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# Diagnosis of the use and occupation of the lands of the hydrographic bowl of the Ribeirão São João-ES, Brazil

Caio Henrique Ungarato Fiorese[1], Gilson Silva Filho[2]

[1]Environmental Engineering, Centro Universitário São Camilo, Cachoeiro de Itapemirim – Espírito Santo, Brazil
Email: caiofiorese@hotmail.com
[2] Environmental Engineering, Centro Universitário São Camilo, Cachoeiro de Itapemirim – Espírito Santo, Brazil
Email: silva.filho.gilson@gmail.com

***Abstract*** *— Studies related to the use of soil in river basins are of extreme importance to, for example, assist in the evaluation of the environmental impacts of human activities. The objective of this work was to evaluate soil use in the Ribeirão São João river basin in the state of Espírito Santo, Brazil, as a way to subsidize actions of environmental improvements in the area. The geographic databases used were: the Integrated System of Geospatial Bases of the State of Espírito Santo, the Jones dos Santos Neves Institute and the National Water Agency. The procedures were performed in the ArcGis program. The basin was delimited to then, based on two land use files referring to the mappings of the years 2007-2008 and 2012-2015, determine and quantify the classes of land use. A thematic map was prepared in order to evaluate the distribution of classes. Pasture was the most predominant class (approximately 40%), followed by coffee farming (20%), arranged under small monocultures. The native vegetation presented low percentages (15,5%), although they did not decrease in this period. The high representativeness of the macega (approximately 5%), predominant alongside native forest fragments, indicates a problem regarding the management and use of local lands. Eucalyptus silviculture presented great growth during this period, together with the expansion of exposed soil areas. The basin of Ribeirão São João presents problems arising from human action, requiring actions such as the creation of ecological corridors, expansion of native forest cover and environmental education with local residents.*

***Keywords*** *— **Hydrographic Basins, Vegetation Cover, Environmental Impacts, Territorial Planning, Geographic Information Systems.***

## I. INTRODUCTION

Historically, the relationship between society and nature has become more complex as a result of the use of space, with currently seen effects, seen for example in the substitution of vegetation cover, in the implantation of industrial enterprises, urbanization and influences on water resources [4]. The landscapes on the terrestrial surface live in constant transformations, since this scenario is linked to the natural changes and, mainly, of the society [20].

Changes in soil use and land cover from anthropogenic action have provided major impacts in these landscapes, which can be mitigated through monitoring using spatiotemporal information on local landscape modifications [3]. Activities such as agriculture and livestock are responsible for changes in land use and occupation, increasing the exploitation of natural resources, directly influencing the quality and quantity of water available [21].

Disordered land occupation associated with deforestation and pollution caused by the use of pesticides, fertilizers, domestic / industrial effluents and garbage, can have serious consequences for the survival of several species [9], both terrestrial and aquatic. Other losses are related to losses of soil organic matter and nutrients, compaction and waterproofing of soils, sedimentation of fluvial channels and losses with floods, causing damage to the equilibrium of water systems in watersheds [11].

Knowing the dynamics of land use and occupation is of fundamental importance in assisting planning and territorial management. Studies with this approach constitute an excellent tool for environmental analysis, helping to identify and locate the factors responsible for the environmental conditions of a given area [17]. In addition, analyzing the soil situation may provide support for the elaboration of other studies, such as monitoring and mapping of fire risks and eradication of erosion in

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places where activities such as agriculture and livestock predominate [13].

A river basin can be defined as the region of the terrestrial surface surrounded by its topographic dividers and drained by a set of water bodies distributed according to the predominance of water and sediments and flowing to a single outlet [10]. The hydrographic basin is adopted as a relevant unit in the development of several studies, such as those that deal with land use, since it constitutes a systemic unit in studies involving fragilities and potentialities of a given landscape, covering the biotic, abiotic and anthropic factors [16].

The problems involved in environmental studies at river basin level can be easily evaluated with the help of geotechnologies, especially in thematic mapping, diagnosis and environmental prognosis and land use planning [8]. Through the so-called Geographic Information Systems (GIS), it is possible to detail the occurrence of conflicts in the use of land in a given river basin, strengthening environmental monitoring actions and assistance to the legal instruments of control and inspection of these sites, of a diagnosis crossing spatial information [24].

