit. It deals with integrated management as a guideline for action and as a means of implementation, water resource plans, the classification of bodies of water into classes according to predominant uses, the granting of use rights, charging for water use, and the system of information on water resources and compensation to municipalities (Constitution of the Federative Republic of Brazil, 1988 apud PORTO and PORTO, 2008).

Porto and Porto (2008) see as objectives to be fulfilled by Law n. 9,433 through the National Resource Management System, coordinate integrated water management; administratively arbitrate conflicts related to the use of water; implement the National Water Resources Policy; plan, regulate and control the use, preservation, and recovery of water resources and; promote charging for water use. Members of the National Water Resources Management System are the National Water Resources Council; the State and Federal District Water Resources Councils; the Hydrographic Basin Committees; government bodies whose powers relate to the management of water resources and water agencies (Lei n. 9,433 apud PORTO and PORTO, 2008).

For Porto and Porto (2008), human activities develop over the territory defined as a watershed, and all urban, industrial, agricultural, or conservation areas are part of some watershed. They claim that all the processes that are part of their system will be represented in their outlet, transforming themselves into forms of occupation of the territory and use of the waters that are found in a given location.

Porto and Porto (2008) show that the hydrographic division of the Brazilian territory takes place at the first level, through macro hydrographic division, being called Brazilian Hydrographic Regions. Resolution n.32 of the National Water Resources Council defines this division as shown below.

Figure 3: Hydrographic division of the Brazilian territory



Source: CNRH, 2003 *apud* Porto and Porto, 2008.

The division of regions occurred in such a way due to economic, social, and cultural differences, as well as the diversity of existing ecosystems, while the state division is made according to the needs of water resources management, with the physical configuration and local characteristics; having, for example, 22 units in São Paulo, 15 in Paraná and 36 in Minas Gerais (PORTO and PORTO, 2008).

3.3 NATIONAL WATER AGENCY (ANA)

The National Water Agency (ANA) was created in 2001 as a way of complementing the institutional structure for the management of water resources in the country. It implements and operates the entire system of the national water resources policy, in addition to overseeing and charging for water use. (PORTO and PORTO, 2008).

It is interesting to note that this system required a continuous administrative structure through the articulation between existing institutions, without the need to create new ones beyond the ANA itself, to promote the decentralization of management, allowing the decision to be taken in the hydrographic basin, with the guarantee of the participation of users and civil society from the National Water Resources Council to the Hydrographic Basin Committees, legitimizing decisions efficiently and guaranteeing their implementation (PORTO and PORTO, 2008).

According to Porto and Porto (2008), after the consolidation of Law n. 9,433/97, extremely important for ordering the use of water; public administrators and users need to be receptive to the partnership process, which had difficulties in acceptance since the law was discussed, and whose main challenge is to decentralize decisions, which should be followed through the principle of subsidiarity (MMA, 2007 apud PORTO e PORTO, 2008).

The National Water Agency (ANA) provides public services to citizens, covering forms of access, main steps, and data necessary for access, as provided for in art. 7 of Law No. 13,460/2017. The Agency is responsible, at the federal level, for implementing the National Water Resources Policy, regulating the use of water resources, providing public irrigation and raw water supply services, for the safety of dams, and for establishing norms benchmark for the regulation of public basic sanitation services. Its mission is to ensure water security for sustainable development in the country and acts in articulation with sectors and spheres of government; in the production and dissemination of information and knowledge; in the establishment of norms that aim to guarantee the right to use water, in minimizing the effects of critical events (droughts and floods), in the provision of raw water supply services, in guaranteeing the safety of dams and in providing a reference for regulation of public basic sanitation services (ANA, 2020).

According to the report Sustainable Development Goals (SDG) 6 in Brazil, ANA's Vision of Indicators, 17 goals, and 169 corresponding targets are proposed, resulting from the consensus obtained in 2015 by the delegates of its Member States; The SDGs constitute the 2030 Agenda of the United Nations (UN) and their implementation will take place from 2016 to 2030, and the global panorama may be monitored worldwide through monitoring by indicators and the results of each country, as well as its historical evolution (ANA, 2019).

SDG 6 consists of 8 goals, which propose "Ensure the availability and sustainable management of water and sanitation for all" and deal with sanitation and water resources from an integrated perspective, allowing the assessment of the scenario of each country regarding the availability of water resources, demands and for human activities, actions for the conservation of aquatic ecosystems, reduction of waste and access to water supply, sanitary sewage and sewage treatment (ANA, 2019).

