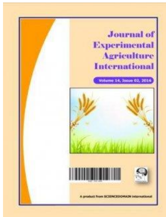

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Assessment of Conformity to Areas under Permanent Preservation and Restricted Use within River Espinharas Hydrographic Sub-Basin

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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ABSTRACT

The changes made in the natural dynamics cause risks that influence the equilibrium, terrestrial and atmospheric. The aim of the study was to characterize the land cover and land use of the Espinharas river sub-basin, with emphasis on the Permanent Preservation Areas (APP) and Areas of Restricted Use (ARU). The Sub-basin of rio Espinharas is part of the Northern Country Depression, it has one of the most typical landscapes of the northeastern semi-arid region. For the

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analyzes, multispectral images of the Landsat 8 OLI satellites were used, from the orbits and points 215/65, 216/64, bands 3, 4 and 5. The delineation of the sub-basin began with obtaining the hydrological attributes in the Software QGIS. For the identification of the areas of land use conflicts in APP and ARU, the map algebra was used to perform an overlay of the land cover and use map with the Map of the APP and ARU, using SIG Idrisi Software. The classes of land use and land cover in the SBH of the Espinharas River has the predominance of the Open Arboreal Shrub Caatinga (OASC) typologies with 2,239.37 km² (68.13%), Closed Arboreal Shrub Caatinga (CASC) with 203.17 km² (6.18%) of the total SBH area. It was also verified that 752.67 km² (22.90%) of the total area corresponds to anthropism. The satellite images allowed to have a clear, comprehensive and current view of the use and land cover of SBH of the river Espinharas. Discrimination, mapping and quantification of land use and land cover areas through the Geographical Information System (IDRISI, QGIS GRASS) classification allowed us to obtain results with greater agility regarding the integration and manipulation of the areas. The data obtained will help recovery plans and planning of the area, since a part of SBH is not complying with the current environmental legislation.

Keywords: Anthropism; semi-arid; Riparian forest; environmental degradation.

1. INTRODUCTION

The changes made in the natural dynamics cause risks that influence the equilibrium, terrestrial and atmospheric, which often ends in the disappearance of species, either by agricultural activities or livestock, in addition to disproportionate human occupation. These facts bring to light the increasingly rapid need for studies aimed at changes and landscape composition, with greater emphasis on land use and coverage in watersheds [1].

From the last decade of the last century, the understanding that it is necessary to combine sustainability with development requires new positions in relation to such farms, currently represented by Federal Law No. 9,433 of January 8, 1997, [2] better known as - "Water Law" establishing the National Water Resources Policy and Creates the National System of Water Resources Management (SIGERH) and Law 12.651 of May 25, 2012, which provides for the preservation of native vegetation and determines the presence of Areas of Permanent Preservation (APP) and Restricted Use (ARU).

According to the new Brazilian Forest Law No. 12.651, dated May 25, 2012 [3], Permanent Preservation Areas (APPs) are protected areas, covered or not by native vegetation, that allow the environmental protection of water resources, landscape, geological stability and biodiversity, in addition to facilitating the gene flow of fauna and flora, protecting the soil, and it is permanently prohibited to carry out anthropic activities in these areas, as far as Areas of Restricted Use (ARU) are allowed to be ecologically sustainable. consider the technical recommendations of the official research bodies, with new suppressions of native vegetation for alternative land use conditioned to the authorization of the state environmental agency in areas of inclination between 25° and 45°, only sustainable forest management and the exercise of agroforestry activities when observed good agronomic practices.

Another factor that corroborates is that the preservation of the vegetal cover is a fundamental condition for the conservation of the water resources. The removal of the same causes a series of modifications in the physical environment and in the water cycle, because the dynamics and behavior of the vegetation directly affect the water regime, both in a beneficial way, by its maintenance and circulation, and by making it unavailable on the planet [4].

Silva et al. [5] reinforce that their removal discharacterizes the original environments as well as, interferes in the water balance of the BH, compromising the water supply and the sustainability of the most varied life forms, notably in the northeastern semi-arid region.

The integrated planning of BH is one of the main management techniques of a given territorial unit with regard to the socioeconomic-environmental aspect. For this, indicators should be used to systematically reduce socio-environmental conflicts, to perform actions of recovery, preservation, conservation and management of natural ecosystems, considering as essential point the quality of life of society [6].

However, when studying BH, it becomes increasingly necessary to analyze and characterize the Permanent Preservation Areas

(APP) and ARU. For Boin [7], the quantity and quality of water resources is influenced by the conflicts between use and occupation of these areas, in which the importance of compliance with legislation is highlighted.

For such management, tools in the area of geotechnology allow an integrated analysis of the environment in order to understand how issues related to environmental changes behave in space. This is one of the strengths, allowing the environment to be studied in parts and understood as a whole [8].

Remote sensing, together with geographic information systems (GIS), are highly efficient tools for surveying, mapping and monitoring natural resources. Through satellite imagery it is possible to have a broad view of the study area, to have frequent monitoring of the changes that have occurred in the region over time, in an economically viable way [9].