With the help of geoprocessing techniques, the objective of this work was to study the use and occupation of the lands of the Ribeirão São João river basin as ways of subsidizing measures to mitigate and mitigate possible environmental impacts.

## II. MATERIALS AND METHODS

This study was based on the Ribeirão São João river basin. With an area of 91,88 km² and perimeter of 57,82 km, it covers the rural area of part of the municipalities of Castelo and Conceição do Castelo, having its mouth in the river Castelo. It is characterized by the fact that there are no urban agglomerates, however, the study of the dynamics of land occupation is justified by the predominance of activities such as cattle raising and agriculture (mainly coffee), which, when handled incorrectly, can lead to serious environmental problems. Fig. 1 shows the location of the studied area.

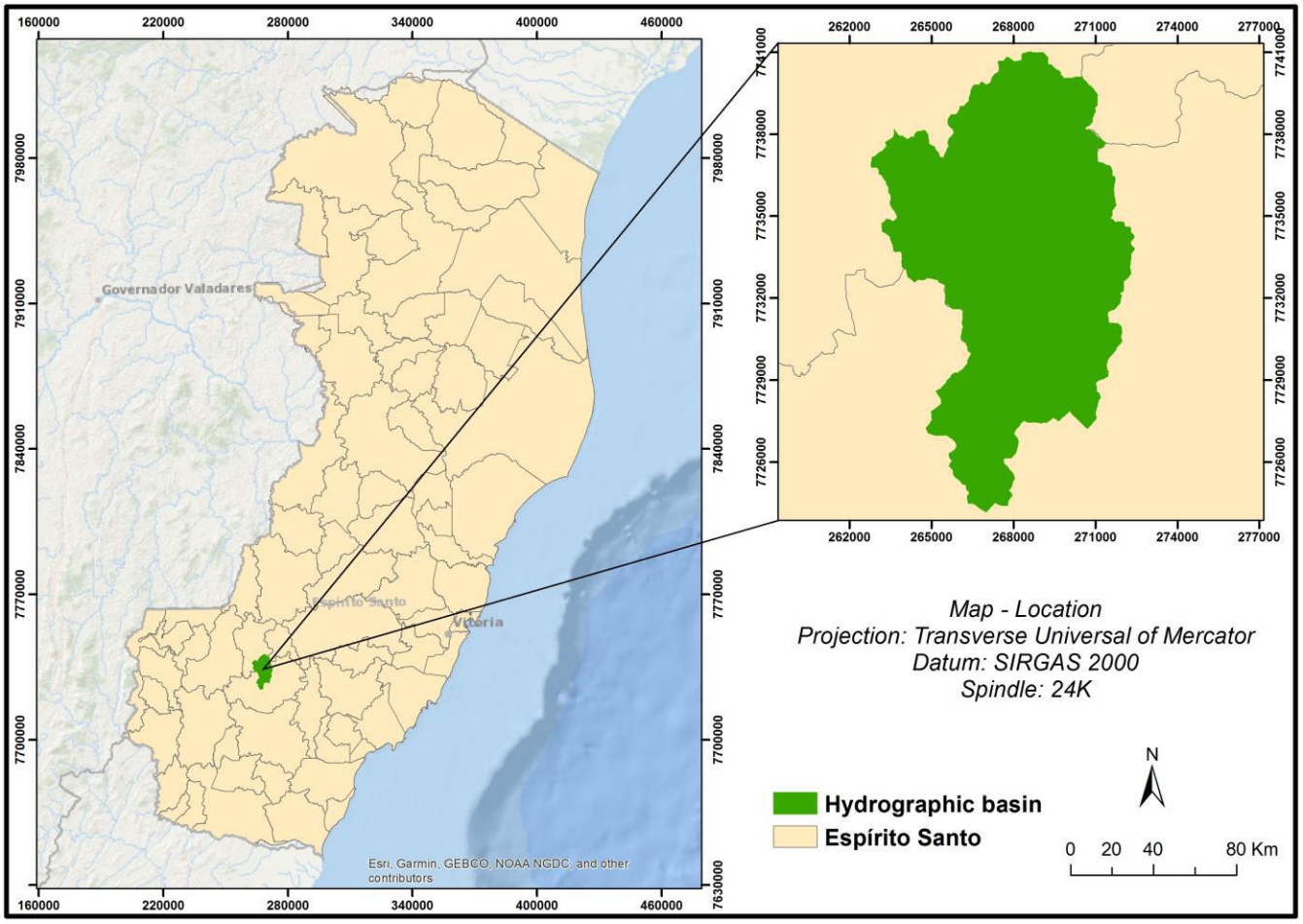


*Fig. 1: Location of the sub-basin of Ribeirão São João, in the state of Espírito Santo, Brazil*

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The ArcGIS® version 10.2 program was used for the basic execution of the procedures. The cartographic databases considered were the Integrated System of Geospatial Bases of the State of Espírito Santo (GEOBASES) [27] and the electronic sites of the Instituto Jones dos Santos Neves (IJSN) [28] and the National Water Agency (NWA) [26].

In GEOBASES, two shapefile (shp) files were collected on land use mappings from 2007 to 2008 and from 2012 to 2015, both handled in a scale equal to or better than 1: 25000, and a file referring to curves of the region studied. Together with the IJSN and NWA, a file containing the boundaries of the municipalities of the state of Espírito Santo and a feature representing the water courses and their respective identifications were acquired.

In ArcGIS®, the Digital Elevation Model (DEM) was initially generated from the contours of the region covered by the Ribeirão São João river basin, and then delimited this basin by means of the following procedures, in the attribute table: DEM correction generated; determination of the accumulated flow; determination of flow direction; definition of the drainage network and water courses; vectorization of the drainage network by converting the feature into raster format obtained for line format (shapefile); demarcation of a point by means of the creation of file shapefile representing the exutório of the basin and; delimitation of the river basin. In order to assist in the identification of the basin, it was added the archive of watercourses, thus making it possible to identify the main water flow line (in this case, Ribeirão São João) and its mouth at the Castelo River.

After the conversion of the file to polygon format obtained about the hydrographic basin, the information regarding the soil use collected in GEOBASES was added. With the help of the clip tool, the soil use was delimited for the BHRSJ.

The identification of the classes occurred through the table of attributes and the respective legend established. The quantification of each class, in square meter (m²), was possible through the creation of a new field in the attribute table and, later, the calculation through the geometric calculator.

## III. RESULTS AND DISCUSSIONS

The hydrographic basins were consolidated as geographic compartments to achieve the integrated planning of land use and occupation, in which economic activities are associated with environmental quality. Rural producers use natural resources (mainly water, soil and vegetation), so that all the beneficial and harmful effects affecting rural areas and other sectors of society are influenced by them [17].

Table 1 presents the description and quantification of soil use and occupation classes of the Ribeirão São João basin for the mapping of the years 2007 to 2008 and 2012 to 2015.

*Table 1: Representation and quantification of land use classes for the mappings carried out.*