Through statistics and indicators that feed the National System of Information on Water Resources (SNIRH), ANA systematically and periodically monitors the condition of water resources and their management in the country through statistics and indicators. Since 2019, the agency has been linked to the Ministry of Regional Development (MDR), which brings together national sanitation and water resources policies, in addition to water security, being the main person responsible at the federal level for implementing actions to achieve the goals. of SDG 6 (ANA, 2019)

There was a great advance of the SDGs about the Millennium Development Goals (MDGs), as it brought the issue of water and sanitation to the center of the discussion, an exclusive objective having been created to deal in detail with the theme, and considered a more comprehensive view of water as a water resource, in terms of quantity or quality, while it was previously limited to access to water and sewage

sanitation services, thus, this insertion of water resource management places water as a central element of themes that have a relationship with several other SDGs, such as public health and the environment (ANA, 2019).

As the goal of SDG 6 – Ensure the Availability and Sustainable Management of Water and Sanitation for All, there is a connection with SDG 2 – Zero Hunger and Sustainable Agriculture, SDG 3 – Health and Well-Being, SDG 7 – Clean and Affordable Energy, SDG 13 - Action Against Global Change and SDG 14 - Life on Water. The relationship between them makes it possible to assess the scenario of each country in terms of water supply and sanitary sewage, water supply and demands and uses of water for human activities, water quality, management of water resources, and conservation actions for aquatic ecosystems (ANA, 2019).

SDG 6 consists of 8 goals shown in figure 2 and is monitored by 11 indicators (ANA, 2019).

Figure 4: SDG Targets



Source: ANA, 2019 p.10.

The concern with the provision of drinking water for all is the focus of goals 6.1 and 6.3., which act together with goal 6.2, which deals with access to sanitary sewage, and its absence can lead to contamination of the soil, rivers, and seas and water sources for supply, impairing quality of life and health (ANA, 2019).

The rational economic use of water, increasing efficiency and optimizing its supply to guarantee multiple uses, is in target 6.4. The efficient and integrated management of surface and groundwater resources, national and cross-border, is addressed in target 6.5 (ANA, 2019).

Goals 6.6, 6. a, and 6. b deal with institutional frameworks to encourage social participation in controlling water use and monitoring the protection of aquatic ecosystems (ANA, 2019).

Information on scenarios and advances in each region is stored in the database that feeds the National System of Information on Water Resources (SNIRH) and subsidizes the preparation of annual

reports on the situation of water resources in Brazil. These works are a reference for monitoring the situation and management of water in the country and their elaboration has the partnership of more than 50 bodies and entities that make up SINGREH, in addition to other public, federal and state bodies that are part of the network for building the indicators (ANA, 2019).

ANA, as a contribution to SDG 6, calculated the indicators of historical series and disaggregation in different spatial cuts, with the idea of facilitating the analysis of the monitoring of its 8 goals and grouping them in the publication into three major thematic axes, these being the Water Supply and Sanitary Sewage; the Quality and Quantity of Water; and Sanitation and Water Resources Management (ANA, 2019).

4 JUSTIFICATION

According to De Souza, et al., (2007), in the agricultural sector,

“(…) The growth and development of this activity in the municipal territory took place in inappropriate areas and at the expense of removing the original vegetation cover, which contributed to the generation of land use conflicts and environmental impacts” (DE SOUZA, et al., p. 215, 2007).

In this way, there must be studies on the impacts and preservation of the original coverage as well as the water axes.

“The geo-environmental characterization of the municipality made it possible to understand the urgent need to recover the main source of water, which comprises the area at the head of the Araras stream, through the creation of a Permanent Protection Area associated with the implementation of actions aimed at its environmental rehabilitation.” (DE SOUZA, et al., p. 215, 2007).

Even with the implementation of actions for the recovery and protection of Ribeirão Araras, it is necessary to understand its entire bed, as well as the head of other springs in the municipality, from its source, passing through its head until the moment they cross the border of the municipality, because only in this way will it be possible to consider, predict and execute adequate actions for their valorization and conservation.

