ABSTRACT

With the economic development and prosperity, use of water resources has diversified and has also intensified specific demands that can cause conflicts among users. The terms river basin and sub-basins are subdivisions that allow to point out diffuse problems, making easier the identification of natural resource degradation areas. Environmental insight along with geoenvironmental analysis allow a systemic view of the river basin dynamics. This paper aims to shed light to future actions in planning and management of water resources and to present geoenvironmental insight reviews in Parauna River’s sub-basin, a tributary of the São Francisco River in the state of Sergipe. The methodology used includes bibliographic review, delineation and characterization of the sub-basin through the use of Geographic Information System, data research in governmental bodies, on-site visit for application of questionnaires, technical visits along the main river channel and drainage area of the sub-basin. The geoenvironmental analysis, based upon a systemic view of the landscape, allowed the identification of the main problems related to water resources management in Parauna River’s sub-basin, such as the absence of riparian vegetation; the occurrence of erosive processes; the lack of water resources management plans and projects; pollution and contamination of surface and groundwater sources; the improper disposal of solid waste; the inefficiency of the water resources management tools (charging for water use); the non-existent treatment of domestic wastewater; waterborne diseases and irregular occupation in Permanent Preservation Areas. The river banks have been under strong anthropic pressure, and a larger study regarding the implementation of permanent preservation areas is needed in order to enable conservation of ecological diversity and functionality of riparian vegetation. The implementation of planning and water management tools suggests a classification of the water bodies and charging for water use.

Keywords: river basin, water resources, geoenvironmental analysis.
1. INTRODUCTION

With the economic development and prosperity, use of water resources has diversified and has also intensified specific demands, such as urban water supply, what could result in conflicts among users. Thus, to prevent and manage potential conflicts, managing the use, control and conservation of water resources is necessary. [1].

River basins are characterized for draining away water, dissolved material, and sediments and for conducting to a specific point of a channel, constituting natural catchment areas of precipitation water, formed by a set of slope surfaces and a drainage network generated by watercourses converging the superficial water flow into a single exit point [1]. Its delimitation is defined from its river basin, corresponding to the hilltop [2].

River basins can be categorized according to a hierarchical order, so if a river is tributary of a main watercourse, its drainage area will be called a river basin. Therefore, the terms basin and sub-basins are subdivisions that allow to point out diffuse problems, making it easier to identify natural resource degradation spots, the kind of environmental degradation processes installed and the commitment level existing sustainable production [3].

In this identification context of environmental dynamics of a sub-basin, geoenvironmental analysis can be employed as a tool for systemic understanding of geo-environmental processes, as part of the delimitation principle of the area, it contributes to the sustainable management of natural resources. According to Souza (2005) geoenvironmental analysis is an integrative concept that comes from the unified study of natural conditions and that leads to a perception of the environment where humans and other living beings coexist.

The sub-basin of Parauna River, a tributary of the São Francisco River, is located in the state of Sergipe, inserted in the municipalities of Brejo Grande and Ilha das Flores. This research is justified because the Parauna River has undergone considerable changes over the years, in the composition of its native vegetation, which alters the environmental dynamics of the area, as well as being used as a source of water abstraction for human consumption, and in its bed and its tributaries are the launching of domestic effluents in natura.

2. OBJECTIVE

Environmental perception coupled with geoenvironmental analysis extends the systemic view of the dynamics of a river basin. The perception analysis brings the judgment of individuals who use water resources, allowing to understand the human-environment relationship. Considering the importance of these aspects, this paper has as objective to contribute to future actions in planning and management of water resources, presenting geoenvironmental and environmental perception assessments in Parauna river’s basin, tributary of the São Francisco river in the state of Sergipe.

3. METHODS AND MATERIALS

This study’s methodology consists on applied research and practical application addressed to the solution of specific problems, involving local truths and interests. From this point of view, the approach will be through quantitative research, translating information into numbers, classifying and analyzing them; and qualitatively, through interviews in the area. As for the objectives, this research can be classified as exploratory with definition of hypotheses and involving bibliographic research; it can also be classified as descriptive establishing relationships between variables. Taking into account the technical procedures, this research is classified as bibliographic and empirical.

The methodology applied was developed in stages, as follows: a) bibliographic review; b) delineation and characterization of the sub-basin by using the Geographic Information System; c) Data Consultation at government agencies and systematization of information: Instituto Nacional de Colonização e Reforma Agrária (INCRA), Secretaria de Estado do Meio Ambiente e Recursos Hídricos de Sergipe (SEMARH), and Companhia de Desenvolvimento dos Vales do São Francisco e Parnaíba (CODEVASF); d) application of questionnaires to identify the population’s environmental perception; e) technical visits by the main river channel and in the sub-basin’s drainage area.