| Classes | Mapping 2007-2008 | | Mapping 2012-2015 | |
|---|---|---|---|---|
| | Area (m²) | Area (%) | Area (m²) | Area (%) |
| Rock outcrop | 4.786.139,85 | 5,21 | 5.019.683,09 | 5,46 |
| Marsh | 27.341,97 | 0,03 | 32.745,76 | 0,04 |
| Rock Field/Altitude | 81.557,06 | 0,09 | 0,00 | 0,00 |
| Agricultural prodution – banana | 0,00 | 0,00 | 15.758,21 | 0,02 |
| Agricultural prodution – cofee | 19.070.481,90 | 20,76 | 20.190.048,54 | 21,97 |
| Agricultural prodution – coconut tree | 0,00 | 0,00 | 4.763,39 | 0,01 |
| Other permanent crops | 405.448,71 | 0,44 | 584.426,96 | 0,64 |
| Other temporary crops | 1.311.016,55 | 1,43 | 645.983,26 | 0,70 |
| Mineral extraction | 22.491,02 | 0,02 | 26.888,20 | 0,03 |
| Macega | 3700029,56 | 4,03 | 3.955.715,98 | 4,31 |
| Body of water | 78.462,80 | 0,09 | 93.516,12 | 0,10 |
| Native forest | 14.209.741,51 | 15,47 | 14.235.669,15 | 15,49 |
| Native forest at na early stage of regeneration | 5.680.998,65 | 6,18 | 5.326.507,48 | 5,80 |
| Other classes | 2.294.371,70 | 2,50 | 2.331.438,98 | 2,54 |
| Pasture | 38.337.495,61 | 41,73 | 36.711.624,74 | 39,96 |
| Reforestation – Eucalyptus | 1.527.055,36 | 1,66 | 2.235.366,46 | 2,43 |
| Soil exposed | 346.395,31 | 0,38 | 468.711,07 | 0,51 |

In both mappings, there was a greater predominance of pastures and coffee cultivation, thus indicating that coffee cultivation and dairy farming and cutting are the basic economic activities carried out in this river basin.

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However, in the analyzed period, there was a small reduction of pasture areas linked to the increase of coffee cultivation, mainly under monocultures.

Agriculture, when improperly managed and disposed of in monocultures, contributes to soil impoverishment by modifying its physical, chemical and biological characteristics [19]. At the same time that dairy farming is widespread in Brazil, a phenomenon seen also in the São João river basin, sustainability must be present in this activity, especially since it is one of the sources of income for family agriculture. It has been the subject of academic interests and concerns, but not enough to contain the environmental impacts caused by the mismanagement of this economic activity [12].

In this way, despite having local economic relevance, livestock and coffee plantations, when managed incorrectly, cause problematic environmental impacts. The environmental impacts of these activities are, for example, the process of degradation of the physical, chemical and biological properties of the soil and the compromise of the local ecosystem [6]. Specifically, the problems caused by the use of agrochemicals and the action of tractors in the soil, causing compaction and greater soil turnover [2].

Regarding soil management in livestock, the problems caused may arise mainly from incorrect methods of plowing in areas of rugged relief, which, over time and through the action of erosive processes (intense precipitation and winds, for example), degrade the soil and may favor the emergence of gullies. Another consequence of improper handling of coffee and cattle breeding is the silting of water bodies, a phenomenon seen in Ribeirão São João and some of its tributaries. These activities are the ones that consume and waste water resources, as well as producing effects on the quality and quantity of water [22].

Therefore, given its high representation, the agriculture in the Ribeirão São João basin needs mitigation actions and mitigation of environmental impacts, linked to a correct territorial planning, in order to provide greater environmental, social and economic benefits.

Consolidated native vegetation was present in relatively low percentages compared to other river basins. The sub-basin of Ribeirão Estrela do Norte, also located in the state of Espírito Santo, for example, has 20% of native vegetation consolidated [5]. However, there was stability in the areas of native vegetation cover, while the vegetation in the initial stage of regeneration showed a small fall. In environmental terms, it means a positive factor, since it indicates that the anthropic action in this area was not drastic in the analyzed period, to the point of removing the native vegetation to give way to another type of soil occupation.

However, the low percentages of native plant cover consolidated and in the initial stage of regeneration indicate the need for mitigation actions and mitigation of the environmental impacts of economic activities, mainly agriculture and livestock, due to the consequences of the suppression of this plant. Some of them are, for example: loss of biodiversity, damage to the quality and quantity of surface water and soil exposure, which in turn leads to erosion and compaction [1]. Therefore, the low percentage of native vegetation is a worrying factor, although it has shown some stability during the period considered, indicating the need for actions that aim at the maintenance and even the expansion of native vegetation cover in this watershed.

Eucalyptus silviculture showed an increase of almost 1% in the analyzed period, indicating, therefore, a trend of growth of this crop in this river basin. Eucalyptus can cause beneficial environmental impacts such as, for example, soil recovery from degraded pasture. However, when handled incorrectly, it causes harmful consequences, such as damage to allelopathic effects and water resources [14].