Therefore, the aim of the study was to characterize the land cover and land use of the Espinharas river sub-basin, with emphasis on the Permanent Preservation Areas (APP) and Areas of Restricted Use (ARU).

2. MATERIALS AND METHODS

2.1 Characterization of the Study Area

The SBH rio Espinharas is localized in the Northern Sertanea Depression, where it has one of the most typical landscapes of the northeastern semi-arid that are, the extensive plain, predominantly soft-wavy relief, residual elevations (Inselbergs) [10].

It is inserted more specifically, in the intermediate regions of Patos (PB) and Campina Grande (PB), Caicó (RN), Serra Talhada (PE) [11], (Fig. 1).

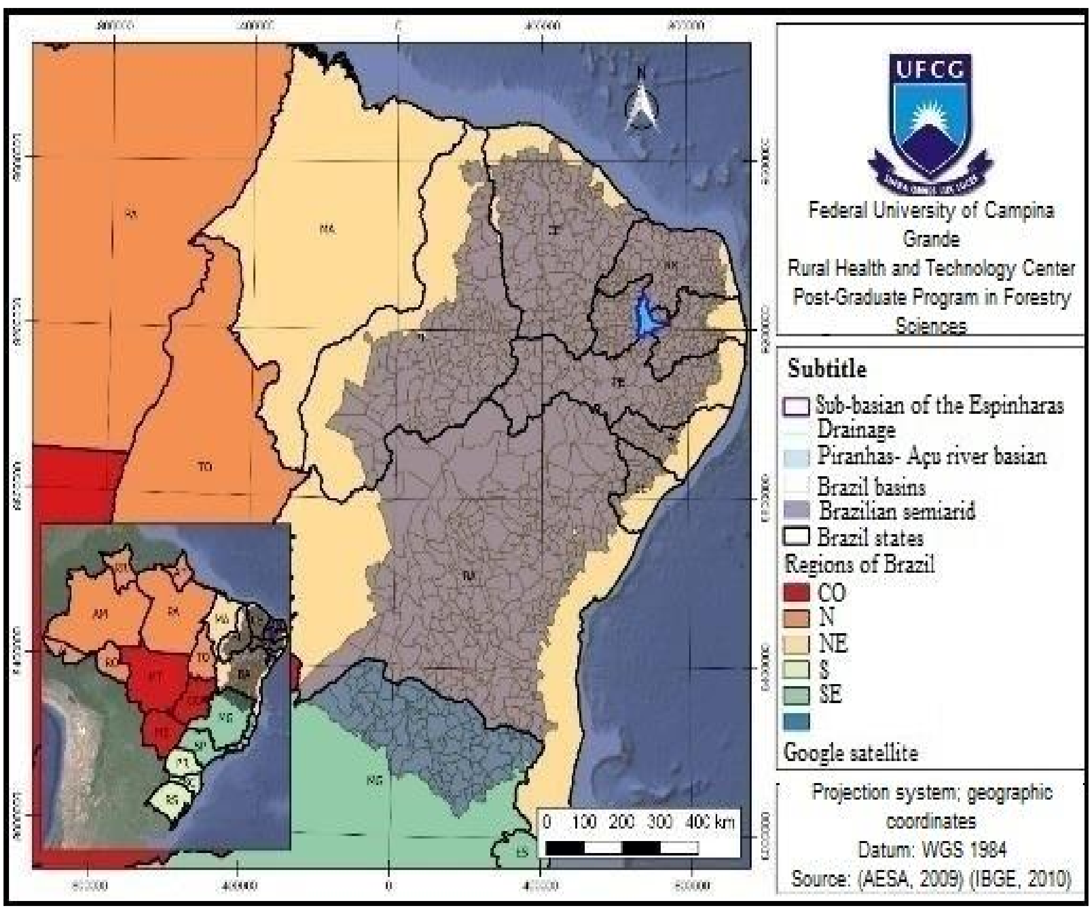

Fig. 1. SBH location map of the Espinharas river, semi-arid northeast, Brazil

Table 1. Identification of orbital images with coverage for the study area

Satellite	Sensor	Orbit / Point	Date
LANDSAT 8	OLI	216/064	06/08/2017
LANDSAT 8	OLI	215/065	15/08/2017

According to Alvares et al. [12] in the SBH area studied, climates such as Bsh and Aw 'are characterized. The Bsh type is defined as a hot and dry climate, with summer rains and with annual rainfall around 500 mm and an annual average temperature of 26°C; the Aw 'type is present in the western center portion of the SBH, presenting warm and semi-humid conditions with summer-fall rains, with a rainfall average of around 500 mm and an average annual temperature of 27°C, and extends through the southeast portion of the sub- basin [13,14].

Soils are generally shallow, stony, of crystalline origin and very vulnerable to erosion, with predominance of the following types: Luvissol chrome and Litho Neosol [15].