3.1 Characteristics of the study area

The Parauna river’s sub-basin is located far in the northeast of Sergipe state, amid the lower course of São Francisco River’s basin, in the municipalities of Brejo Grande and Ilha das Flores.

Although the two municipalities contribute to the drainage, the highest concentration of sub-basins lies in Brejo Grande, 92.6%, while Ilha das Flores contributed with 1.55% of its territory. The sub-basin’s central coordinate is UTM 777181/8842976.

The municipality of Brejo Grande is located approximately 113 km of capital of Sergipe, Aracaju, and Ilha das Flores is 109 km from this capital. The main access to study areas, from Aracaju, is by BR 101 north, heading to Maceio and also
SE-335. There is also access through the state highways SE-100, SE-439 and SE-204. It is possible to go through SE-100 as well, though there is an unpaved passage near the municipality of Pirambu.

Brejão dos Negros is the largest village of Brejo Grande, its access, through the headquarters of this municipality is a 4km route on SE-200 and following on SE-204 shortly after, to the left. The Village is a Remnant Quilombo Community. Its territory is located in the municipalities of Brejo Grande and Pacatuba. The perimeter covers the main mills, islands, rivers, lakes and wetlands existing in the municipality of Brejo Grande. [4]

Parauna River is tributary of the São Francisco River in Sergipe’s lower course, to delimit its sub-basin, physical characteristics of the watershed, such as the flow of the water flow were used, obtained through the Digital Elevation Model (DEM) of the Low São Francisco available on the Digital Atlas of Sergipe’s Water Resources.[5]

In order to mark out the regional mapping, publications from the Mineral Resources Research Company (CPRM) were consulted, year 1997, scale 1: 250,000, geomorphological units, from Japan International Cooperation Agency’s work, 2000, scale 1 : 500,000, mappings made by the Department of Water Resources of Sergipe, 2012, as well as cartographic base of Sergipe’s municipalities available by Seplantec.

The sub-basin’s delimitation will facilitate the planning and managements of water resources by monitoring the characteristics of this territorial unit. Thus, in order to mark out all actions taken in this study, an “automatic”river basin delimitation methodology was employed. MDE data were used, provided by Sergipe’s Water Resources Superintendence (2012), and processed in Geographic Information System (GIS) using ArcGIS 10.1 software.

In this way, automation of river basin’s delimitation through GIS practices had become quite consistent and advantageous in relation to the coastal basin under study, which does not present significant variations in altitude, a fact that limits the delimitation of its topographic divisors by contour line analysis.

The methodology for delimiting Parauna river’s basin can be subdivided into seven stages: Filling the depressions; mapping the flow direction; cumulative flow; length of the stream; order of watercourses; conditional condition, and finally, delimiting basins.

The delimitation of Parauna river’s sub-basin (Figure 1) once performed allowed the identification of geological, geomorphological, soil, water resources, land use and occupation features, as well as identification of municipalities inserted in the basin and its social and economic aspects.

Figure 1. Sub-basin of the Paraunariver, tributary of the São Francisco River.
The area studied has 30.88 km² of territorial extension, with 0.44 km² in the territory of Ilha das Flores and 30.44 km² in Brejo Grande. The municipality of Brejo Grande contributes with the largest drainage basin area, 98.57%.

3.1.1 Climate

The climate of the area studied is characterized as tropical humid with an average temperature of 25 °C, precipitation ranging from 1200 to 2000 mm/year.

In this region occurs a distinct change in annual rainfall distribution, due to the proximity to the ocean, which are distributed throughout the year, although more concentrated in the fall and winter. The main rainfall in this region occurs from March to September [6].

3.1.2 Regional Geology

Parauna river’s basin is located over Cenozoic Superficial Coverages, which cover the eastern edge of Sergipe’s grounding - Faixa de Dobramento Sergipana (FDS).

The Meso / Neoproterozoic grounding of FDS corresponds to structures produced by the convergence processes in active margins of tectonic plates, that is, the Brazilian / Pan-African collages. The subdivision of this range follows criteria set by Davison and Santos (1989), delineated according to major structural discontinuities and distinct geologic features, with general direction NNE. They are: Domínio Estância, Domínio Vaza-Barris, Domínio Macururé, Domínio Marancó, Domínio Poço Redondo e Domínio Canindé.