The growth of eucalyptus forestry, which is linked to its improvement with technological research of genetic improvement and management, besides the use of wood in the production of cuttings and charcoal in small properties. However, planting must be done adequately, based on compliance with environmental preservation standards [24]. This growth is also seen in other river basins, such as the sub-basin of Ribeirão Estrela do Norte [5], thus highlighting the extraction of wood from eucalyptus as one of the economic activities that have been growing throughout the territory of the São João Ribeirão basin.

The macega presented percentages above 4% and succinct growth in the Ribeirão São João basin. However, these areas indicate a problem regarding the management and occupation of local lands, since they could be used with, for example, environmental recuperation or agroforestry systems. These systems present a higher level of sustainability, combating rural poverty, providing food security and conserving natural resources, contributing to a better quality of life in rural areas [15]. Therefore, they would bring greater use to the areas of macega and, moreover, would improve the local agricultural production to the detriment of the local monocultivos.

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The areas of exposed soil, although low coverage, had an increase in the analyzed period, which can be considered bad, because the soil is more vulnerable to erosive processes. These areas, in the sub-basin of Ribeirão São João, are arranged on unpaved roads and earthworks. In view of this situation, it is important to adopt measures such as the implementation of dry boxes to improve rainfall drainage and minimize soil erosion, good planning and maintenance of rural roads [5]. These measures are important for the improvement of the environmental quality of the sub-basin of Ribeirão São João, given the growth of this class.

Another class that is important to highlight is that of rocky outcrop, which presented percentages higher than 5%, which are significant values, justified by the local relief. However, the areas of mineral extraction do not predominate, indicating that the extraction of rocks is not a prominent activity in the region. The other classes had low representativeness, standing out only temporary and permanent crops, which, together, represented percentages lower than 2%. Fig. 2 and Fig. 3 show, respectively, the land use and occupation of the Ribeirão São João basin in the mapping of the years 2007-2008 and 2012-2015.