The vegetation present in the study area is composed of small woody species, endowed with spines and usually deciduous leaves that lose their leaves in the dry period, with a marked presence of cactáceas and bromeliáceas [5].

According to SUDEMA [16], the Open Arboreal Shrub Caatinga (OASC) is present in most of the studied area, characterized by sparse vegetation with some arboreal individuals with a mean height of 3 m, with herbaceous and cactaceous vegetation, being high degree of degradation in the flat relief areas.

The vegetation is classified as Closed Arboreal Shrub Caatinga (CASC) and is found on the slopes of hills and mountains [17]. This vegetation has as characteristics the predominance of arboreal individuals.

2.2 Materials Used

The delimitation of the sub-basin was performed automatically using the Digital Elevation Model (MDE) of the Shuttle Radar Topographic Mission (SRTM) project covering the scenes 07_w038_1arc_v3.tif.aux;s08_w038_1arc_v3.tif. aux, correcting them when necessary based on SUDENE Planialtimetric Charts, edited in 1985 and scanned in 1996; (SB.24 - Z - A - VI), Serra Negra do Norte - RN (SB.24 - Z - B - IV), Piancó - PB (SB.24 - Z - C - III) and Ducks-PB (SB.24-Z-D-I). This and subsequent steps were developed with the help of the QGIS Softwares plus add-ons and GRASSGIS and IDRISI. The same is free and easy to handle.

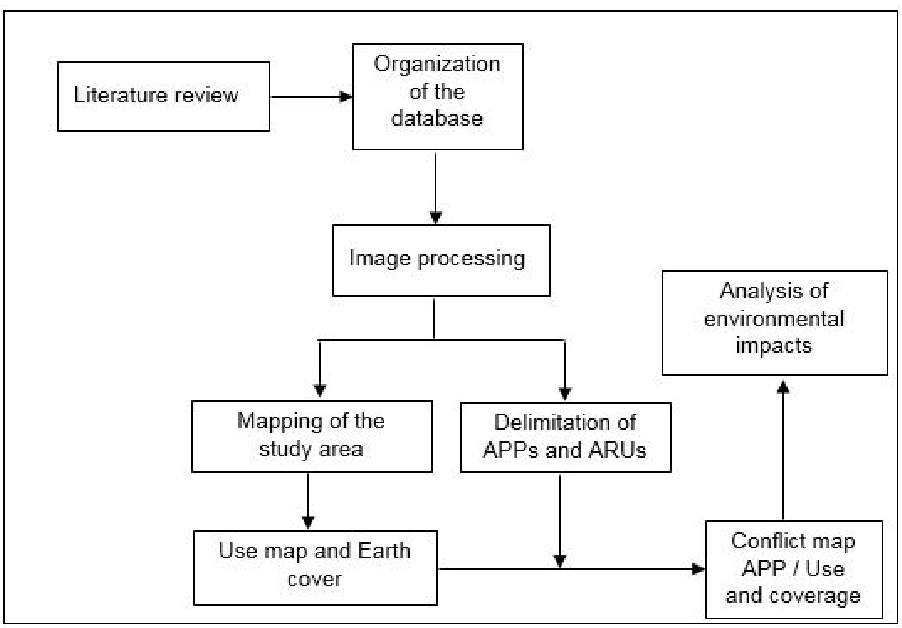

Fig. 2. Flowchart of the methodological steps

The land uses for the year 2017 were obtained from the visual interpretation of satellite images Landsat 8, OLI Sensor, resolution 30 m, bands 3, 4 and 5. The images of Landsat 8, present better spectral resolution than their predecessors, as also cover a larger catchment area.

The Landsat 8 satellite images were used at 9-day intervals, due to the time it takes for the satellite to travel through the same site (Table 1).

The realization of the research comprised the following steps, visualized in the flowchart of Fig. 2. The first step was the literature review to deepen and contextualize some concepts such as Hydrographic Basin, caatinga biome, remote sensing, geoprocessing, land use map.

The second step was to select the software to be used in the data processing, a limitation is the cost involved in the acquisition of the same, however an alternative way is the use of open source programs, such as the QGIS and GRASS GIS, indicated for data processing, analysis and visualization, and used in this work, making this type of operation, previously costly, much more economical. Then, the images were processed to generate the mapping of the study area and the delimitation of the Permanent Protection Areas (APP) and restricted area of use (ARU). After mapping the study area generated the map of land use and land cover. The next step was the overlapping of the APP and ARU delimitation with the land use and coverage map, and with that generated the map conflict with Permanent Preservation Areas / use and coverage and finally analyzed the environmental impacts of the sub-basin, for further recovery measures.

2.3 Methods Applied

2.3.1 Processing Digital Elevation Model (MDE) Shuttle Radar Topographic Mission (SRTM)

For the generation of the Digital Elevation Model (MDE) it used data from the Shuttle Radar Topographic Mission (SRTM), was acquired in GeoTIFF format from the USGS Earth. s08_w038_1arc_v3.tif.aux with a resolution of 1 arc of a second, which corresponds to approximately 30 meters, referenced in the WGS84 Datum.