“Furthermore, the municipality has little explored tourist potential, adding to this the need to implement an industrial center to generate jobs, as well as properly dispose of the waste generated in the urban area. The diagnosis of the physical environment and the environmental zoning of the municipality of Piumhi make up the works developed within the scope of the municipal Master Plan (2006/2007 biennium) and were prepared with the purpose of meeting the provisions of the Statute of Cities” (DE SOUZA, et al., p. 215, 2007).

Its tourist potential can be better explored through knowledge about the axes, being reverted into tourism, and, in this way, job creation and population awareness through the dissemination of knowledge that leads to discussions with popular participation on generated waste.

The City Statute is of great value regarding urban guidelines to be followed, to mitigate impacts for the benefit of the well-being, safety, and health of the population, in addition to environmental preservation.

"The vast majority of municipalities grew and are still growing today, with their inhabitants solving the problems arising from the lack of housing and access to basic services (electricity, water, garbage disposal, and sanitary sewage) by themselves. The most immediate and evident consequences of this disorderly expansion model are directly linked to the emergence of problems related to the use of the physical environment, mainly concerning the stability of slopes and slopes, flooding in urban and rural areas, contamination of aquifers and water sources to supply the cities, and the waste of natural resources" (DE SOUZA, et al., p. 216, 2007).

Only by mapping and monitoring the municipality's water resources will we be able to manage natural resources and avoid future problems for the population arising from their misuse.

De Souza, et al., (2007), also refers to the need to minimize and/or mitigate existing problems, to order future expansions by carrying out studies that characterize the natural physical environment, with action planning and management of land use appropriate to current use, as there is what is called water stress, with the lack of freshwater mainly in large urban centers and also the decrease in water quality, mainly due to water pollution by domestic sewage and industrial.

Within sustainable development, the part dealing with the management of water resources comprises actions aimed at guaranteeing water quality standards within its conservation unit, the hydrographic basin. (DE SOUZA, et al., 2007). The concept of integrated management of water resources is currently accepted and almost all countries have some kind of "water legislation". In Brazil, it is configured by Law 9.433/97, called the Water Law, and seeks to give relevance to the need to integrate water management in terms of its different types of use, the different dimensions of knowledge that are involved, and the different types of institutions (DE SOUZA, et al., 2007).

According to these principles, the valuation of water is due to its renewable and fluid nature. Water management actions can be: preventive or corrective; punctual or distributed; and/or educational and legislative (DE SOUZA, et al., 2007).

5 METHODOLOGY

To carry out the project, surveys were carried out in the territory in question, seeking to identify the existing sources, whether they were already named or not, by consulting the Spatial Data Infrastructure (IDE) – Sisema website, inserting the city's geographic coordinates in question, which were taken by searching the Google web search engine, entering "Piumhi" in the search bar, clicking on the map that appears on the right side of the screen and copying the coordinates that appear on the screen.

After the insertion in the site, the layers of hydrography and relief are enabled for visualization of basins. You can use this data in other software through the "Import Layers" icon in the lower right corner of the screen, choose the type of map that will be used, click on "Base Map" and click on one of the five available options. It is also possible to enable subtitles, adjust the opacity of the boundary lines, download a specific layer and disable layers within the "Active Layers" icon; and demarcate something on the map through the "Drawing Tools".

On the sides of the map, there are zoom tools; start, forward, and back; distance and area meter, in addition to the search icon, used for location. In the sidebar, after expanding it by clicking on the symbol with three parallel lines, you will find "Insert coordinates"; "Manuals" (to use the tool); "Metadata"; "What is IDE-Sisema"; "What's new?"; "Common questions"; "Web Services"; and "Support".

For the elaboration of the maps with the results obtained through the geomorphological survey, the QGIS software was used. To perform the download, you need to enter the site, directly on the "Download now" tab and act like the long-term version, as it is more stable, which is "3.16". It is necessary to choose the 32-bit or 64-bit compatible option according to the computer, found in "Settings", "About", and "System type". When you click to download the version, a tab will open on the computer to confirm the action, and QGIS-OSGeo4W-3.16.13-1-Setup-x86_64 will be downloaded.

Subsequently, the federation units, municipalities of Minas Gerais, and the municipal network for the year 2020 (the latest version available on the website) of the city of Piumhi and the states of Brazil in 2020 were downloaded, made available on the Instituto Brasileiro website of Geography (IBGE). When you enter the site, you will already find, at the top, indicators such as estimated population, inflation, gross domestic product (GDP), unemployment rate, and a window with other indicators.

