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Ecological-economic zoning as an instrument for the environmental management of hydrographic basins

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ABSTRACT

This study presents a proposal of ecological-economic zoning using the hydrographic basin of the Una River, Ibiúna, São Paulo, as a study area to subsidize the application of zoning as a management tool for water resources in the context of integrated environmental analysis. The zoning comprised four stages: delimitation of morphometric, physical, biotic, and socioeconomic parameters; definition of the environmental scenario; determination of management zones; and characterization of zones and definition of objectives, conflicts, permitted uses, potential, management actions, and legislation. The results indicate that the basin has 96 km², with an irregular and elongated shape, an average altitude of 937 meters, a maximum elevation of 1,175 meters, and a strongly undulating relief. Temporary agriculture (36.33%), dense rain forest (37.05%), and oxisol or Argisols predominate in the area. The socioenvironmental characteristics indicate that the sanitation rate of households, residents, and environment were higher in the urban area. About 86% of the population living in the basin are literate, while the percentage of access to the water and sewage system in the rural area is precarious. The EEZ comprised eight management zones, the main ones being agricultural and conservation zones, considered satisfactory and efficient for environmental management and favoring coordination and replication in similar areas.

Keywords: land use, environmental planning, water.

Introduction

Ecological-economic zoning (EEZ) is an instrument of territorial and environmental planning in Brazil. With legal framework in the National Environment Policy, it is regulated by the Decree number 4.297/2002, in addition to being an instrument for sustainable development on the 2020 Agenda (Brasil, 2002; Mâcedo et al., 2019). The EEZ is an instrument to aid environmental planning and management and has been ratified to organize densely occupied, fragmented territories with a high environmental impact (Barros, 2015; Lopes et al., 2019).

ZEE proposals derive from knowledge of physical, biotic, and socioeconomic aspects, which serve as reliable sources for the characterization of management zones. These

aspects include parameters that vary according to the intent of the study, its characteristics, and the local importance of the assessed territory. Among the parameters that subsidize the EEZ, the mapping of land use and vegetation cover is unanimous in EEZ proposals due to the need to know effective uses and activities in the territorial space (Silva Neto, 2014; Elhag, 2015).

The EEZ can be considered a permanent field of environmental study, as it allows the inclusion of a series of parameters, techniques, and methods to analyze different areas with differential characteristics in geographic and ecological terms. Even so, the study of the preparation of an EEZ allows considering various technologies and analyses that cooperate towards

a scientific development and aggregation of information for the conservation of natural resources.

Once the local attributes have been assessed and the environmental panorama has been obtained, the integration of these data is carried out seeking to indicate management zones to support the determination of where to allow, restrict, and improve the activities that occur within the zoned area. Integration techniques work in the spatial context due to the easiness of combining data in a Geographic Information System (GIS) and the potential of geotechnologies to translate quantitative and qualitative information at a spatial level. Among integration techniques are the use of map algebra, fuzzy logic, identification of susceptibility to erosion, cartographic interpretation, environmental vulnerability, multivariate analysis, and multicriteria analysis, as studies by Silva Neto (2014), Elhag (2015), Yates et al. (2015) e Lopes et al. (2016).

Cartographic interpretation has been shown to be the main way of zoning. It is defined as a subjective assessment of the organization of the type of use in management zones. The use of regression and multivariate analyses, map algebra, and multicriteria analysis are also required. The latter allows a debate between the team and specialists to assess the importance of each parameter, criterion, and established zones. Often, multicriteria analysis is difficult to deal with in order to obtain diagnoses but, although it seems complex, the greatest obstacle is the practical knowledge of the analysis software (Geneletti e Duren 2008; Leitão et al., 2019).

This process can also be characterized by the ability to transform technical and scientific data into additional information for framing land use and vegetation cover in management zones. It is worth mentioning that the process of integrating spatial information is costly in different aspects: acquisition of software when open source or free software is not available, basic knowledge on and mastery of the software, and advanced knowledge in robust techniques for environmental analysis.

Considering these issues, this study addresses the perspective of using ecological-economic zoning as an instrument for the environmental management of hydrographic basis, proving it to be an instrument for the conservation of natural resources in a basin, especially water resources, in view of the growing

demand for water in agricultural activities and in urbanized spaces.

This study hypothesizes that the definition of an ecological-economic zoning is an instrument capable of subsidizing the environmental management of water resources, allowing territory organicity and management actions to conserve, preserve, and recover the hydrographic basin. In order to prove this hypothesis, this study proposes a zoning in a highly anthropized hydrographic basin with multiple uses of natural resources, so that the barriers of use and occupation are assessed and solved during the integration of parameters.