The model was used to extract the APP from the water courses and from the top of the hill with the help of the QGIS tools and complements, being the processing of the data contained in the MDE. Initially the composition of the scenes 07_w038_1arc_v3.tif.aux;s08_w038_1arc_v3.tif. aux to form the STRM mosaic. Afterwards, the mosaic reprojection occurred for flat coordinates, and the same ones referenced to the Datum Sirgas2000, Zone 24 S because they present a greater precision and to be used for small area extensions. After this, the image was cut to represent the study area. Finally, we obtained the filling of regions without data in the SRTM MDE using the "r.fillnulls" module, which operates with the Spline Regularizer of Stress – [18] algorithm, implementing in SIG GRASS.

2.3.2 Processing orbital images

Multispectral images of the LANDSAT 8 OLI satellites, orbit and points 215/65, 216/64 were used. The dates of the satellite images were selected corresponding to the dry period, and presented lower cloud interference in order to provide a better evaluation of the soil use and cover, through the contrast between vegetation and soil [19].

According to Silva [19], to perform the georeferencing of orbital images, the SIRGAS 2000 horizontal Datum and the UTM Projection System are used, using control points in the field (PC), based on intersections between roads, roads and paths , confluences of rivers and other reliable and recognizable mooring points, both in orbital images and images of Google Earth 6.0.2.2014. In this way the images will be corrected geometrically applying the resampling by the method of the nearest neighbor.

2.3.3 Delimitation of the study area

The Sub-Basin Hydrographic (SBH) delimitation was started with the hydrological attributes obtained in the QGIS Software, in which they were executed by the GRASS complement "r.watershed" [20]. This module derives maps of flow accumulation, drainage direction, drainage location and Sub-Basin Hydrographic (SBH) boundary.

2.3.4 Characterization of the cover and land use of Sub-Basin Hydrographic (SBH) of the Espinharas river

For the generation of the land cover map and land use, a pre-analysis of the different land cover patterns was carried out. After the preprocessing of the images, visual and supervised classifications were performed.

The second stage consisted of the vector representation of each identified theme, rasterizing on a mask previously generated with definition of the polygon of the basin.

The subjects chosen for use map were based on field sampling, and three samples were selected previously for the thematic class. For automatic classification, the likelihood method (Maxlike) was used. Ten samples of each class were verified, considering the training based on the labeling formulated in the visual interpretation of the image and related knowledge of the study area. From the overlapping of the two classifications, a hybrid image was generated with which the land use and cover map was created with the following typologies: Open Arboreal Shrub Caatinga (OASC) - with predominance of grasses, tree and sparse trees and Closed Arboreal Shrub Caatinga (OASC) with the presence of shrubs and trees with height varying from 6 to 8 m [16], Area antropizada Urban Area, Corpos D'água and Rocky Outcrop. Then, the area values of each category of land use were calculated. After the classified image, the Kappa statistic was used to evaluate the agreement between the results observed and those classified in a contingency table (error matrix). According to Landis; Koch [21], Kappa values are equivalent to classification quality (Table 2). During the field work, the "terrestrial truth" was verified, in which areas with possible classification errors were analyzed.

2.3.5 Delimitation of the Permanent Preservation Area (APP) and Restricted Use Area (ARU) of the SBH of the Espinharas river

The automatic delimitation of the areas of permanent preservation (APP), based on the digital model of hydrographically conditioned elevation. Following the specifications in art. 4º of the Resolution of the Forest Code Law nº 12.651 [3], the categories of PPAs located in the upper third of the hills, on slopes with slopes higher than 45°, were delineated in the sources and their respective contribution areas, in the riparian zones and in the upper thirds of the sub-basin.

For the delimitation of the Areas of restricted use, the Digital elevation model was also used. Areas of restricted use (ARU) were delineated according to article 11 of the Forest Code, Law 12.651 of 2012 [3], where the areas located at the top of elevations were considered (top of hills, hills or mountains) with slope greater than 25° from elevation or (area equal to or greater than 100 meters).

2.3.6 Verification of the conflict between land use and land cover classes, APP / ARU

In order to identify the areas of land use conflicts in APP and ARU, map algebra was used to perform an overlapping of the land cover and use map with the Map of APP and ARU. The procedures were performed in the IDRISI SIG Software, through the "CROSSTAB" module.

After the overlapping of these maps, the areas were duly quantified and characterized as to the use and coverage of the soil taking into account the current environmental legislation, executing the area calculation functions, by the tool "Database Query" menu area, belonging to the module IDRISI Analysis.

3. RESULTS AND DISCUSSION

3.1 Characterization of Land Use and Land Cover

The validation of the land use classification (Maxlike) presented a Kappa Index of 0.8852 (88.52%), considered in the range of excellent quality according to the classification used.