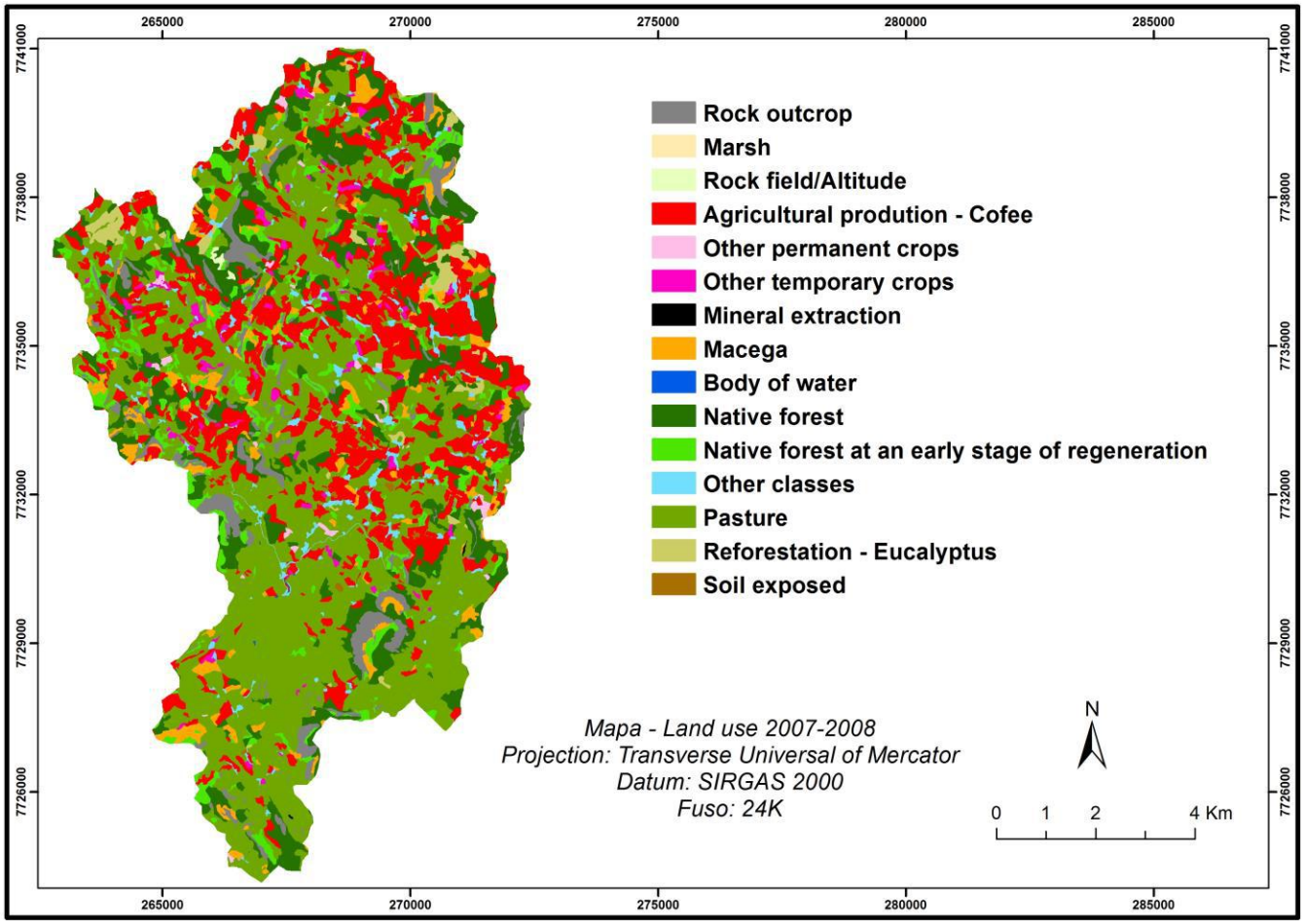


*Fig. 2: Use of soil referring to the mapping of the years 2007-2008.*