The methodological process was the “analytical-aggregative integration.” It is characterized by obtaining an EEZ proposal using a simplified method, without disregarding the technical quality of the process or the validity of complex techniques. In these terms, this study aims to propose an ecological-economic zoning using the hydrographic basin of the Una River, Ibiúna, São Paulo, as the study area and subsidize the application of zoning as a management tool for water resources in the context of an integrated environmental analysis.

Materials and methods

Study área

The Rio Una hydrographic basin is in the municipality of Ibiúna, in the southeastern state of São Paulo, Brazil (Figure 1). The basin area is in a strategic position for the conservation of regional environmental attributes, as it is located entirely in the Itupararanga Environmental Protection Area and its water resources contribute significantly to the formation, together with other rivers, of the Itupararanga dam, which is used for water supply in the Sorocaba region and for hydroelectric power generation for the Companhia Brasileira de Alumínio (CBA).

This area was chosen for this study because it has relevant attributes that converge to the performance of an integrated management of land use and water resources, as the National Water Resources Policy of Brazil (PNRH) provides for, and for presenting a high spatial fragmentation in terms of land use. These characteristics compete to create a challenge of environmental management. They create increasingly degraded, fragmented spaces and a

hodgepodge of activities that require a complex study of environmental attributes and pose a challenge for managers and researchers to indicate

ways to harmonize conservation with development.

Figure 1. Location of the basin of the Una River, Ibiúna, São Paulo, Brazil.

Delimitation of analysis parameters

Table 1 lists the variables investigated for the proposal of EEZ. They are subdivided into four main axes: landscape, morphometry, physical environment, and biotic and socioeconomic variables. The parameters were analyzed in a spatial way from data processing routines using geoprocessing and remote sensing techniques, as described below, performed with the Geographic Information System (GIS) environment of the software ArcGIS 10.8 (Esri, 2019), licensed to the Laboratory of Geoprocessing and Environmental Mathematical Modeling at the UNESP Sorocaba.

To conduct the analyses, a cartographic database was created containing planialtimetric information, delimiting the limits of the hydrographic basin and its sub-basins based on information from topographic maps of the

municipality of Ibiúna deposited at the Geographic and Cartographic Institute (IGC) free of charge, in digital format, through the collection of the Environmental Spatial Data Infrastructure of the State of São Paulo (DATAGEO) (Igc, 1978; Datageo, 2015).

Regarding the landscape parameters, the mapping of land and forest use was based on the orthorectified multispectral image of the RapidEye satellite, year 2013, using the technique of visual interpretation and class definition and technical manuals as a basis of Land Use and Brazilian Vegetation of the Brazilian Institute of Geography and Statistics (IBGE) (IBGE, 2012; 2013). The classification results were validated by field observations using an Etrex Vista Garmim GPS navigation device and a digital camera. The delimitation of the PPAs of hydrography, slope,

and hilltops were performed according to the measures provided for in the Brazilian Forest Code (Brasil, 2012).

For the morphometric axis, the analyses were performed using a construction of the Digital Terrain Model (MDT) and the TIN method. The hydrological information was obtained through the slope and aspect modules. The geometric and drainage characteristics were calculated with the Hydrology and Integrated Water Management modules in the software Idrisi Selva (Clark Labs, 2012), licensed to the Laboratory of Geoprocessing and Environmental Mathematical Modeling at the UNESP Sorocaba.

In the physical axis, the soil was characterized based on the soil map of the state of São Paulo, at a cartographic scale 1:500,000, and on the analysis of soil texture and organic matter in a sampling with 35 points distributed between land and forest uses, according to the pipette method of the Air-Dried Fine Earth (TFSA) and the combustion method, respectively, according to the methodology of the Agronomic Institute of Campinas (Iac, 2009).

Table 1 - Parameters and variables analyzed in the EEZ proposal.

Axis	Parameter	Variable
Landscape	Land use	Mapping land use and forests
	Permanent Preservation Area (PPA)	PPAs of rivers, springs, lakes, ponds, reservoirs, slopes, and hill tops
Morphometry	Geometric characteristics	Total basin area (A)
		Total basin perimeter (P)
		Basin length (L)
		Basin width
		Average basin altitude
		Average slope
		Compactness coefficient (Kc)
		Circularity index (Ci)
		Form factor (KF)
	Drainage network characteristics	Order of courses
		Total length of watercourses
		Main watercourse length
		Drainage density
		Initial main course altitude
		Final main course altitude
		Sinuosity coefficient
		Concentration time (CT)
	Hydrological characteristics	Slope
		Relief orientation
		Shading
Physical environment	Soil	Soil texture
		Soil type
		Organic matter
Biotic environment	Flora	Normalized difference vegetation index (NDVI)
		Photochemical Reflectance Index (PRI)
		Carbon flow index (CO ₂ Flux)
		Shape, structure, and distribution of natural fragments
		Relationship fragments and hydrography distance
		Relationship fragments and hypsometry
		Relationship fragments and slope
	Birds	Composition and inventory of birds
		Bioindicator species
		Rare, endemic, and/or endangered species
	Social/Human/Economic Influence	Demographics (total population, urban and rural)
		Housing Quality Index
		Social Insertion Index