Table 2. Quality of the classification associated with Kappa index values

Kappa index	Quality
≤0,00	Poor
0,01 a 0,20	Bad
0,21 a 0,40	Reasonable
0,41 a 0,60	Good
0,61 a 0,80	Very Good
0,81 a 1,00	Great

Source – Landis; Koch (1977)

As can be observed, the classes of land use and land cover in the SBH of the Espinharas River shows the predominance of the Open Arboreal Shrub Caatinga (OASC) typologies with 2,239.37 km², representing (68.13%) of the total area, characterized by a sparse vegetation with some arboreal individuals with a mean height of 3 m, with cactaceous and herbaceous vegetation being found, in most cases, with a high degree of degradation, located in the most flat areas and also in areas with strong slopes (Table 3).

Another typology with the presence of vegetation is the Closed Arboreal Shrub Caatinga (CASC) with 203.67 km² (6.18%) of the total SBH area. In this typology, trees and shrubs occur more frequently in areas of higher slope, such as slopes of hills and mountains, where dense vegetation is present, with less herbaceous and cacti (Fig. 3).

It is known that the vegetation cover is important in the control of erosion, floods and in the recharge of the water table. The use of these areas, for the removal of wood and for extensive livestock activity, was verified "in loco", contributing to a greater degradation of the same ones.

In other works carried out in the northeastern semi-arid region, the predominance of vegetation was found occupying most of the BH's area, such as Andrade; Oliveira [22], Mendonça et al. [23], Silva [24], Souza [25], Assis et al. [26], Marcelino [27], Silva et al. [4] and Assis [28].

Table 3. Land use and cover and their respective areas and percentage in relation to SBH area of Espinharas, Paraíba, Brazil

Usage and Coverage	Area (km²)	Area (%)
OAAC*	2239,37	68,13
Anthropized area	752,67	22,90
CASC*	203,17	6,18
Urban area	44,63	1,36
Bodies of Water	25,05	0,76
Rock outcrop	22,06	0,67
Total	**3286,95**	**100**

** OAAC – Open Arboreal Shrub Caatinga*
** CASC – Closed Arboreal Shrub Caatinga*

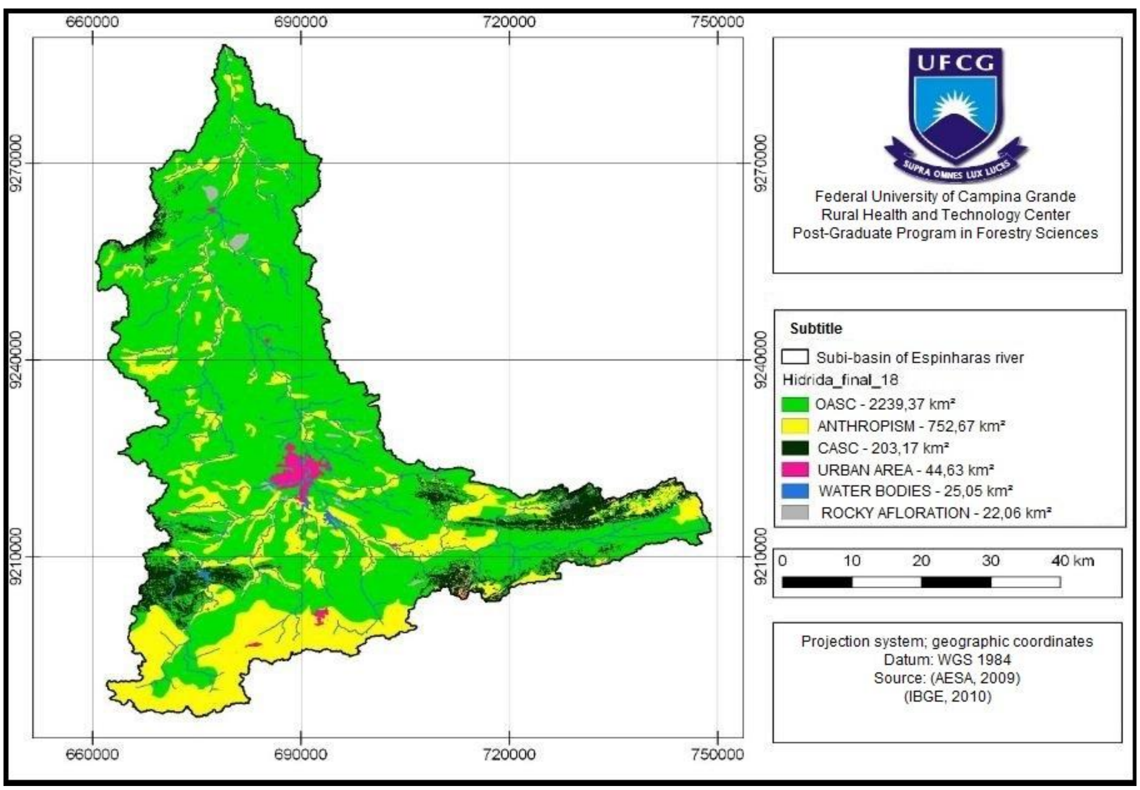

Fig. 3. Use and land cover map of SBH of the Espinharas river

It was also verified that 752.67 km² (22.90%) of the total area correspond to the anthropized area being the second largest typology found. This topology was classified between pasture (native and planted), subsistence agriculture where maize and beans predominate and mineral extraction. It is located to a large extent on the banks of the rivers and extends to the headwaters of the water courses that feed the SBH where they can contribute to the increase of the degradation of the area, mainly by the erosion, silting and pollution of the surface waters.