3.1.3 Local Geology

In the basin’s area, it is possible to detect quaternary sedimentary covers, represented by fluvial-lagunar and littoral (coastal or wind) deposits. Exposure of quaternary fluvial-lagunar lithotipes is observed due to the performance of Paraunariver and its tributaries.

The fluvial-lagunar deposits, occupy 22.99 km² of the area studied, these deposits occur associated with topographic lowlands occupied, sometimes by the waters from the region’s water resources. The typical sedimentation of this region may be associated with deposits of marginal dams, meander bars and aborted channel (Alves, 2010). It is worth noting the progressive nature of these deposits into the sea creating several wavy and parallel structures among themselves, characterized as ridges.

The coastal deposits that occupy 6.03 km² of the basin are deposits that are arranged throughout the deltaic coast of São Francisco River, including two generations of dunes, the first being innermost from Pleistocene age and stabilized by vegetation, the second of Holocene age occurs outermost developing rapidly, occasionally covering part of the first. Generally the second generation of dunes occurs more significantly in the deltaic coast, state of Alagoas, and a sharp mangrove clogging process located downstream of this system can be noted.

3.1.4 Geomorphology

To better understand the geomorphological modeling of a given coastal region, you have to take into account the relationship between the geosphere’s three main provinces: the ocean, the continent and the atmosphere. Based upon this relationship, the coastal area receives different streams of matter and energy that will directly influence the origin, evolution and current configuration of these environments.

As a response to interrelationship of the three provinces, the deltaic region of the São Francisco river, and therefore Parauna river’s sub-basin, is characterized as deltaic progradational system, which relates eight evolutionary stages,
taking into account only the sea level’s variation for the formation of deposits (Dominguez, Bittencourt & Martin, 1981). This classic model of coast moves towards the ocean as a consequence of sedimentation. The fluvial plains occupy protected portions under influence of the tide, like Parauna river’s flood plain. In protected areas, under influence of the tide, mangroves are found in full development with substrate consisting predominantly of silty-clay materials rich in organic matter.

3.1.5 Pedology

Soils have specific characteristics that distinguish them from other elements of nature and it is these attributes as well as the processes and mechanisms originating soils that constitute Pedology. The origin of the soil is in “the atmosphere and biosphere actions on lithosphere” or what is conceptually known as intemperism, “which causes changes in the geological substrate, originating to the soil” [8]. The factors involved in these processes are linked to climate (rainfall, temperature, humidity), the organisms (flora and fauna), the source material (resulting from the underlying rock intemperism or transported from another location), the relief (acts on the soil water dynamics) and the time (degree of evolution or development of horizons). All these factors act simultaneously, but alternating the intensity of their performances. [9].

The Brazilian System of Soil Classification (SiBCS) defines soil as a collection of natural bodies consisting of solid, liquid and gaseous, three-dimensional, dynamic parts, composed of mineral and organic materials which occupy most of the surface mantle of our planet, contain living matter and can be vegetated in nature where occurs and, eventually, having been modified by human interference [10].

This system began to be structured in 1979 and its new version, from 2006 brings significant changes and expands some soils class definitions, such as the Nitosols, Ultisols, Neosols, Spodosols and Planosols. Based on this system, and Sergipe’s Pedologic Distribution Map (SEMARH, 2012), it is possible to address the classification and description of soil units present in Parauna river’s sub-basin.

The Spodosols are soils composed of mineral material, developed mainly from arenquartzosos materials, under high humidity conditions, and in the regions of tropical and subtropical climate. This type of soil is present on the western boundary of the sub-basin and has as characteristic low fertility, moderate to high acidity, and there may be high levels of aluminum [10].

The Gleysols are hydromorphic soils composed mostly by quartzitic mineral material with saturation through natural flow, or sometimes by capillary rise. Usually this system is associated with recent sediments in the surroundings of water bodies, and colluvial-alluvial material subject to hydromorphic conditions [9].

3.1.6 Physiographic Features

Parauna river’s sub-basin is characterized by a low drainage density, enhanced by sandy formation of its substrate which guarantees a good permeability rate of its sediments. It is still possible to identify the little sinuosity of these water resources, with the presence of some meanders. The presence of water resources associated with low-lying topographic areas inserted among the intersandy ridges formed by deltaic formation of São Francisco river.

The drainage density is expressed by the ratio between the total length of all water courses of the river basin (ephemeral, intermittent or perennial) and its total area. The area studied has a low drainage density, 1.03 km / km², given that below 5 indicate that feature.