Socioeconomic	Socioeconomic Quality Index
	Households with water supply (HWS)
	Households with sewage network (HSN)
	Waste destination (WAS)
	Own and paid households (DP)
	Households with an income of 1 to 2 minimum wages (HI)
	Literate people (LP)
	Housing Quality Index (HQI)
	Social Insertion Index (SII)
	Socioenvironmental Quality Indicator (SEQI)

For the biotic axis, the analysis of the shape and fragmentation of vegetation was performed by a classification in size: < 5 ha (small fragments), 5-50 ha (medium fragments), and > 50 ha (large fragments), according to Pirovani et al. (2014). Subsequently, the landscape metrics for the fragments were calculated using the V-LATE extension. The spectral evaluation of the vegetation quality was performed considering the spectral bands of the RapidEye satellite image. The NDVI was analyzed according to Rouse et al. (1974); the PRI according to Gamon (1992); and the CO2Flux according to Rahman et al. (2000). The fauna was incorporated into the study through an inventory of birds conducted in forest fragment areas within the study area, indicating the species composition and bioindicator and threatened species (Sales, 2017; Sales, 2019).

The socioeconomic axis consisted of the analysis of secondary data from the IBGE demographic census, through which information on education, income, demography, and environmental sanitation was screened to determine the Housing Quality Index (HQI) and the Social Insertion Index (SII), which originated the Socioenvironmental Quality Index (SEQI), according to Vedovato et al. (2011).

Delimiting the Ecologic-Economic Zoning (EEZ)

Using the information for each axis, an environmental scenario was defined. The environmental scenario consists of a stage at which one seeks to describe the largest number of characteristics of the basin, whether spatial or not, facilitating the process of compartmentalization of the territory into management zones. The environmental scenario can also be understood as a stage at which each unit of land must be superimposed on the variables analyzed for a detailed description of characteristics, making it possible to obtain consistent data to indicate the

pertinence of the activity, its regularity, and future orientations for the activity in management zones.

From the environmental scenario the study area is critically analyzed. Management zones are therefrom delimited, which considers the spatial rearrangement of land use activities based on technical information on the following attributes: landscape, physical environment, morphometric aspects, biotic environment, and socioeconomic aspects of the hydrographic basin, as Figure 2 shows.

Delimited by four stages, the management zones allow obtaining a EEZ proposal capable of being analyzed and implemented to manage water resources. At Stage I, after defining the management zones, the spatial area of these areas is defined using joining, intersection, and clipping procedures. Then, the characterization of the zones is made following a spatial scope. The use of these tools supports the compilation of the activities of the territory within the zones, encouraging the execution of simplified methodological processes, even when revising and adjusting the zoning proposal.

At Stage II, the environmental characterization of these zones is made through the environmental scenario and new intersections between the zones and the parameters analyzed. At Stage III, the management actions for the zones are defined by delimiting the objectives, uses, potentialities, environmental conflicts, and applicable municipal, state, and national legislation. Finally, Stage IV is carried out, which consists of the union of vector files of management zones to obtain the EEZ proposal in a single file and the performance of its segmentation for sub-basins aiming to obtain a second document to guide the management of the area in a feasible and efficient way.

The delimitation of zones for the hydrographic basin and its respective sub-basins is relevant because in cases of fragmented territories, the segmentation of an area facilitates

the management and the EEZ implementation process.

Figure 2. Stages for determining management zones.

Results and discussion

Agricultural activities account for the highest rate of land use. This is the main economic activity of the hydrographic basin, aiming the commercialization of plant species that supply several regions of the state of São Paulo. Seabra et al. (2014) reported similar rates. In addition to identifying the highest percentage of agricultural area in a hydrographic basin in Paraíba, the authors warned about the problems caused to the water sector due to sudden changes in land use and vegetation.