Different results were found by Mendonça et al., [23] when studying SBH of Rio Jatobá, Patos-PB, inserted in the study area, in which it was identified that, in this section, 41.4% of SBH area were occupied by anthropic area; 29.7% for OASC, 23.2% for CASC and 5.7% for Water bodies. This different result for anthropic area occurred due to the SBH of the Jatobá dam is located in an area closer to the urban area of the municipality of Patos-PB, resulting in greater anthropic action and pressure by natural resources.

In the semi-arid, most soils are fertile, but shallow [4]. This peculiarity requires the man of the field to use soil conservation practices, eliminating or reducing the risk of erosion and transporting the thin layer of arable land, which normally does not occur. To that end, it is important to provide technical assistance, which must be prepared to face the low level of schooling of the rural producer and the few financial resources to invest in a sustainable and economically viable agriculture Mendonça et al. [23].

The typology of water bodies that presented an area of 25.5 km² (0.76%) of the total area of the SBH where it is represented by dams, dams and barriers.

In the sub-basin studied, there are few reservoirs of greater representativity, the best known being the Jatobá Dam with a capacity of 17,516,000 m³, Flour Açude with a capacity of 25,738,500 m³, both located in the municipality of Patos-PB and Capoeira Water is the most representative with 53,450,000 m³ located in the municipality of Santa Terezinha-PB [12] The rest of the water bodies are smaller, categorized as barriers and small dams, not constituting reservoirs that can store water for periods of drought, a fact that leaves the population depending on cars kites or even cacimbas and wells built emergentially.

The other typologies were Urban Area with 44.63 km² representing (1.36%) and finally Rocky outcrops with 22.06 km ² representing (0.67%) of the total area of the SBH of the river Espinharas. The SBH drainage area of the Espinharas River extends through thirty-one (31) municipalities, twenty (25) in the State of Paraíba, three (03) of the State of Rio Grande do Norte and three (03) of the State of Pernambuco. The most representative municipalities in the São José de Espinharas and Patos-PB study area. The immediate geographic region of Patos is composed of nine municipalities, and presents the highest population index of the region, becoming one of the factors, together with its privileged geographic position, relevant to the strengthening of its centrality [29].

The outcrops are part of the most typical landscapes of the northeastern semi-arid region, being inserted in the Northern Sertaneja depression, with an extensive pediplanada plain, with altitudes varying from 250 m to 700 m. Some of these rocks are granitic in nature and are quite exploited for use in construction. Satellite imagery has provided a clear, comprehensive and current view of land use. Discrimination, mapping and quantification of land use areas through classification by the Geographic Information System (IDRISI, QGIS GRASS) allowed results to be obtained with greater agility regarding the integration and manipulation of the áreas.

3.2 Mapping of APP and ARU

From the current forest legislation and the aid of the geoprocessing, as described in the methodology, the map of APP and ARU was obtained (Fig. 4).

It is observed that the ARU occupy a larger area with 105.64 km² (3.21%) followed by Drainage APPs with 82.36 km² (2.51%) APP of Water bodies, 56.45 km² (1, 72%) (Table 4). APPs are considered as protected areas, covered by native or exotic vegetation, with the environmental function of preserving water resources, landscape, geological stability and biodiversity, as well as facilitating the gene flow of fauna and flora, protecting the soil and ensuring the well-being of human populations [30].

In the SBH of the river Espinharas, anthropic activities have caused impacts to the natural environment, mainly by the removal of vegetation, such as silting, erosion of drains due to lack of riparian forest.

In a similar study, Melo et al. [31], in a study carried out in the sub-basin of Itapemirim, Sergipe, observed that the plant formation of the Seasonal Semideciduous Forest and Seasonal Steppe-Forest Contact was suppressed due to anthropic activities such as agriculture and agriculture, and mining activity as extraction of clayey sediments, so as a consequence of these factors, the riparian forests were removed causing the silting of rivers in the surroundings.

Another issue that deserves attention is the obligation of the APPs to be covered by native or exotic vegetation, since, according to Garcia et al. [32], these areas have the function of reducing the transportation of material to the watercourses, silting up its banks, minimizing erosion processes and, finally, helping to maintain and preserve biodiversity.

Silva et al. [33] In a study in the Ribeirão Ubá-MG Hydrographic Basin, found a restricted use area (ARU) of 3.9%, while the Permanent Preservation area was 0.037%.

In the recreational catchment area of Alegre-ES, Silva et al. [34], the Permanent Protected area occupied 8.85% of the microbasin, and the restricted use area was 1.83%.

