

## ACTIVE SPRINGS USED FOR WATER SUPPLY IN THE STATE OF PERNAMBUCO

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### Abstract

World's fresh water can be found as groundwater (29.9%) and surface water (0.3%) sources. The exploitable portion of these sources is about 200.000 km<sup>3</sup> - 0.01% from the world's water. The surface water resources generated in Brazil represent 11% from world resource. However, in order to consume water there must be some basic needs that have to be attended. Some limitations in terms of its components. The Brazilian law responsible for water potability standards is Ordinance MS n° 518/2004 and CONAMA Resolution n° 357/2005. Thus, to know water characteristics is relevant to maintain good life quality. The State of Pernambuco has about 185 municipal districts, being 171 and the archipelago of Fernando de Noronha supplied with water by COMPESA. This paper aimed to identify and locate the springs used by COMPESA as water supply. GIS techniques allied to the attributes from those springs were used to compose thematic maps.

**KEYWORDS:** Water Demand, Surface Springs, Geographical Information System.

### Introduction

According to Barros (1995), spring is a portion of world's water used more easily to human consumption. It is a really small portion and because of that the water resources' preservation is essential to guarantee the water consumed by the populations and the springs can be divided in three big groups: surface water, groundwater and rainfalls.

Water is a limited and scarce natural resource with high economic value and it is public domain (Federal Law n° 9.433, 1997). Globally talking, the fresh water sources are unevenly distributed and the pollution generated by human activities is compromising the ones that are still preserved (Sirigate et al., 2005).

As the most abundant substance in the biosphere, it is distributed in the states: solid, liquid and gas. It is found in oceans, rivers and lakes, polar caps and glacier-free areas, air and subsoil. Oceans water represents approximately 97% from the available world's water. From the remaining part, about 2.4% are ice formations and atmosphere. The fresh water represents 0.6% and it is distributed as 97% groundwater and 5% surface water. The portion of water resources available is the smallest of them all: 0.3% from the fresh water is found in soil, the rest is below 800 m deep and, virtually, it is not accessible for consumption (Philippi Jr. et al., 2004).

It is one of the natural resources most used by humankind, not only for their needs, but also for various other purposes, such as animal watering, irrigation, industry, electric energy generation, environmental preservation, landscaping, leisure, navigation. In fact, water supply in adequate quantity and quality for a city is crucial to disease control and preservation, to guarantee comfort and to the social-

economic development. On the other hand, the use of water as supply also brings, as consequences, increased wastewater production, resulting in numerous impacts on the natural environment (Teixeira, 2004).

Thereby, potable water becomes a less abundant resource and with its quality compromised as a result of increasing deforestation, erosion processes and springs siltation, effluent discharges and industrial and domestic waste. Consequently, preoccupation towards the public water supply, when talking about quantity and quality, is increasing (Brasil, 2006b).

The water availability is directly related to the way mankind has been using this natural resource. Studies show that XXI century will be marked by conflicts caused by its scarcity and that approximately 45% from the global population will be affected by lack of water (Barros, 1995).

The problems of water stress in Brazil are due to, mainly, the combination of the overgrowing localized demands and water degradation. This is a consequence of urbanization, industrialization and agricultural expansion (Setti et al., 2001).

The contribution of domestic, agropastoral and industrial sewage - without adequate treatment - discharged in water bodies and the erosion caused by improper maintenance of riparians are two of the main causes of physical, chemical and biological characteristics changes of rivers and lakes, particularly when dealing with springs used for public water supply (Sirigate et al., 2005).

According to information from "The Global Water Supply and Sanitation Assessment 2000" report, launched by the World Health Organization (WHO) and the United Nations Children's Fund (UNICEF), nowadays 2.4 billion people from world's population do not have acceptable sanitation conditions and other 1.1 billion people do not have access to a proper water supply. Also according to this report, in developing countries this situation also occurs where approximately a quarter from the 4.8 billion people do not have access to adequate sources and half of this total do not have access to proper water services (OPAS, 2001).