In the upper left corner, there are three bars, where the options Statistics, Geosciences, Panel of Indicators, Cities, and States, Our Sites, Upcoming Disclosures, and Access to Information can be found. Select Geosciences, then Environmental Information, and finally Geomorphology. On the page that appears, select "Geomorphology 1:250,000", go to the "Vectors" folder, and "Scale 250,000", in the most recent version available (at the time of execution, it was 2021); select the desired file, in this case, "Geomorphology of the area" and complete the download.

Through the website of the National Water Agency (ANA), we obtain Metadata for download, accessing the website, searching for the basin of interest, in this case, the São Francisco River Basin, the option "Watercourses" and completing the action.

It is also interesting to point out that research was carried out using data from the sources offered by the Autonomous Water and Sewage Service of the municipality - SAAE and consultation with residents of rural and urban areas for information on the existence of a source that was not possible to obtain identification from of the digital methods performed previously.

After gathering all available information, it is interesting to place all the extracted and uncompressed data in a folder, considering that only files in shapefile format (.shp) will be used to help locate points in the municipality.

When opening the installed QGIS, you need to insert the files using the vector layer tool or drag and drop the file in the layers bar that is on the left side of the screen and wait for the loading to be done.

First, you must insert the file of the municipalities of Minas Gerais and the file of watercourses. To use only the data from Piumhi, right-click, open the attribute table, press the pencil to edit, in the options select all, search for the municipality of Piumhi, select it and then click on the trash can, in this way, you

will be erasing all the rest of the map that will not be used. To save the modifications, perform the action on the layer and then right-click, and choose the rename option, in this way the geomorphology of the municipality is obtained, which will be used as a basis for the construction of the other maps.

Going to the Layout Manager tool, create a new one from the model, choose the type of map you want to use as a base, selecting the type of sheet to be used in the construction of the map, which, in this specific case, will be the A4 Portrait. To execute the action, right-click on the sheet, and go to the page properties option. A window will open in the right corner of the screen where you can enter the desired settings for the sheet to be used.

To change existing texts or add new ones, right-click on the rename option, and select the desired formatting and font, as well as the thickness. This should be done on behalf of all waterways. After this step, go to vector, geoprocessing, cut, place on the "Piumhi" overlay layer, and select the city polygon. Repeat the process at the entry of "Course of water", if you want to save, click on the three points below and select the folder of your choice, after executing this process, you must do the same with the data of the catchment area, thus obtaining the municipality and its defined geomorphology.

When the existing source on the map does not have a name, they will be described by letters and numbers according to the way we obtain this data and, later, they will be replaced by the discovered nomenclature or baptized.

To create the legend, you must use the bar located in the left corner of the screen, and you will be able to choose the name of the layers, the size of the text, the highlight, and the font. To view it on the map, go to vision, then panels, and finally items. With the caption ready, we will place the North indication on the map, through the left sidebar, insert the frame, click on the map, go to the right corner of the screen, click on the Item Properties tab, and look for the Frame option that will be deactivated It must be activated by clicking on the item to the left of the word.

A frame is added to the map, right-clicking on it and clicking on the option of the same name. Following the same path, click on grids, add a new grid and adjust the scale to be used, the font, and the scale bar that is on the left of the screen.

The added title must be placed at the top, centered and within the map frame, and in bold.

After all the steps above, the map will be created with the name of all the sources, following these steps: Within QGIS, go to the option "new print composer, add the map, add a new map to the layout". To place the appropriate worksheet, right-click on properties, choose the A4 size options, portrait, and then on view page properties and follow the steps above.