The areas of natural vegetation represent 38.09% of the territory, 37.05% of which is Montana Dense Ombrophylous Forest and 1.04% is alluvial community. According to Bosa et al. (2015), this forest formation plays an important role in hydrographic basins, as it acts in the control of erosive processes, the infiltration and gradual release of rainwater, and the maintenance of river springs.

Urban buildings are aggregated in the low course of the Una River hydrographic basin and rural buildings predominate in the medium and high river courses due to the local rural vocation. The basin territory is home to two important areas related to environmental sanitation in the municipality of Ibiúna: the municipal landfill and the water treatment plant.

The basin presents 60% of the territory with anthropogenic influence, and of the 2,091 ha of PPAs, approximately 51% are in accordance with the environmental legislation, while irregular

areas are characterized by the existence of temporary crops, buildings, and degraded fields.

On the physical, morphometric, and pedological structure, the basin has an area of 96 km², a perimeter of 75 km, a length of 19.74 km, and a width of 4.88 km. It has an irregular and elongated shape, culminating in the low occurrence of floods and a good flow to the main watercourse. These data point to the fact that the area has a good capacity for recharging groundwater (Bajabaa et al., 2014).

The watercourse is considered extensive (25.50 km in length) and the total drainage corresponds to 207.04 km, with five orders, a good density, and a dendritic pattern (Villela e Mattos, 1975). The altitude varies between 850 and 1,175 m, and 54% of the area is represented by altitudes between 900 and 1,000 m. The relief has a slope with wavy characteristics throughout the territory, with punctual areas to the north and south, presenting 3.87% of slopes above 45%.

In the basin, there are predominantly Latosols and Argisols. Regarding the textural characteristics, the areas of forest and temporary crops have textures between clayey and sandy-clay; in the alluvial community, there are loamy and loamy soils and in forestry areas there are loamy soils. Organic matter predominated between 10% and 67%, with higher percentages in areas of natural vegetation.

As for natural vegetation, the size of the patch of forest fragments is estimated at 3,589 ha, an average size of 17 hectares, and a total of 905 m of edges with an average density of 266 m/ha. There are 197 forest fragments, with a greater number of fragments smaller than 5 ha, representing 53% of its total. These fragmentation rates can be explained by the anthropic agricultural and urban uses around the vegetation, making them barriers to the flow of fauna and flora and to the maintenance of local biodiversity, favoring deforestation for new productive áreas (Valente e Vettorazzi, 2002; Muchailh et al., 2010; Bizama et al., 2011; Goerl et al., 2011).

The largest number of fragments is found at an intermediate altitude of 850 to 950 m. 141 fragments have with some drainage, reinforcing the need to conserve these areas to maintain the water quality of the Una River hydrographic basin.

The vegetation indexes identified an NDVI at an interval of [0.50 - 0.80], considering the vegetative vigor of the forest fragments as

optimal. The PRI indicates that the fragments had a moderate capacity for photosynthetic production, with an interval of [0.47 - 0.60]. The highest PRI values occur in fragments within the limits of the basin associated with the margins of water bodies and the highest scores of NDVI.

The CO2Flux reveals a moderate content of carbon absorbed by the forest vegetation, at an interval of [0.20 - 0.42]. The fragments with the greatest uptake of atmospheric carbon are in the west and south of the basin, with hydrography in their interior, altitude of approximately 900 m, wavy to strongly wavy reliefs, and the highest NDVI and sPRI scores. The spectral values of the fragments were also associated with physical variables. The highest scores of NDVI, PRI, and CO2Flux concentrated in fragments with drainage inside, at higher altitude, and steeper slopes.

The inventory of the birds in the forest fragments carried out by Sales (2019) identified the presence of 147 species, grouped into 46 families and 20 orders. The family Tyrannidae has the largest representation (23 species). Among birds species, five of them are considered bioindicators of environmental quality, namely: *Theristicus caudatus* (buff-necked ibis) observed in the southern fragments, *Euphonia pectoralis* (chestnut-bellied euphonia) in the middle portion, *Tinamus solitarius* (solitary tinamou), and *Euphonia pectoralis*, present only in large fragments, as it quickly disappears in small, isolated forests. The *Procnias nudicollis* (bare-throated bellbird) was the only species found which is included on the vulnerability list and located at higher altitudes (Sales, 2017).

Regarding the socioeconomic characterization, the rate of households in the urban area represents about 60% of all households and the total population of the basin corresponds to 29,906 inhabitants. The highest demographic and household rates occur in the flatter reliefs. The educational sector had 25,616 literate inhabitants, corresponding to 86% of the population in the basin.

At least 3,173 households have an income between one and two minimum wages, with approximately 65% of the total households having other values or lack of income. The highest rate of owned and paid households is also in the urban area. Approximately five thousand households are in this situation, representing more than half of the households (54%) in the area.