Most of the water used for public water supply in the State of Pernambuco comes from reservoirs (ponds). Many of its rivers, which run along urban areas, are found at high degradation process, absorbing a large amount of pollutants. These pollutants are carried to these reservoirs compromising water quality to public supply (Melo, 2007).

As reported by the Ordinance 518/2004 from the Ministry of Health, the water supply system to human consumption is defined as "the installation consisting of a set of civil works, material and equipments, for production and piped distribution of potable water to population, under the responsibility of the government, even if given under concession or permission". Thus ensuring a greater security to population and providing infrastructure, giving priority to overcome health risks posed by water is of fundamental importance.

When the surface springs are used to public water supply and become a part of a collection system, one should carefully examine all the elements related to minimum water quality (Gasparini, 2001).

Ergo management of springs used for public water supply is a necessity. Once contaminated, these springs can affect the water treatment process and, consequently, offer health risks to the supplied population. Uma vez contaminados, estes mananciais podem prejudicar o processo de tratamento da água e, conseqüentemente, oferecer riscos à saúde da população abastecida. The wastes are likely to accumulate in human tissues and cause illnesses such as cancer, also increasing the cost of the treatment process (Sirigate et al., 2005).

Geoprocessing, according to Silva (2007), is primarily intended to transform data in information, with the aid of environmental phenomena perception structures which provide the transformation of georeferenced data into information.

GIS is a methodology which enables the perform of complex spatial analysis, for it permits data integration from multiple sources, handling great amount of data and rapid retrieval of stored information, making it an essential tool for the manipulation of spatial information (Brasil, 2006). For environmental research, GIS associated to Geoprocessing techniques has contributed as a subsidy for environmental managers and can be used as a repository of an inventory to effectively manage the resources potential, protect them against predatory activities and model the complex interactions between the phenomena that make it possible to make provisions, enabling a more complete and efficient decision-making (Silva, 2003; Marques et al., 2011).

Lopes; Loch (1992) stress the importance and the value of satellite images for updating thematic maps, given the repetitiveness of the image, the possibilities to obtain images with different spectral resolutions and improvement in precision.

In accordance with Lopes, Loch; Bahr (2004), results of a research presented in graphical forms and thematic maps, makes the information more impacting and stimulate a positive reaction in the administrator, encouraging him to provide the solutions more quickly.

Thus, it was aimed with this work to identify and locate the active springs used by Pernambuco Sanitation Company (COMPESA) for water supply in the State of Pernambuco and evaluate the necessity of a new spring or expansion of the system to supply the demand for 2015, as stated in *Atlas Brazil* from National Water Agency (ANA).

## Methodology

### Study Area

The study area (Figure 1) comprises the State of Pernambuco, located in the Northeast region of Brazil, between the coordinates 7° 0' 00" S and 10° 0' 00" S and 34° 0' 00" W and 42° 0' 00" W, with an area of 98.311 km<sup>2</sup>.

Pernambuco has a narrow spatial configuration North-South, presenting a coastline of just 187 km long. It extends itself considerably in East-West direction reaching 784 km long. This West projection locates about 80% of its territory in semi-arid region, where scarce and irregular rainfalls lead to droughts phenomena, periodically (CONDEPE/FIDEM, 2005).

As a result of this longitudinal configuration, Pernambuco has, from seaside to countryside, a succession of landscapes and changes in the organization of the space. Therefore Brazilian Institute of Geography and Statistics (IBGE) has divided the territory into three physiographic regions: Litoral-Mata (11%), Agreste (19%) and Sertão (70%).

The mean temperatures values range from 20 to 27° C. The highest values occur in the Sertão region, along the São Francisco Valley, where the annual mean temperature is around 26° C (SECTMA, 2006). The rainfalls are unevenly distributed, being more abundant on the seaside, reducing as they go to the West. Rainfall pattern has direct influence on the State water system, since all the Rivers depend directly on the distribution and intensity of the rains. (CONDEPE/FIDEM, 2005).