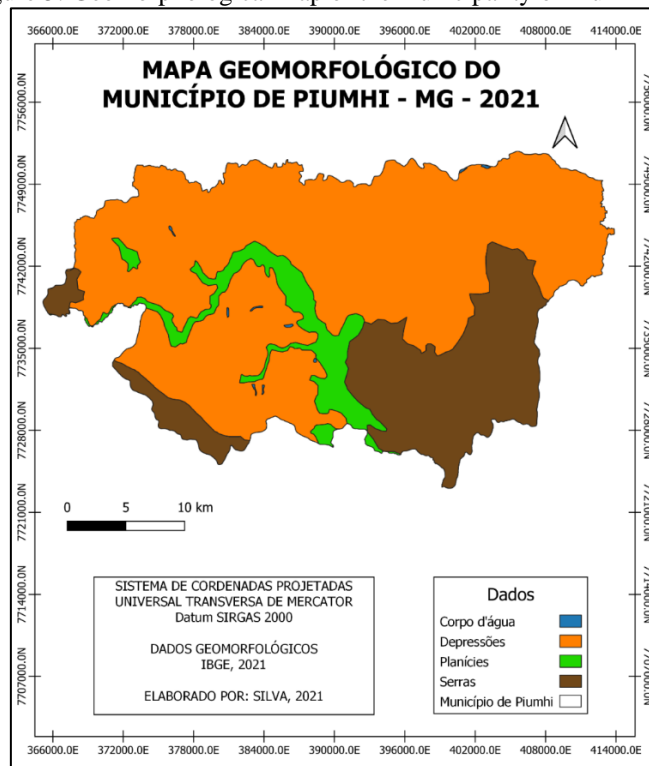
6 RESULTS

With the files extracted from the website of the Brazilian Institute of Geography and Statistics (IBGE) (2021), containing information on geomorphology, the first map was made, taking advantage of accurate and reliable data from the municipality of Piumhi, which was used through the QGIS software to

the elaboration of the cartographic work. Data were used in Shapefile formats, which were obtained through government websites and free software.

The map resulting from the data and research (Figure 5) shows the geomorphological structure of Piumhi-MG, enabling the location of water bodies, depressions, mountains, and plains present throughout the region.

Figure 5: Geomorphological map of the municipality of Piumhi-MG.



Source: Drafted by authors, 2021.

For Florenzano (2008), Geomorphology studies the relief forms, composition, that is, the soil materials, and the natural processes acting on it. This information can be complemented with the study below:

“Geomorphology is the science that studies relief. The shapes represent the spatial expression of the surface, composing the different configurations of the morphological landscape. It is its visible appearance, its configuration, that characterizes the topographic modeling of an area.”

“Relief forms are the object of Geomorphology. But if the forms exist, it is because they were sculpted by the action of a certain process or group of processes. We can define a process as a sequence of regular and continuous actions that develop in a relatively well-specified way and lead to a determined result. In this way, there is a very strong relationship between forms and processes: the study of both can be considered as the central objective of this branch of knowledge, as the fundamental characteristics of the geomorphological system. The forms, processes, and their relationships constitute the geomorphological system, which is an open system because it receives influences and also acts on other component systems of its universe” (CHRISTOFOLETTI, p.1,1980).

The studies by Girão and Corrêa (2004) say that applied research in Geomorphology involves the collection and analysis of geomorphological data, aiming at land use, feeding planning, management, and decision-making procedures about potential areas for occupation. These types of research are relevant to

Geomorphological Science since they contribute to expanding knowledge and understanding of interactive flows with the other components of the physical environmental system.

According to Florenzano (2008), through geoprocessing techniques, in addition to evaluations of subspaces or different spatial cells of all morphoclimatic and topographical domains, the use of different processing and resolutions of different interpretive qualities unfolds, which, therefore, in addition to characterizing the morphology of different regions, they present a vision of regional geocological and anthropogenetic mosaic, in addition to the arrangement of agrosystems, in addition to urban ecosystems of different categories and positions.

For Girão and Corrêa (2004), to understand the dynamics of the morphological and morphogenetic processes of the terrestrial relief, Geomorphology, being a scientific branch that is part of studies related to Physical Geography, comprises studies of the morphological aspects of topography, in the way it is considered the sculpture of topographical landscapes, to allow a better understanding of the terrestrial model, which is an element of the physical environmental system, and an important conditioning factor for human activities and consequent spatial organizations.

Florenzano (2008) points out that the earth's surface is neither flat nor uniform throughout its extension. It is characterized by elevations and depressions of different shapes that form part of the relief. These shapes can be horizontal or tabular, convex, concave, angular, and steep, which is complemented by the following information:

"The relief of the Earth's surface is the result of the interaction of the lithosphere, atmosphere, hydrosphere, and biosphere, that is, of the processes of energy and matter exchange that develop in this interface, in time and space. In space, the relief varies from the planetary scale (continents and oceans) to the continental scale (mountain ranges, plateaus, depressions, and great plains) and the local scale (scarps, hills, hills, terraces, small plains, etc.). In time, its formation varies from the geological scale to that of man" (FLORENZANO, p. 1, 2008).