3.3 Conflict between Land Use and Coverage, APP and ARU

Despite their importance and being reserved by law, APP and ARU has been the target of anthropic activities, leading to conflicting interests in land use and occupation.

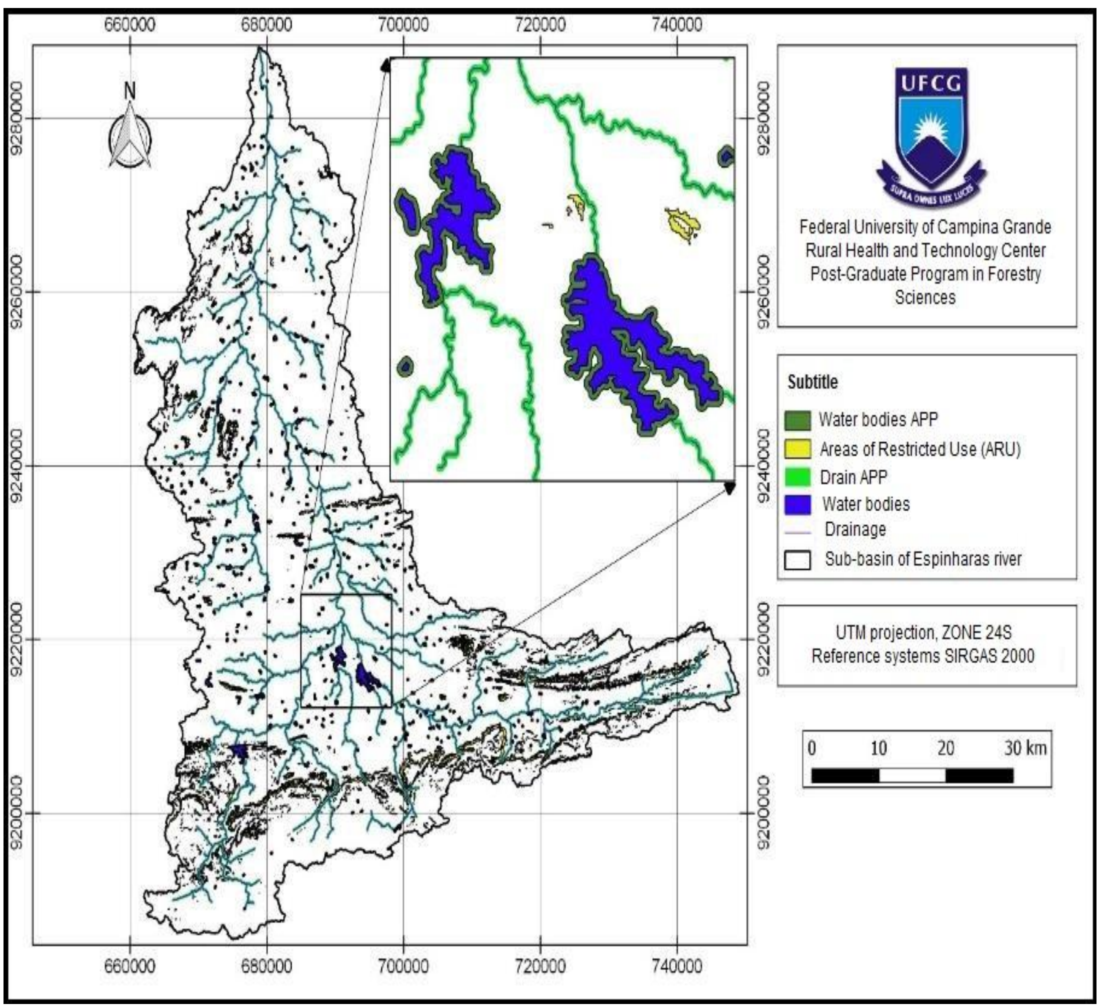

Fig. 4. Map of APP and ARU of SBH of the Espinharas river

Table 4. APP and ARU and their respective areas and percentage in relation to the SBH area of the Espinharas river, Paraíba, Brazil

Type of land use	Area (km²)	% in relation to the sub-basin area
Areas of Restricted Use	105,64	3,21
Drain APP	82,36	2,51
Water Body APP	56,45	1,72
Total	244,45	7,44

Regarding compliance with environmental legislation, especially with regard to the protection of APP and ARU, it is verified that the SBH of the Espinharas river presents a reality different from what is foreseen in the legislation.

It is observed in (Table 5) that most of the permanent preservation areas present conflicting use in relation to what is established by the current environmental legislation [30], with 144.95 km² of APP and ARU areas (59.85%) covered by Open Arboreal Shrub Caatinga (OASC) and 29.53 km² of APP and ARU areas (9.77%) are covered by Closed Arboreal Shrub Caatinga (CASC). On the other hand, 60.31 km² (26.73%) of APP and ARU areas are being used for anthropic activities.