The length of the six perennial water courses that make up the sub-basin and the stream’s order obtained through the hierarchical ordering of rivers by Strahler method. The Parauna River presented, by that method, order 3, which indicates a sub-basin with little ramification and consequently slightly irregular relief.

After delimiting the contour of Parauna river’s basin, it was possible through a sand dispersion show a consolidated format in 2D. It is evident that this shape can be attributed to runoff, or being intimately related to the basin’s hydrology.

In order to determine the basin’s shape, some indices were used, which attempt to relate it to known geometric shapes, like a circle. Compactness coefficient were calculated (Kc) and the form factor (Kf).

In general, the lower the Kc, the greater the probability of flood peaks in the basin, since the TCp will be lower and higher the tendency to flooding. To calculate the compactness coefficient, the relationship between the perimeter of the basin and the perimeter of a circle of the same area as the basin was evaluated. The value obtained for Kc, will always
be greater than 1 because values equal to one represent a perfect circle. Parauna river’s sub-basin presented coefficient higher to 1.50, specifically 1.99, indicating basin not subject to severe flooding.

The form factor (Kf) is obtained by the ratio of the average width of the basin and the axis length of the basin, axial width 10.00km. The lower the value of Kf, less susceptible to flooding peaks, this is because higher will be its concentration time, which refers to the time when the entire basin will contribute to superficial runoff in exutory. The form factor of the sub-basin in the study was 0.30 which indicates that the area is not subject to flooding.

### 3.2 Land use and occupation

Table 1 shows the classes of use and occupation of soil most expressive in the sub-basin under study. The agricultural cultivation represents 70.95% of the basin’s land use, comprising the entire contribution territory of the municipality Ilha das Flores in the sub-basin and along with the municipality of Brejo Grande totals 21.91 km² of land use. The land use and occupancy classification was obtained through geo-referenced data available on the Digital Atlas of Sergipe’s Water Resources [5].

<table>
<thead>
<tr>
<th>Area (km²)</th>
<th>Proporção of area occupied in relation to total area (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agricultural cultivation</td>
<td>21.9100</td>
</tr>
<tr>
<td>Sandbanks</td>
<td>7.6200</td>
</tr>
<tr>
<td>Wetland</td>
<td>0.5300</td>
</tr>
<tr>
<td>Mangroves</td>
<td>0.0071</td>
</tr>
<tr>
<td>Water courses</td>
<td>0.8129</td>
</tr>
<tr>
<td>TOTAL</td>
<td>30.88</td>
</tr>
</tbody>
</table>

Source: Digital Atlas of Sergipe’s Water Resources.

Table 1. Classes of land use and occupation in Parauna river’s sub-basin area

The percentage corresponding to the area of agricultural cultivation are included the areas occupied by the headquarters of Brejo Grande and by the Village Brejão dos Negros, being also part of those areas outside of the study area, according to the delimitation of the basin approached in this study.

The native vegetation, including sandbank, mangrove and wetland area does not exceed 5% of the basin’s total area, which indicates strong anthropic influence, regarding deforestation. The highest concentration of sandbank located in the northwestern portion of the sub-basin and a small part on the Southeast along with wetland and mangrove areas.

Through on-site visits alongside the channel of the main river in the study area, come up about 7 km of its length, maximum point with favorable conditions for navigability. It was possible to identify another use and occupation of unidentified soil in Atlas database of Water Resources in the State of Sergipe [5], it is a fish farm that in addition to infrastructure on land, features fish breeding cages inside Rio Parauna’s channel. In this study there was no obtained information on the environmental licensing of this activity.

According to information obtained from Instituto Nacional de Colonização e Reforma Agrária - INCRA (2013) on the quilombo community Brejão dos Negros soils are occupied by native forests and regenerating, natural pastures, mangaba, coco-da-baía, short-cycle crops such as rice, cassava, corn, beans and watermelon, corresponds to the southeast and southwest in the study area.

As for plant composition of the area, although strongly anthropized, features sandbank typologies, mangroves and swamps. According to AguiarNetto et.al. (2011) the dominant vegetation in the Lower São Francisco de Propríá region - SE up to Brejo Grande, is characterized by ecological tension zone between the Caatinga and the Atlantic Rainforest, extending to the city of Piaçabuçu - AL. With vegetational typologies of mangroves and sandbanks to the region of Foz do São Francisco [11].