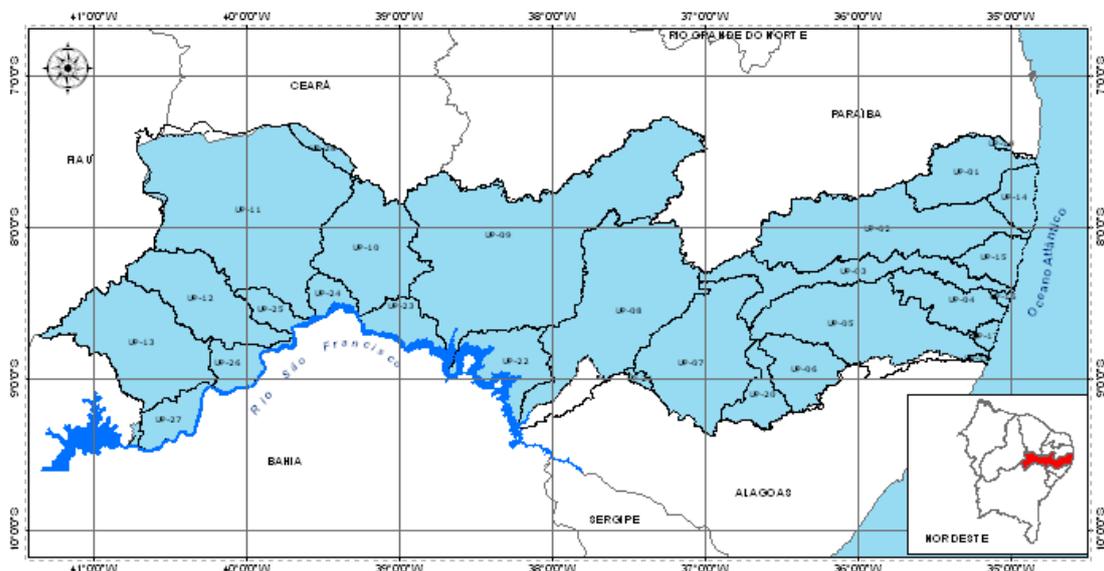


Figure 1. Location of the study area.

### Data Collection

The data collection involved collection of geographic coordinates of active springs used for water supply in the State of Pernambuco provided by COMPESA and thematic maps presented in *Atlas Brazil* from ANA. The generated maps were compared to those in *Atlas Brazil*, in order to obtain a general perspective of the active springs' situation nowadays and up to the year of 2015.