Regarding environmental sanitation, the best rates are concentrated in the urban area. Among them, the best rate was for garbage collection, which serves about 93% of all urban households, followed by the presence of a water and sewage network. The percentages referring to the water and sewage network in rural areas are considered low, representing 19% and 0.6% of rural households, respectively. It is worth mentioning that, according to Rodrigues et al. (2010), the pollution of water resources, the deposition of pollutants, and domestic sewage in urban and rural areas cause damages due to the lack of adequate environmental planning of the hydrographic basin.

The SII in the basin had scores ranging from [0.42 to 0.77]. Areas in the center, east, and west showed better socioeconomic conditions. Areas to the south presented SII values below 0.60 and are distributed throughout the territory. The HQI showed the best qualification for the urban area and the decrease in quality is proportional to its distance.

When analyzing the Socioenvironmental Quality Index (SEQI), there is a spatial variation between [0.31 and 0.80], corresponding to a quality between excellent and regular for the basin. The buildings that presented an excellent SQI classification are found exclusively in the north of the basin in the urban area, while a good SEQI is distributed throughout the territory. The areas qualified with regular SEQI are to the south, in the rural zone.

The challenge of understanding the multiple uses that occur in the hydrographic basin domain and its interactions with water resources demanded the investigation of qualitative and quantitative parameters of different orders, since this study does not focus on establishing a zoning without considering the social and economic influence on natural resources, a fact that motivates an ecological-economic zoning. In addition, the studies on these characteristics have allowed the creation of indicators and indexes that condense information that guide, monitor, and evaluate the territory and allow for in-depth knowledge of territorial environmental management (Butsic et al., 2010; Pereira et al., 2011).

Table 1 shows the quantitative of management zones and Figure 3 shows the proposed EEZ for the basin and its sub-basins. In this proposal, there are eight management zones.

They were based on the environmental scenario prepared, namely: consolidated and unconsolidated residential zone, conservation zone, monitoring zone, recovery zone, permanent preservation zone, and primary and secondary agricultural zone.

Table 1 - Quantitative of the management zones of the proposed EEZ.

ZONE	AREA (ha)	AREA (%)
Hydrography	42	0.43
Lakes/Reservoirs	81	0.84
Consolidated Residential Zone	244	2.52
Unconsolidated Residential Zone	919	9.50
Conservation Zone	2,524	26.05
Recovery Zone	1,138	11.75
Monitoring Zone	427	4.40
Permanent Preservation Zone	1,001	10.33
Primary Agricultural Zone	1,903	19.64
Secondary Agricultural Zone	1,409	14.54
Total	9,688	100

The characterization of each zone was conducted considering the grouping of zones, the technical characteristics acquired in the environmental scenario, legislation, programs, relevant projects, and local information. The zones were delimited considering the intended objectives, the uses, potentialities, environmental conflicts, and management actions.

The EEZ originally has a scale of 1:25,000, considered as a document on a detailed scale for environmental management (Brasil, 2006; Barros, 2015).

The conservation zone has the highest percentage of area (26.05%), but if the junction of

the two agricultural zones is considered, the total represents 34.18% of the territory and accounts for the largest zoned area. The two zones with the lowest percentage of area are the consolidated residential zone and the monitoring zone.

The monitoring zone shows an irregular use of activities in the basin, causing environmental degradation and making it impossible to consider these areas as permanent preservation and conservation areas, for example. It reinforces the pattern of irregular occupation and suggests the need to discuss the situation of PPAs in Brazil. Consolidated zone denotes the existence of a basic infrastructure defined by the IBGE as the one capable of offering quality of life in terms of urban infrastructure, education, health, and sanitation.

The recovery zone has 1,138 hectares of areas in need of intervention. With 12% of the area, one can consider a high rate of activity with environmental impacts or with irregular practices in land use and water management.

Table 2 shows the quantitative of the basin's EEZ management zones for each sub-basin. The sub-basin 1 houses, in its entirety, the consolidated residential area, which corroborates the location of a part of the urban area of the municipality of Ibiúna exclusively to the north of the hydrographic basin. This area has a developed urban infrastructure with a considerable flow of people resulting from the installation of a diversified commerce and land parcels and is the exit route from the municipality to the surrounding cities.

As one moves away from the north of the Basin, there is a variation in the percentages of the conservation zone of each sub-basin, with an increase in the rates of both primary and secondary agricultural zones.

Figure 3. Ecological-Economic Zoning Proposal for the Una River Hydrographic Basin.