Law No. 12,651 / 2012, known by the name of “The New Forest Code”, provides for the protection of native vegetation, and conceptualizes Permanent Preservation Area (APP), such as:

Protected area, covered or not by native vegetation with the environmental function of preserving water resources, landscape, geological stability and
biodiversity, facilitate gene flow of fauna and flora, soil protection and ensure the well-being of human populations. [12]

The preservation of the riparian vegetation or lowland (flood area) contributes to the prevention of flooding in the flood season, the removal of this important ecosystem results in erosive processes and in urban areas, causes environmental and human losses. Okuyama (2012) adds that APP are strategic areas of high environmental fragility, that operate in climate, hydrological and geomorphological stability and gene flow of fauna and flora.

In the perception obtained in the field, on the riverbed, the absence of riparian vegetation is observed throughout the segment covered and agricultural activities on its banks, besides erosive process and dominance of exotic species such as Cocosnucifera (coconut) and water species such as Montrichardialinifera (Aningas), observed across the riverbed. The Brazilian Forest Code regulates the margin bands of any natural watercourse, perennial or intermittent. Measuring the thickness of a riverbed consists on the elaboration of a study that should include the geomorphological analysis of the river channel’s transversal profile [13].

Based upon this principle, the study area’s profile was analysed and it appeared that the entire course of Parauna river features variable width of its regular riverbed, reaching its estuary with width 140 meters, and has an environmental protection section, which according to the New Forest Code, Law No. 12,651 is one hundred (100) meters for water courses that are 50 (fifty) to 200 (two hundred) meters wide.

4. RESULTS AND DISCUSSIONS

4.1 Water Resources and Environmental Sanitation

Water is surely one of the natural resources that has greater diversity of use, being called water resource when employed for society uses. Recognized as a renewable resource, but limited, which has a strategic relevance and high vulnerability, given the pollution problems [14].

According to the National Water Resources Policy (PNRH), established by Law 9.433 / 1997, in its Article 5 shall be management tools of a river basin: the Water Resources Plans; the classification of water bodies into classes, according to the predominant uses of water; the granting of usage rights for water resources; charging for the use of water resources; compensation to municipalities; the Water Resources Information System.

As for the Water Resources Plan, for the studied area, there is the Water Resources Plan for São Francisco’s river basin managed by the São Francisco River Basin Committee, both documents mark out the management of water resources, one at the state level and the other specific to the São Francisco river.

4.1.1 Sanitary Draining

The municipalities of Brejo Grande and Ilha das Flores have no sanitary sewage system in place. It was verified on site that in both cities are being implemented such systems, the cities already count on a sewage disposal system, however, until this year, 2015, the Development Company of the São Francisco and Parnaíba Rivers - CODEVASF is implementing the lifting stations and the Effluent Treatment Station - ETE.

In the municipality of Brejo Grande the dumping point of the treated effluent from the ETE will be in a tributary of the Parauna River, Riacho do Melro, the geographic coordinates of effluent dumping point are 778190m E; 8846024m S (CODEVASF, 2011). The system under implementation is composed of a collection network divided into two sewage basins, two lifting stations, with their respective emissaries and treatment unit formed by stabilization ponds [15].

4.1.2 Water Supply

In the study area there are records of three grants regarding water abstraction for human consumption, all issued for Sanitation Company of Sergipe - DESO. Two of the grants was for underground source and one for surface water source, the latter although located within the the studied area, with pickup point of its main river, the Parauna river, does not meet the resident population in the basin, the assisted location is the Village Saramen, Table 2. The Saramen Village belongs to Brejo Grande and it is located southeast of Parauna River’s Basin.

<table>
<thead>
<tr>
<th>Source</th>
<th>Flow rate (m³/h)</th>
<th>Volume (m³/h)</th>
<th>Reservatory (m³)</th>
<th>Location attended</th>
<th>Geographical coordinates (UTM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Superficial</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paraúna</td>
<td>5.796</td>
<td>4173.12</td>
<td>-</td>
<td>Povoado Saramén</td>
<td>780599</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>8842277</td>
</tr>
</tbody>
</table>
Abstractions for groundwater meet localities inserted in the study area, however, according to information obtained on site there was an alteration of the underground abstraction source to superficial in the municipal headquarters. The Village Brejão dos Negros is supplied with water coming from the underground source, the well is located in the village center and has tank for storage and distribution of 200 m³.

In addition to the above abstraction points, in the Digital Atlas of Sergipe’s Water Resources (2012) there is an indication of six (6) wells inserted in the study area, two of which are abandoned, three in operation and one not installed. For wells in operation there is only information about flow rate of the wells belonging to DESO.