The relief, for Girão and Corrêa (2004), is seen as one of the components of the natural environment, in which its faces constitute an important element for the development of civilizations, being the place of occupation and providing resources for growth, such as the development of agricultural activities in the flood plains of the Nile (Egyptian civilization) and Tigris/Euphrates (Mesopotamian civilization). The authors also say that the relief is of great importance for the growth of contemporary society, as it serves as a basis for the expansion of human action over space, occupying new areas for the creation of housing, establishments, access roads, and planting areas. and/or creation.

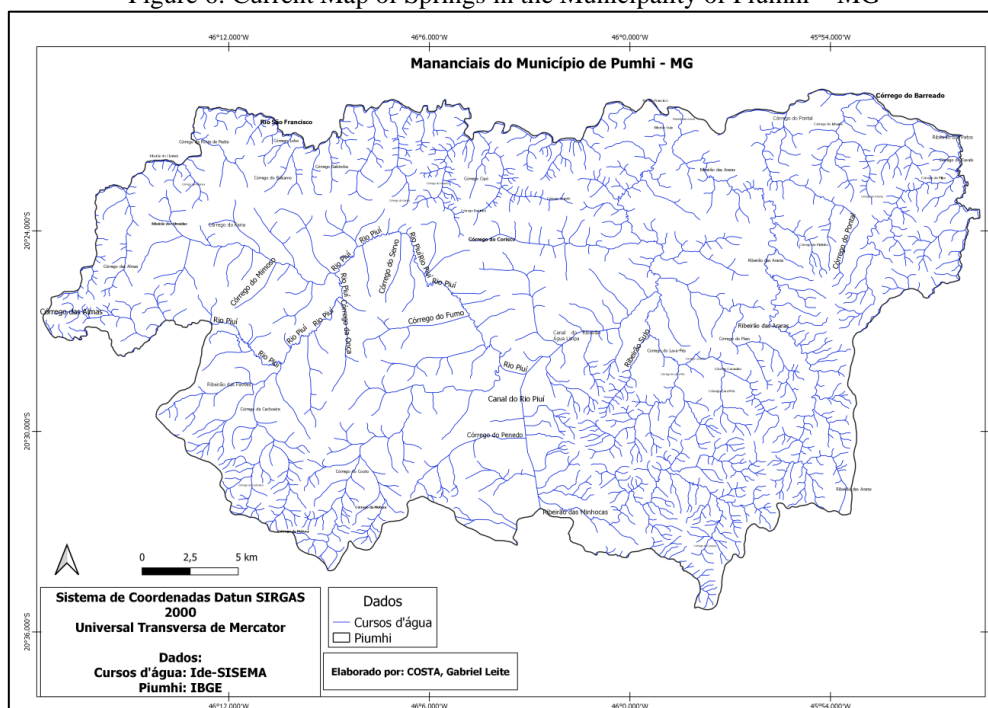
For Florenzano (2008), the importance of relief analysis is not only for Geomorphology but also for Earth sciences that study its surface through its components, such as rocks, soils, vegetation, and water (a point of extreme importance in the present study); the definition of the fragility and vulnerability of the environment results in the creation of occupation and protection laws. It can hinder or favor the occupation of the relief by man depending on its characteristics, as it can be an obstacle to its use in addition to making

construction more difficult and expensive. On the other hand, the relief and the rivers can serve as a delimitation between cities, states, and countries.

For the execution of the water map, data from watercourses in the municipality were used, taken from the website of the National Water Agency (ANA), the Spatial Data Infrastructure of the State System of Environment and Water Resources of Minas Gerais (Ide- SISEMA), from the Autonomous Water and Sewage Service (SAAE) of Piumhi, as these institutions have quality and accuracy in information and provide information in shapefile format (.shp), which is used in the QGIS software, which is free and a reference when it is about the execution of geoprocessing maps, remote sensing, cartography, etc.

The Springs Map (Figure 6) shows all watercourses in Piumhi. With this data in hand, it was possible to identify the location, length, and route of each bed and, in this way, contribute to future studies by researchers, work by professionals in the area, and preservation by residents and competent bodies.