This variation is the result of a predominance of the territory for agricultural production. Such observations are emphatic when observing the sub-basins 3 to 9, where the sum of the agricultural zones equals or exceeds the percentages of the conservation zone, showing that the area of the basin's middle course is widely used for economic development. For the sub-basins 10 and 11, the opposite occurs: there are higher and steepest areas, and higher conservation rates.

The permanent preservation zone does not exceed 15% in all sub-basins. Although the sub-basins 4, 6, 7, and 9 have high rates of agricultural

activity, they also showed higher percentages of PPAs. This may reflect the awareness by owners of productive areas of the conservation of water resources or the implementation of the Rural Environmental Registry in Brazil (Brasil, 2012).

The sub-basin 8 showed the most alarming percentages. The zones with anthropic activities represent the highest rates in this sub-basin, while the areas of restrictive preservation and conservation are small. This factor confirms the state of degradation to which this sub-basin is subjected.

Table 2 - Quantitative of the management zones in the sub-basins.

ZONE	Sub-basin 1		Sub-basin 2		Sub-basin 3		Sub-basin 4		Sub-basin 5		Sub-basin 6	
	4.64	0.40	1.87	0.38	2.76	0.46	6.80	0.42	5.06	0.35	2.61	0.45
Hydrography	8.13	0.62	3.24	0.67	9.65	1.60	9.28	0.60	17.02	1.20	4.66	0.81
Lakes/Reservoirs	243.67	19.10	-	-	-	-	-	-	-	-	-	-
Consolidated Residential Zone	106.81	8.36	68.03	14.10	105.20	17.50	128.20	8.00	243.27	17.10	10.81	1.90
Unconsolidated Residential Zone	424.56	33.22	171.40	35.55	132.80	22.10	407.80	25.40	257.15	18.06	129.90	22.70

Conservation Zone	109.99	8.60	62.44	12.94	81.77	13.60	146.00	9.10	176.38	12.40	65.74	11.50
Recovery Zone	40.48	3.12	17.34	3.60	27.94	4.65	54.81	3.41	111.42	7.82	14.26	2.50
Monitoring Zone	109.62	8.60	42.64	8.85	69.46	11.55	179.20	11.16	103.86	7.30	69.20	12.08
Permanent Preservation Zone	203.72	15.95	56.95	11.81	79.60	13.23	438.00	27.30	301.20	21.17	110.20	19.26
Primary Agricultural Zone	26.01	2.03	58.27	12.10	92.10	15.31	234.40	14.61	208.06	14.60	164.80	28.80
Secondary Agricultural Zone	1,277.63	100	482.18	100	601.28	100	1,604.49	100	1,423.42	100	572.18	100
Total	4.64	0.40	1.87	0.38	2.76	0.46	6.80	0.42	5.06	0.35	2.61	0.45

	Sub-basin 7		Sub-basin 8		Sub-basin 9		Sub-basin 10		Sub-basin 11	
ZONE	5.07	0.45	2.06	0.40	5.56	0.55	1.90	0.51	3.75	0.53
Hydrography	5.51	0.50	5.95	1.20	7.56	0.75	3.68	1.00	6.75	0.96
Lakes/Reservoirs	-	-	-	-	-	-	-	-	-	-
Consolidated Residential Zone	96.49	8.55	46.05	9.12	84.42	8.33	13.76	3.70	15.14	2.15
Unconsolidated Residential Zone	329.49	29.20	68.37	13.55	187.05	18.45	142.51	38.16	271.60	39.00
Conservation Zone	120.98	10.72	77.88	15.45	165.00	16.30	57.99	15.53	73.17	10.40
Recovery Zone	47.32	4.20	29.04	5.75	48.50	4.80	16.33	4.37	18.99	2.70
Monitoring Zone	122.20	10.82	33.83	6.70	123.54	12.20	45.47	12.18	102.04	14.53
Permanent Preservation Zone	178.68	15.83	185.60	36.78	211.34	20.86	29.80	7.98	106.56	15.17
Primary Agricultural Zone	222.61	19.73	55.78	11.05	179.93	17.76	61.89	16.57	104.38	14.80
Secondary Agricultural Zone	1,128.35	100	504.56	100	1,012.9	100	373.33	100	702.38	100
Total	5.07	0.45	2.06	0.40	5.56	0.55	1.90	0.51	3.75	0.53

Table 3 shows the characterization of each management zone and the definition of its management parameters to ensure the ordering maintenance within each area. Conservation and preservation zones aim a total protection of natural resources, while monitoring zone seeks to organize activities, avoiding expansion.