### Data Geoprocessing

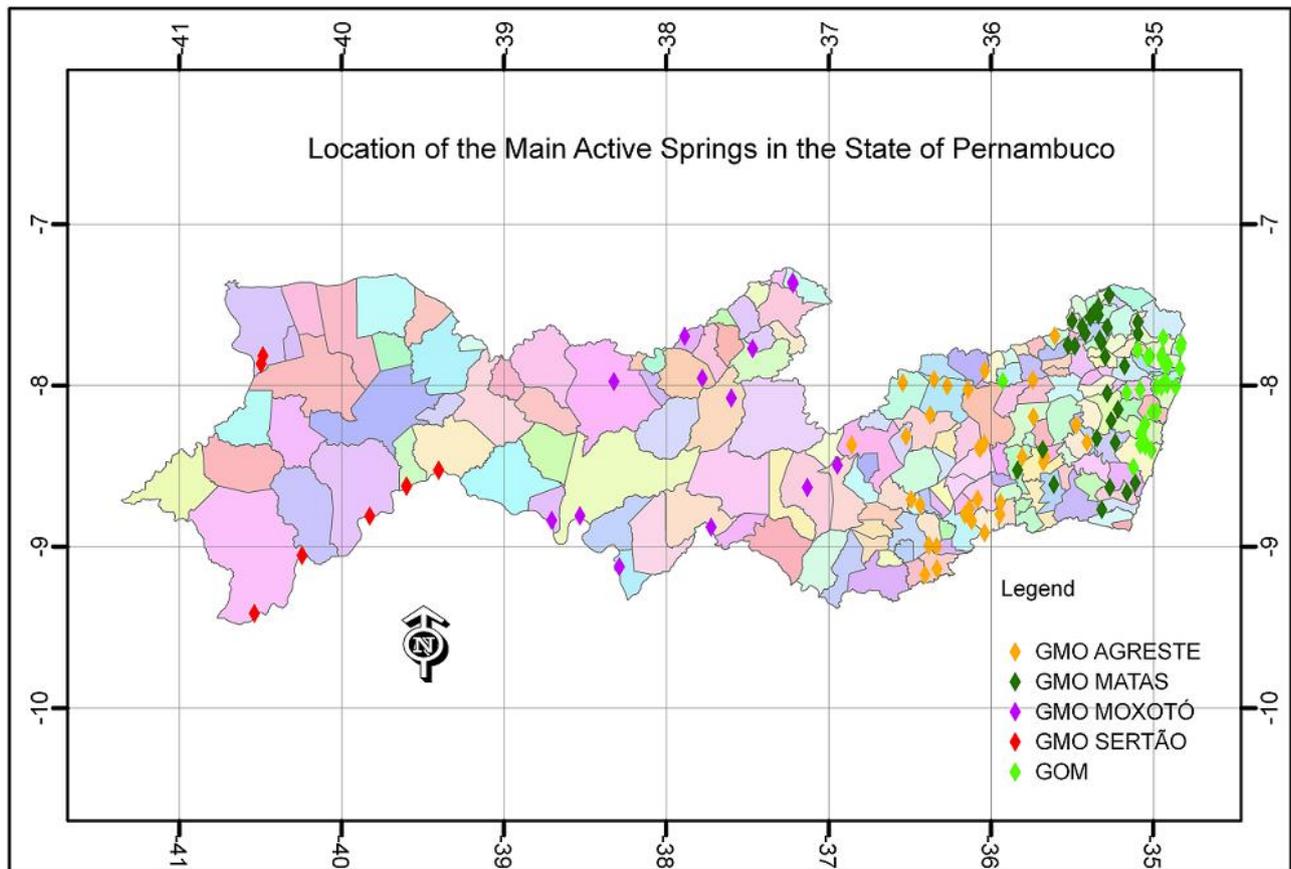
GIS has the function of integrate spatial information from georeferenced data of various sources in only one data base. Therefore, the combination of that information is possible, through crossings and overlays to generate derived maps, reproducing, visualizing and plotting geocoded data.

In order to generate de thematic maps, a geodatabase was created using the ArcGIS 9.1 software, available at GeoLab (Geotechnology Laboratory) at Federal Rural University of Pernambuco. It was adopted the cartographic projection system UTM, Datum WGS-1984 (Zone 24S).

### Results and Discussion

There are 401 active springs in the State of Pernambuco, according to COMPESA data. However, they provided geographic coordinates of 190 springs. These springs were plotted in three different thematic

maps, being analyzed under three aspects (municipal, hydrographic and drainage network division), and described in figures 2, 3, and 4, respectively. They were grouped according to their regional management as GMO AGRESTE, GMO MATAS, GMO MOXOTÓ, GMO SERTÃO e GOM.



**Figure 2.** Location of the main active springs in the State of Pernambuco, conforming to Municipal division. GMO (Maintenance and Operation Management); GOM (Metropolitan Operation Management).