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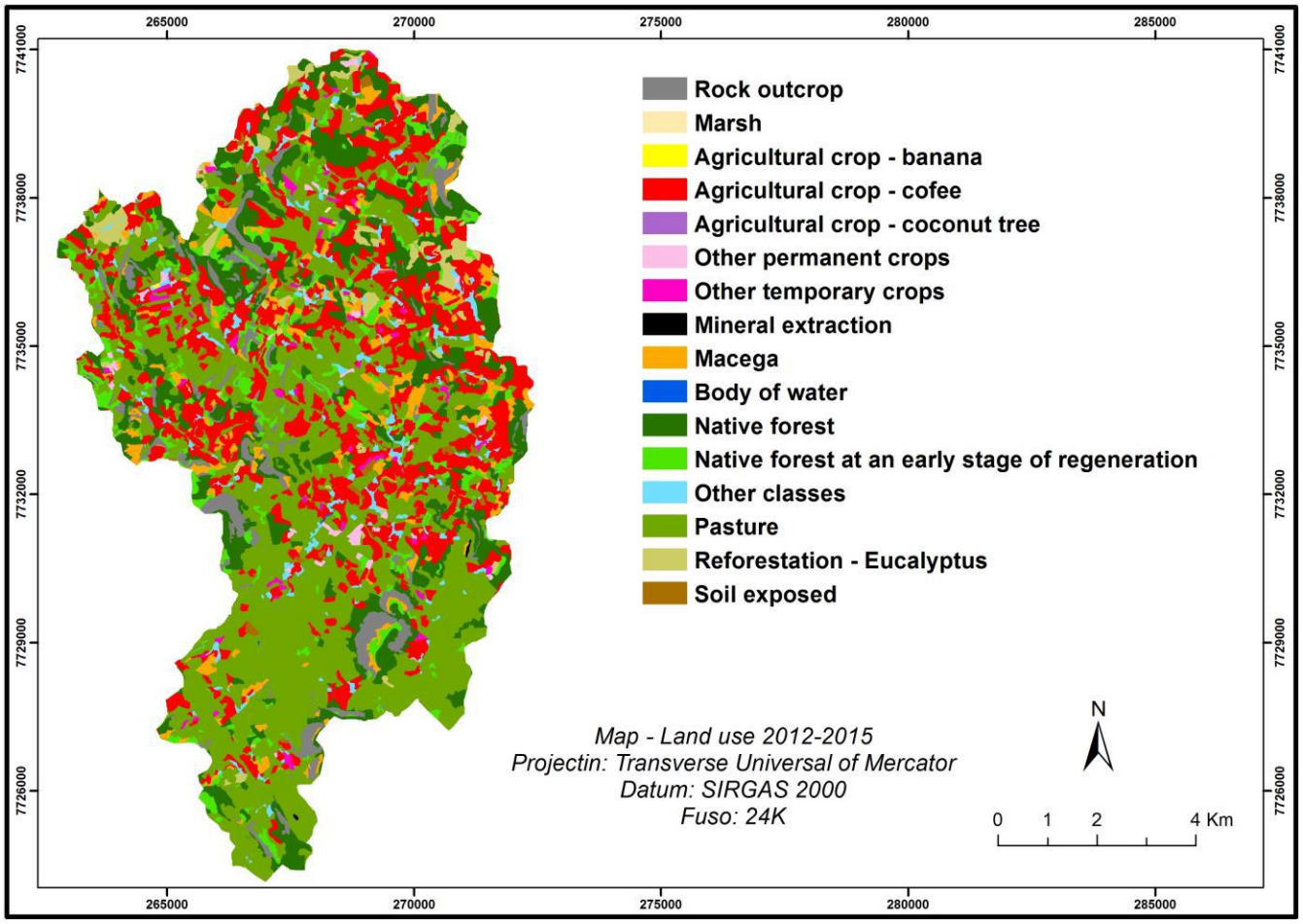