In the APPs of water bodies and drainage there are (28.88%) and (43.57%) areas of anthropic and (0.68%) and (1.17%) urban areas respectively, the anthropic area corresponds to 7.73% and the urban area to 0.35%, thus demonstrating a clear conflict of land use in the SBH of the Espinharas river.

Similar results were obtained by Silva et al. [35], in the Paraiba basin, where areas with aptitude for forest protection or afforestation due to marked declivity were also used in agriculture (7.62%) and pasture (6.34%).

According to Medeiros [36], one of the main impacts found in the Espinharas river is the removal of the trees from the riparian forest. He also mentioned that in these places the presence of solid and liquid wastes is more and more visible, invasion and irregular occupation.

Drainage APPs that are located along the perennial and intermittent riverbanks and the Water Bodies APP that are located at the banks of dams and dams together represent an area of 138.67 km² and are 52.14 km², 37%) of the area occupied by anthropic activities.

These are areas with soils with higher moisture content and higher natural fertility and are present in the vicinities of water reservoirs, which are widely used with little or no conservation by man from the field for subsistence farming or pasture [23].

There are also conflicts where APP, ARU are occupied with 1.72 km² of urban area (0.73%) of the total area of the SBH of the river Espinharas. It is observed that, even if the APPs have legal protection at the federal, state and municipal level to control their occupation and degradation, they are occupied by the classes of land use and land cover, occurring non-compliance with the legislation, probably due to lack and / or omission of the competent bodies [37].

The riverside population is one of the main causes of these impacts, and also the first to be harmed, since, corroborating Mendonça et al. [23], in order to achieve a reversal of these processes, it is necessary to change society's position, that of managers in a joint action of the public authorities, of the population and of the entrepreneurs, contributing to the reduction of the impacts that afflict the SBH of the river Espinharas, as well as its recovery.

Similar results were observed by Nardini et al [38], in a study carried out in the Ribeirão do Morro Grande, SP, Brazil, that 21.13% of APP and ARU areas are being used for anthropic activities such as pasture and agriculture.

In the sub-basin of the Córrego dos Bois in Minas Gerais, Silva et al. [39], verified that most pastures are pasture, corresponding to 22.52% and with perennial crops with 1.47% respectively.

In the work done by Santos et al. [40], it was observed in the Piauitinga-PE basin, that the areas of APP present conflicts with urban area 4.3%, agricultural crop 19.11% and pasture 44.11%.

It is observed that most of the permanent preservation areas in watersheds present conflicts with other anthropic activities, this is related to the incorrect use of the soil and also the environmental legislations are not long. For this, more studies are needed in watershed

Table 5. Conflict between use classes and soil coverage and app and restricted use area in SBH of the Espinharas river

Classes	Area (km²)							
APP \ Usage and Coverage	Water Body APP	Área (%)	Drain APP	Área (%)	Restricted use area	Área (%)	Total (km²)	Total (%)
CAAA	38,17	67,76	40,04	48,63	66,74	63,17	144,95	59,85
Anthropized Area	16,27	28,88	35,87	43,57	8,17	7,73	60,31	26,73
CAAF	1,23	2,18	1,27	1,55	27,03	25,58	29,53	9,77
Urban area	0,38	0,68	0,96	1,17	0,37	0,35	1,72	0,73
Bodies of Water	0,25	0,45	4,08	4,95	0,10	0,10	4,44	1,83
Rock outcrop	0,03	0,05	0,11	0,14	3,23	3,06	3,37	1,08
Total	56,34	100,00	82,33	100,00	105,64	100,00	244,31	100,00

areas to establish recovery and conservation measures and also to establish public policies that encourage communities to use sustainable natural resources.

4. CONCLUSION

The classes of soil cover and use in the SBH of the Espinharas River show the predominance of the Open Arboreal Shrub Caatinga (OASC) typologies with 2,239.37 km² (68.13%) and anthropic area with 752.67 km² (22.90%) of the total SBH area of the Espinharas river. Another typology found is the Closed Arboreal Shrub Caatinga (CASC) with 203.17 km² (6.18%).

The typology of water bodies presented an area of 25.5 km² (0.76%) of the total SBH area represented by dams, dams and barriers. The other typologies found were urban area with 1.36 km² (44.63%) and rocky outcrops with 22.06 km² representing (0.67%) of the total area.
The adoption of measures and practices for soil conservation in these areas is fundamental to maintain the ecological quality of these resources in the long term. Failure to observe this balance in the formulation of agricultural systems has been responsible for the breakdown of this balance and the continuous degradation of this resource, mainly due to the loss of soil via erosion in the growing areas.

Satellite imagery has provided a clear, comprehensive and current view of land use. Discrimination, mapping and quantification of land use areas through geographic information system classification (IDRISI, QGIS GRASS) allowed results to be obtained with greater agility regarding the integration and manipulation of the areas.

The data obtained will help in the future recovery and planning projects of the area, since a part of SBH has not been preserved and is failing to comply with the current environmental legislation.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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