### 4.1.3 Solid Waste

In Brazil, Law No. 12.305 / 2010 that adopts provisions concerning the solid waste policy, valid throughout the national territory, is arranged by federal regulations, and envisages the elaboration of participatory and permanent planning, capable of enabling an adequate solid waste management in its various dimensions, in Brazil’s municipalities. In Sergipe, the Intermunicipal Plan for Solid Waste in Sergipe’s Lower São Francisco (PIRS | BSF) was elaborated, besides the plan there is a public consortium of basic sanitation covering about 28 municipalities in the Lower São Francisco region, among them Brejo Grande and Ilha das Flores.

Even though Sergipe is developing actions regarding the management of solid waste, effective actions in the municipalities of Brejo Grande and Ilha das Flores, have not yet been implemented. There is no sanitary landfill for final disposal of waste. The waste is collected and forwarded to dumps located outside the boundaries of the basin, although nearby, as shown in Table 3. As visualized on site, the dumps do not have any kind of environmental controls to prevent contamination of soil and groundwater.

<table>
<thead>
<tr>
<th>Location</th>
<th>Geographic coordinates (UTM)</th>
<th>Distance from Parauna’s basin (Km)</th>
<th>Direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brejo Grande</td>
<td>Prainha Village 775887 8840726</td>
<td>0.69</td>
<td>Southeast</td>
</tr>
<tr>
<td>Ilha das Flores</td>
<td>Headquarters 773092 8842277</td>
<td>0.32</td>
<td>Northeast</td>
</tr>
</tbody>
</table>

Table 3. Location of the dumps, final destination spot for solid waste generated in Brejo Grande and Ilha das Flores.

### 4.2 Economic and Social Aspects

The municipalities Brejo Grande and Ilha das Flores, components of Parauna river’s Sub-basin, have a resident population of around 7,742 people and 8,348 people, respectively. The population is concentrated, mostly in urban areas (Table 4). The urban area in Ilha das Flores is not inserted in the basin. However, Brejo Grande’s urban area is on the northeastern side of Parauna river’s basin.

<table>
<thead>
<tr>
<th></th>
<th>Urban</th>
<th>Rural</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brejo Grande</td>
<td>4,022</td>
<td>3,720</td>
<td>7,742</td>
</tr>
<tr>
<td>Ilha das Flores</td>
<td>5,435</td>
<td>2,913</td>
<td>8,348</td>
</tr>
</tbody>
</table>

Source: IBGE - Censo Demográfico 2010.
Table 4. Resident population, by situation of the household in the municipalities inserted into Parauna river’s sub-basin

The region’s economy has low dynamism, with low diversity of economic activities. Many people do not have jobs or any occupation. Most of the population 10 years of age or older declared having no income, according to data from the most recent census, about 44% in Brejo Grande and 51% in Ilha das Flores. The class with the highest percentage income, after "no income" was that of those who reported receiving "more than ½ to 1 minimum wage" in both municipalities, reflecting a low income frame in the researched area. (Table 5).

<table>
<thead>
<tr>
<th></th>
<th>Brejo Grande</th>
<th>Ilha das Flores</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 1/4 of minimum wage</td>
<td>14.49</td>
<td>12.48</td>
</tr>
<tr>
<td>More than 1/4 to 1/2 minimum wage</td>
<td>12.39</td>
<td>8.52</td>
</tr>
<tr>
<td>More than 1/2 to 1 minimum wage</td>
<td>21.78</td>
<td>22.1</td>
</tr>
<tr>
<td>More than 1 to 2 minimum wages</td>
<td>4.87</td>
<td>4.01</td>
</tr>
<tr>
<td>More than 2 to 3 minimum wages</td>
<td>0.92</td>
<td>1.05</td>
</tr>
<tr>
<td>More than 3 to 5 minimum wages</td>
<td>0.92</td>
<td>0.77</td>
</tr>
<tr>
<td>More than 5 to 10 minimum wages</td>
<td>0.38</td>
<td>0.32</td>
</tr>
<tr>
<td>More than 10 to 15 minimum wages</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>More than 15 to 20 minimum wages</td>
<td>0.03</td>
<td>0.06</td>
</tr>
<tr>
<td>More than 20 to 30 minimum wages</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>More than 30 minimum wages</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>No income</td>
<td>44.21</td>
<td>50.68</td>
</tr>
<tr>
<td>Undeclared</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Source: IBGE - Censo Demográfico 2010.