Agricultural zones reinforce the management of the main economic activity and the residential zone aims the correct use of the territory for the housing area. In this way, the descriptions cooperate to make decisions that allow the environmental management of the Una River hydrographic basin as a measure of conservation and development.

Table 3 - Characterization of the EEZ management zones of the Una River Hydrographic Basin.

CONSERVATION ZONE	
Characteristics	Zone composed of areas of natural vegetation of the alluvial community, located exclusively to the north and close to the exutory and the fragments of montana dense ombrophylous forest. The zone is dispersed throughout the basin, with a road network built over the entire area. The alluvial community is in a flat relief, 850 m high, and well lit, in areas of Latosol with clay texture. The fragment areas are in flat to strongly undulating reliefs, altitude between 850 and 1,050 m, in well-lit areas, and 75% of the total with presence of hydrography. About 78% of the fragments are in Latosols, with a predominance of clayey, sandy-clay-loam and sandy-clayey textures, requiring greater conservation efforts due to their intermediate water retention capacity. The percentages of organic matter may reach 70%. It favors microclimate development inside the soil through a biotic quality provided by physical and biotic conditions. Vegetative biomass is considered dense (NDVI between 0.50 and 0.79), the photochemical reflectance is moderate (PRI between 0.32 and 0.57), and the carbon flux is regular (CO ₂ Flux between 0.20 and 0.41). The birds inventory in this area identified 147 species (46 families and 20 orders), with an abundance of 9,025 individuals.
Objective	Conservation of the natural vegetation area, making a sustainable use when allowed to use it.
Environmental Conflicts	Introduction of exotic species; Anthropogenic influence due to the proximity to residential areas and agricultural crops; Edge effect on forest fragments.
Allowed Uses	Development of scientific research in the field of fauna and flora conservation; Development of environmental education activities; The areas of forest fragments with larger sizes can be used for ecotourism;
Potentialities	Development of a management system for green areas with the creation of reserves, PRNHs,

	and parks; Development of ecological tourism.
Management Actions	Inspection and monitoring of the activities surrounding natural areas seeking to minimize incident edge effects; Inspection and monitoring of deforestation and irregular extraction of local flora; Inspection and monitoring of hunting activities and trade of fauna species. Guidance for the importance of vegetation cover to soil conservation, its structure, and its composition.
Legislation	Constitution of the Federative Republic of Brazil Law no. 6,938/1981 - National Environment Policy Law no. 7,663/1991 - State Water Resources Policy of the State of São Paulo Law no. 9,433/1997 - National Water Resources Policy State Law no. 9,509/1997 - São Paulo State Environmental Policy Decree no. 4,297/2002 - Criteria for the Ecological-Economic Zoning of Brazil Law no. 11,428/2006 - Atlantic Forest Law Ibiúna Urban Master Plan

RECOVERY ZONE

Characteristics	Zone composed of exposed soil, degraded areas to the south, and areas of PPA at a degraded state occupied by agricultural crops, livestock, and forestry. The zone has a road network along its territory, allowing good access to its areas. The degraded areas are located on a slope between 0 and 354%, flat to steep relief, altitude between 850 and 1,090 m, with shaded or well-lit areas. Predominantly in Latosols, the texture in the center is clayey with a greater water retention, and in the south, it may vary from sandy clay loam to sandy-clayey, favoring erosion and leaching processes. The crop areas are located on a slope between 0 and 212%, flat to steep relief, altitude between 850 and 1,093 m, with shaded or well-lit areas. The silt percentages vary from 2 to 27%, total sand varies between 11 and 69%, clay varies between 10 and 60%, and organic matter reaches up to 68% in Latosols and Argisols.
Objectives	Recover degraded areas of the basin by reforesting native species and preventing soil erosion and leaching; Correction of physical and chemical characteristics of the soil, especially in abandoned agricultural areas; Maintain vegetation cover in areas with exposed soil and recover areas of PPAs identified as irregular;
Environmental conflicts	Soil exposed in areas close to residential areas; Degraded fields in a fallow state or abandoned by the owners without proper soil management; Soil erosion and leaching; Suppression of natural vegetation; Permanent preservation areas with irregular activities.
Allowed Uses	Environmental studies for the recovery of permanent preservation areas. Areas not belonging to PPAs can be used to build accesses to residential and commercial areas. Degraded areas can be used for environmental compensation by companies that act irregularly on the basin or by new ventures as an adjustment term;
Potentialities	Reincorporation of recovered areas in PPA areas, abiding to the Forest Code, and increase in the quantitative and qualitative percentages of these areas; The other areas, when recovered, can be incorporated into the conservation zone; If there is no possibility of recovery of natural systems, the zone can be used in the public interest to build headquarters for public properties of collective interest.
Management Actions	Encourage the implementation of plans to recover degraded areas; Monitor irregular areas in PPA ranges; Inspection and monitoring of area use aiming to guide activities with conservationist practices.
Legislation	Constitution of the Federative Republic of Brazil Law no. 6,938/1981 - National Environment Policy Law no. 7,663/1991 - State Water Resources Policy of the State of São Paulo