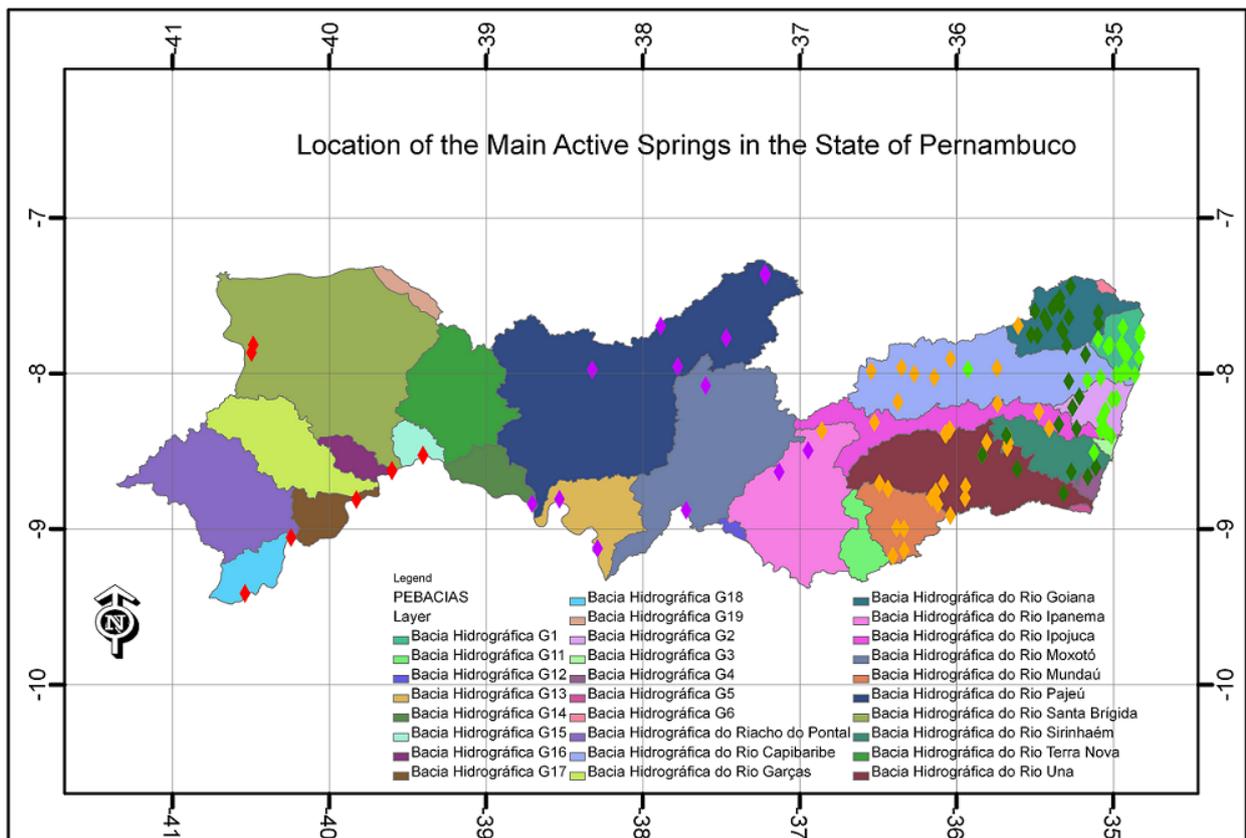
Through figure 2, it can be depicted that the active springs accumulate in the Litoral-Mata region. The greater population density in this region, and hence the greater water demand, requires a bigger number of springs, justifying this behavior. As stated in *Atlas Brazil* (ANA, 2010) Recife Metropolitan Region (RMR), constituted of 14 municipalities, corresponds to 51% of the urban population of Pernambuco.

As one moves from east to west, the number of springs reduces, due to the fact that the West region of Pernambuco is semiarid. In accordance with Garjulli (2003), semiarid region is characterized, mainly, by the lack of water, due to rainfall incidence just in short periods (from three to five months per year), unevenly distributed in time and space, highlighting the difficulties that this region faces regarding water.