Table 5. Percentual of persons 10 years of age or older, by monthly nominal income classes

Brejo Grande’s GDP, according to IBGE data for 2012, was approximately 57 million, and Ilha das Flores 48 million reais. In both municipalities the services sector is the most representative. The revenues are originated from trade, agriculture, livestock and oil exploration.

The municipality of Brejo Grande has had importance in the cultivation and production of sugarcane, but the cultural crisis throughout the twentieth century led to other cultures gaining prominence. The crab fishing activities are also important for families. [16]. Currently, the crops that stand out are the rice and coconut. In 2013, these crops reached the production value of 5.15 million and 2.27 million reais, respectively. (Table 6).

Data on agriculture from Ilha das Flores, similarly, features the cultivation of rice, which reached in 2013 the production value of 2.70 million, and the cultivation of coconut with 844,000 reais.
The municipalities livestock farming data shows as highlights the herds of cattle, pigs and poultry (Table 7). Data from 2013 reflect effects of the drought, which occurred in most of Sergipe’s municipalities, causing losses to farmers and ranchers.[17].

<table>
<thead>
<tr>
<th>Type of Herds</th>
<th>Brejo Grande</th>
<th>Ilha das Flores</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bovine</td>
<td>3,613</td>
<td>3,618</td>
</tr>
<tr>
<td>Equine</td>
<td>535</td>
<td>529</td>
</tr>
<tr>
<td>Pig – total</td>
<td>1,205</td>
<td>1,201</td>
</tr>
<tr>
<td>Pigs – pigmatrices</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Caprine</td>
<td>126</td>
<td>110</td>
</tr>
<tr>
<td>Ovine</td>
<td>989</td>
<td>842</td>
</tr>
<tr>
<td>Poultry – total</td>
<td>10,175</td>
<td>10,026</td>
</tr>
<tr>
<td>Poultry – chickens</td>
<td>1,600</td>
<td>1,590</td>
</tr>
</tbody>
</table>

Source: IBGE - Pesquisa Pecuária Municipal - PPM

Table 7. Actual herds, by type of herd in Parauna river’s sub-basin

The Municipal Human Development Index (IDHM) of the municipalities surveyed, based on the latest data published by the UNDP in its Human Development Atlas of Municipalities (2010) are: 0.540 (Brejo Grande) and 0.562 (Ilha das Flores). Both municipalities present IDHM below presented to the state of Sergipe which was 0.665. [18].

4.3 Environmental Perceptions of the Population

The existence of different perceptions in the same community can hinder environmental protection by the lack of knowledge about how everyday actions can impact the environment, in order to grasp a way of perceiving human relations with the population residing environment in the area studied, questionnaires were applied in the municipal headquarters Brejo Grande and the Village Brejão dos Negros, 52 individuals were interviewed, then 30 and 22, respectively.

Environmental perception is today, a recurring theme that contributes to the consciousness and practice of individual and collective actions, thus the study of environmental perception is of such relevance to better understand the interrelationships between humans and the environment, their expectations, satisfactions and dissatisfactions, judgments and behaviors [18]).

The questionnaire was prepared from bibliographic references with the objective of identifying the environmental perception of individuals residing in the territory of the Parauna’s sub-basin, thereby attempting to identify the growing awareness about environmental issues, besides, trying to grasp the understanding of the population in the context of interrelation with the environment.

Among all the people surveyed, almost 60% were native to the area and almost 35% have resided in the area for over 10 years. This shows that practically all of those interviewed could properly answer the questionnaire about the area. Over 90% of people had a home, some of which were obtained through government housing programs.

Questions were asked about the origin of the water used for drinking, domestic and work activities, the following response options were given: well water, running water, river or “don’t know”. In both locations, 100% of the sample affirms that in their homes there is piped water supplied by the Sanitation Company of Sergipe (DESO), which is the only source of water used for human consumption, domestic and work activities.

Regarding the form of water use, most of the interviewed population consume water provided by DESO naturally, 65.28%. It was noticed that some people responded more than one form of use as a consumer, since the number of people surveyed is 52 and the total presented in this table is 54, which results in a percentage greater than 100%.
Another important observation in this item is that people from both visited locations showed different behaviors regarding how to use the water. While at the headquarters more than 85% of respondents use water naturally, as they consider to have good quality water, in the village this percentage is approximately 35%. This difference is directly related to water source abstraction, since according to data from interviews DESO takes water directly from the river at the headquarters and in the village it is abstracted from an artesian well. For respondents from the municipal headquarters, the water quality improved when DESO changed the water source from underground to superficial.