*Fig. 3: Use of soil referring to the mapping of the years 2012-2015*

In both maps, pasture was predominantly predominant in the southern portion of the watershed, while coffee cultivation was mostly disposed under small monocultures. However, several coffee growing areas were close to fragments of native forest, which in turn presented a fragmented pattern throughout the basin. Thus, one of the measures that could be considered would be the adaptation of agroforestry systems to these monocultures, as they would, for example, increase the circulation of fauna and flora in native forests, as well as improve the profitability of smallholders.

Another important factor is that several fragments of native forest were not linked to one another in a large part of the São João river basin. In view of this scenario, the implantation of ecological corridors linking these fragments is a relevant suggestion. These corridors represent one of the most promising strategies for effective regional planning for the conservation and preservation of flora and fauna. The Atlantic Forest, which is the predominant biome in the Ribeirão São João basin, for example, is one of the biologically richest and most threatened regions on the planet and urgently needs this type of planning [23].

The connection of forest fragments is of paramount importance due to the consequences of forest fragmentation, such as the extinction of species. Many of them require more forest area to survive. Most of the time, these remnants are surrounded by human activities [18], such as eucalyptus silviculture and agriculture, which are predominant economic activities in the area.

Some areas of macega were arranged close to the forest fragments, evidencing, therefore, needs of better management of the use of the local lands. In these areas, restoration or environmental restoration would be relevant because, in addition to increasing the vegetation cover of the soil, it would provide greater area for the circulation of the fauna and would improve the gene flow of the flora, besides softening the edge effect.

This effect is the set of modifications in the physical, chemical and biological parameters detected in the contact area of the plant fragment with the surrounding matrix [7], a phenomenon that can be emphasized for the

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Ribeirão São João basin and, while at the same time worrying about environmental issues.

## IV. CONCLUSION

In general, the river basin of Ribeirão São João suffered a degradation process, due to the high representativeness of agriculture (pasture and coffee cultivation, mainly) and the low percentage of native vegetation cover, while eucalyptus silviculture presented a high evolution. The fragmented pattern of native vegetation is a concern, especially in ecological terms. Therefore, the adoption of measures aimed at mitigating the environmental impacts mentioned in the course of the work is of great necessity, providing better environmental quality and greater sustainability in this river basin. In this way, it is expected that this work can subsidize improvements and the accomplishment of future studies in the considered area.

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