More than 83% of the municipalities covered in the *Atlas Brazil* (ANA, 2010) are exclusively supplied by water from surface springs. In the coastal region, small perennial rivers are used to supply many cities. São Francisco River is the main source for water supply in Sertão region, since it has a small number of active springs. Na região litorânea, são utilizados pequenos rios perenes para o abastecimento de diversas cidades.

Pernambuco is characterized by the predominance of low hydrogeological activity lands, having more than 80% of its territory on the crystalline shield. Therefore, only 9% of the urban areas are supplied by groundwater and 8% by mixed systems (ANA, 2010), since the drilling methodology is time consuming and costly. According to Costa (1995), 20% of the RMR required demand comes from groundwater sources.

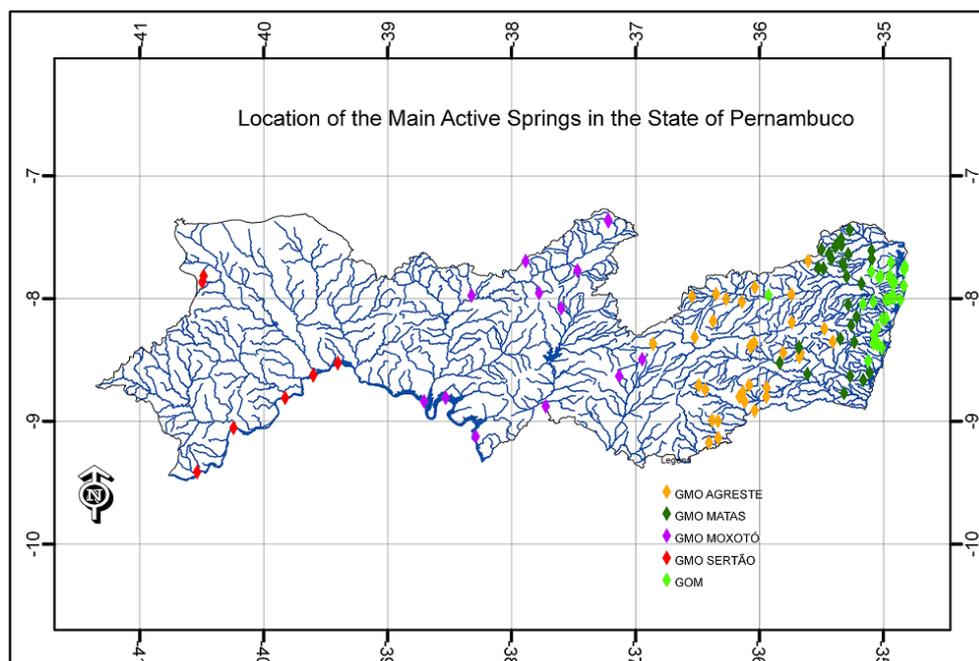
According to figure 3, eight watersheds do not have active springs used by COMPESA to water supply. Five of those watersheds are located at the semiarid region of the State, reinforcing the difficulty in obtaining water for public water supply.



**Figure 3.** Location of the main active springs in the State of Pernambuco, conforming to hydrographic division.

In figure 4, it can be verified the spatial distribution of the springs in the State of Pernambuco and their relation to drainage network. Also, it is depicted that most of the sources used for water supply are surface springs, reiterating the great dependence of this kind of source to human use.

It is noteworthy that most of the sources used in semiarid region are from São Francisco River. It is a stream of huge importance to Northeast population. Many agricultural activities are viable in this region due to its water uptake, improving significantly the social condition in the areas around the river. As reported by Pereira (2007), besides irrigation, São Francisco River has its hydroelectrical potential widely used, with many hydroelectric plants installed along the watershed.