In Brejão dos Negros, although 35% of respondents use the water naturally, most of the respondents, a percentage higher than 50% confirmed that the water that comes in their homes is of good quality. Almost the entire population of the village stated that the quality of groundwater, abstracted by DESO is poor.

When referring to water quality the population considers those parameters that can be perceived by human senses, organoleptic properties, which are color, smell, taste and texture. In addition, one of the interviewees stated that she consumes mineral water, bought in bottles, for acquiring water related disease and having been recommended by a doctor to no longer consume tap water.

The headquarters and villages of Brejo Grande have no the sanitary sewage network, with that part of the population interviewed pours their residential sewage in the rainwater drainage network, others use septic tank and cesspit. Although the Parauná river is an important tributary of the São Francisco River in the Brejo Grande region, about 40% of respondents do not know it, or at least do not know it by name. Among respondents who know the river, the majority, 38.46% do not consider it clean. According to information of the interviewees, Parauná river is also known as Praúnas, Praúna or Barriga Grande river.

Among the forms of using Parauná river and its tributaries, most of the respondents reported that they use it for fishing activity 21.15%, none of the respondents reported to use it for commerce or agriculture.

Over 70% of the people interviewed think that their daily activities do not harm the river. About 23,63,46% of the population believes that the community of Brejo Grande has been suffering from some sort of environmental problem.

For most residents, the decrease in water level (55.77%) and the change in water quality are the most significant changes in the river, but three respondents said they had not noticed any changes in the river.

At the end of the questionnaire, there was an open question that aimed to identify the judgment of the interviewee on environmental preservation of the area. Difficulty in interpretation in part of the sample was noted, but the result is considered efficient for capturing the population’s exact environmental perception.

Although the results obtained do not show statistical significance, the environmental perception captured by applying the questionnaire to individuals, allowed to propose actions for the population and public management can protect and take care of the watershed and their interrelations with man.

5. FINAL CONSIDERATIONS

The geoenvironmental analysis, based on the systemic view of the landscape, allowed to identify the main problems related to water resources management in Rio Parauna’s sub-basin, they are: the absence of riparian vegetation; occurrence of erosive processes; lack of water resources management projects and plans; pollution and contamination of surface and groundwater sources; improper disposal of solid waste; inefficiency of the water resources management tools (granting and charging for water use); non-existent treatment of domestic wastewater; waterborne diseases and irregular occupation in APP (banks and floodplains).

The GIS techniques used in this study were of great importance for the geoenvironmental analysis and made possible the area’s delimitation. The satellite images facilitated the basin’s integrated analysis contributing to an idea of sustainable practices, looking to reduce aspects that compromise the basin’s potential. According to the Forest Code (Law N°. 12,651), the surrounding area perennial and / or intermittent streams are considered as Permanent Preservation Area (APP), surrounding strips are attributed, with varying thickness depending on the width of these rivers, this strip is known as riparian forest, the vegetation protecting the river banks, in Parauna river’s case, there is no such protection due to deforestation and agricultural crops.

It is identified that the river banks have been under strong human pressure, and a larger study regarding the establishment of areas of permanent preservation is needed, to enable the conservation of biological diversity and functionality of riparian vegetation.

The research facilitated the local community’s identification, and most part of it practice subsistence agriculture. These practices are done on the margins of rivers and streams placed in the river basin, resulting in significant environmental
degradation, due to improper use of agrotoxics and domestic sewage discharge. Environmental aspects with potential to cause environmental damage are visible in the community, yet the judgment of the interviewees, regarding the existing environmental problems in the community showed variation, which can be related to the individual form of understanding how humans can influence the environment and how their actions may represent risks to environmental health of the location where they live.

However, we consider environmental perception an important tool for management and planning of water resources, for reporting information that assists in the management process, mainly on land use and occupation process and the main uses of water resources. Especially regarding the community’s environmental perception, with effective methods for generating sustainable practices on economic and environmental interface.

It is recommended that planning and water management tools are implemented: embodiment of water courses and charging for water use. Existing catchment grants are accorded only for human consumption, implanting to other uses is suggested, primarily for use in agriculture as it corresponds to the greater use and occupation of soil in the sub-basin. Finally there is the need to develop and implement a planning and water management to assist in minimizing the environmental impact, contributing to sustainability of Parauna river’s sub-basin.

REFERENCES