Figure 6: Current Map of Springs in the Municipality of Piumhi – MG



Source: Drafted by authors, 2021.

Despite the help of several sources and robust data, which will serve as a basis for future studies to be carried out by the city's administrative institutions, study institutions, and non-governmental organizations (NGOs), the maps do not have the name of all the courses due to the period in which the work was carried out, as it was a pandemic, there was no possibility of physical contact between project members, field visits and we had disease prevention measures being taken to make it difficult even more the whole work.

According to Tundisi (2009), the water crisis currently has many components of social, economic, and environmental origin, the main ones being excessive use, increased demand, sectorial management,

and a lot of focus on quantity. In addition to these, water contamination, eutrophication, and changes in the water cycle as a result of global changes can be mentioned.

Borsoi and Torres (1997) say that water scarcity impedes the development of several regions, but it is also seen as an environmental resource, as water changes can result in the degradation of environmental quality. Directly or indirectly, this environmental degradation affects the health, safety, and well-being of the population, social and economic activities, fauna and flora, aesthetic and sanitary conditions, as well as the quality of environmental resources.

Tundisi (2009) also says that if you think about the long term, as a solution to the problems mentioned above and planning and management strategies, the relevant programs and approaches can be: Integrated management action for the watershed, planning and scientific research; Advanced system of governance of hydrographic basins with the support of the population that makes use of it with the public and private sectors; Studies on water, economy and energy in metropolitan areas; Structure of international cooperation between shared international basins; Economic evaluation of water resources (surface and underground water, rivers, lakes, and dams); and Training programs with an integrated, predictive, technical and technological approach.

For Moraes and Jordão (2002), few regions in the world do not have problems with lost freshwater sources, with a decrease in water quality and source pollution. There are even more serious problems that affect the water quality of rivers and lakes that occur in different situations and range from inadequately treated domestic sewage, inadequate control of industrial effluents, loss, and destruction of catchment basins, authorization of industrial units in inappropriate locations, deforestation, uncontrolled agriculture, and poor agricultural practices, not to mention the damage to aquatic ecosystems.

Brazilian energy production, from the perspective of Tundisi (2009), is dependent on the availability of water resources, as 50% of the country's energy matrix depends on it. Its transport depends on energy for pumping, which increases costs.

According to the World Bank (1994) apud Borsoi and Torres (1997), the economic activity that consumes the most water is agricultural irrigation, using 69% of the available water against 23% of industries and 8% of residences. In the case of developing countries, such as Brazil, this number is even higher, reaching 80% of the water used by agriculture.

According to Tundisi (2009), Brazil has an unequal distribution of volume and availability of water resources, despite having 14% of the planet's water and this disparity results in economic and social problems, even more so when the availability equation is analyzed. by the demand and health of the peripheral population of large cities, one of the main problems of this century. Basic sanitation, sewage treatment, and recovery of infrastructure and water sources are priorities, as well as advancing the management of water resources through consolidated decentralization and government policies to address watersheds.

Borsoi and Torres (1997) say that water consumption can result in losses. It is the difference between the volume of water taken from the water body to be used by the volume returned after use. Discounting losses through the distribution network, in urban supply, this type of use is around 10%, while in industrial around 20%, and irrigation, around 90% is used. In electric energy generation, the loss considered is only due to evaporation.

7 CONCLUDING REMARKS

The work obtained a satisfactory result concerning both the water resources map and the geomorphology map of the entire extension of the municipality of Piumhi.

The geomorphological map made it possible to understand the structure of the region and analyze the relief, showing in detail the present structure and its exact location. It was possible to analyze large existing slopes and, as it is a region where agriculture is practiced, care with the location of plantations close to water courses must be doubled, so as not to occur contamination of the water table or water courses with the use of pesticides and compromising the springs in all their extension.

With the map of springs, showing the names of the water courses in the municipality, there is a scientific basis to assist in various projects by the city hall, educational institutions, and the population itself, as it shows in great detail the exact region where each watercourse is located, which facilitates the real verification of the area.

These maps will be able to help in several others that may be to come, such as, for example, pedological, geomorphological, hypsometric, land use and occupation, and several others that can be made as more data and information about the area are registered and academic works are produced about it, to have more and more complete information in the collection.

For professionals, students, researchers, residents, or tourists who wish to contribute to the region, the maps will serve as a method of locating quickly and accurately.

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