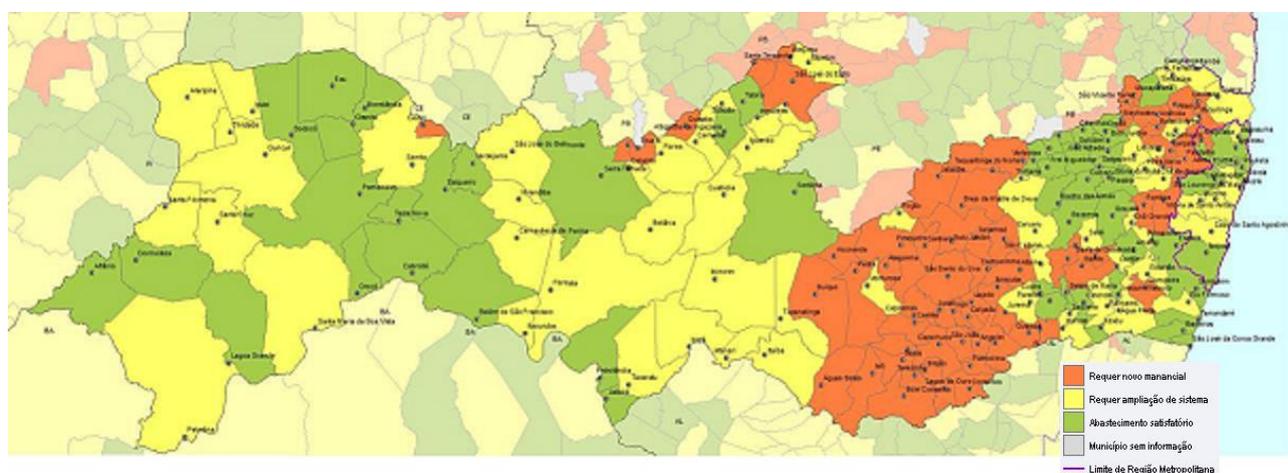
**Figure 4.** Location of the main active springs in the State of Pernambuco, conforming to drainage network division.

As reported by *Atlas Brazil* (ANA, 2010), the diagnosis presented in figure 5 aims to verify the springs and the water production systems situation regarding the meeting of the future water demands. When the spring and the production system showed conditions to attend the urban demands until the year of 2015, the water supply to the municipality was considered satisfactory (green). On the other hand, when the balance between the supply and the demand was negative (deficit), it was identified the necessity of investments in projects for the exploitation of new springs (orange) or the adequacy of existing systems (yellow).

Also according to the same *Atlas*, only 52 municipalities (28% of all municipalities) have shown satisfactory supply conditions to attend future demands. For the others, the planning of projects in water supply results in total investments of R\$ 2.4 billion. It is noteworthy that the Litoral-Mata region shows satisfactory supply in more municipalities and, on the contrary, Sertão region shows the need to expand the public water supply system.

For 81 municipalities were proposed connections to integrated systems, due to the presence of many regions with low or no water guarantee, what leads to the predominant construction of great aqueduct systems. It was predicted the adoption of a new spring in 23 municipalities, according to the vulnerabilities related to surface water availability. For 29 municipalities, it was proposed to adequate/expand the existing system, being 25 of them supplied by isolated systems and 4 by integrated systems (ANA, 2010).

In addition, GIS have shown an important role to evaluate these characteristics for that it is a reliable tool and its results are obtained faster than the usual ones.



**Figure 5.** Diagnosis 2015 – Need of Investments.

## Conclusions

- ✓ The use of surface springs remains the most usual form of water supply in the State of Pernambuco;
- ✓ Semi-arid region presents the greatest deficiency in water supply because the number of spring is not enough;
- ✓ In the State of Pernambuco, water supply from groundwater is less comprehensive, though it can an excellent alternative to Sertão region;
- ✓ Future investments and adoption of new springs are needed since the water demand increases with the increase of population;
- ✓ GIS can be used to identify and locate springs and their relation to hydrogeological characteristics.

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