	<p>Law no. 9,433/1997 - National Water Resources Policy State Law no. 9,509/1997 - São Paulo State Environmental Policy Decree no. 4,297/2002 - Criteria for the Ecological-Economic Zoning of Brazil Law no. 11,428/2006 - Atlantic Forest Law Law 12,651 / 2012 - Brazilian Forest Code Ibiúna Urban Master Plan</p>
MONITORING ZONE	
Characteristics	<p>Zone with buildings located in the permanent preservation range. Included in these environments are small forest fragments, interspersed with residential areas, agricultural crops, the Effluent Treatment Station, the Sanitary Landfill of the municipality of Ibiúna, and a road network allowing ample access to these areas.</p> <p>The forest fragments of this area represent areas of vegetation smaller than 5 ha, in a wavy relief, altitude between 900 and 110 m, with hydrography in 81% of these areas. This area has 22% of Argisol, with clayey texture and organic matter reaching 66%, thus inducing a predisposition to water retention, good moisture rates, and favorable microclimate to other organisms inside it. Vegetative biomass is considered dense (NDVI between 0.50 and 0.76), the photochemical reflectance is moderate (PRI between 0.43 and 0.57), and the carbon flux is regular (CO₂Flux between 0.22 and 0.39). The birds inventory in this area identified 147 species (46 families and 20 orders), with an abundance of 9,025 individuals.</p> <p>Buildings have a social insertion index ranging from good to excellent, with satisfactory levels of income, education level, and households. The housing quality index is between poor and excellent, with buildings with or without basic sanitation, resulting in an indicator of environmental quality from regular to excellent.</p>
Objectives	<p>Control activities in areas of permanent preservation aiming to minimize the expansion of urban buildings in these areas;</p> <p>Control and conserve human activities in areas of forest fragments smaller than 5 ha, including in the surroundings.</p>
Environmental conflicts	<p>Areas inside PPAs with the impossibility of total/partial recovery of natural systems;</p> <p>High anthropic effect around forest fragments smaller than 5 ha;</p> <p>Edge effect and pre-disposition of forest fragment areas to winds, light, humidity, temperature etc.;</p> <p>Buildings have low rates of basic sanitation.</p>
Allowed Uses	<p>Environmental studies of re-composition of vegetation of small forest fragments;</p> <p>Environmental studies on forest fragmentation in residential and agricultural areas;</p> <p>Environmental studies on richness, distribution, and extinction of fauna and flora species;</p> <p>Collection and treatment of domestic, industrial, and hospital waste inside the Municipal Landfill;</p> <p>Collection and treatment of effluents inside the Domestic Effluent Treatment Station.</p>
Potentialities	<p>Connectivity to nearby forest fragments seeking to increase the area of natural vegetation in the basin;</p> <p>Development of scientific research on the residential and urban influence and on forest fragmentation;</p> <p>Development of environmental education programs for the local population;</p> <p>Investment in basic sanitation programs for buildings with low water, sewage, and garbage network rates.</p>
Management Actions	<p>Inspection and monitoring of land use in PPA areas aiming to minimize the expansion of buildings already installed and associated activities;</p> <p>Sensitization of the ecological functions of permanent preservation areas for the local population;</p> <p>Monitoring the quality of post-treatment effluent discharge into the hydrographic network;</p> <p>Control of soil erosion, suppression, and deforestation of natural vegetation;</p> <p>Restoration of the riparian forest of watercourses with residences already installed in them.</p>
Legislation	<p>Constitution of the Federative Republic of Brazil Law no. 6,938/1981 - National Environment Policy Law no. 7,663/1991 - State Water Resources Policy of the State of São Paulo Law no. 9,433/1997 - National Water Resources Policy State Law no. 9,509/1997 - São Paulo State Environmental Policy</p>

	Decree no. 4,297/2002 - Criteria for the Ecological-Economic Zoning of Brazil Law no. 11,428/2006 - Atlantic Forest Law Law 12,651 / 2012 - Brazilian Forest Code State Law No. 12,300/2006 - State Policy on Solid Waste Ibiúna Urban Master Plan
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PERMANENT PRESERVATION ZONE	
Characteristics	Zone with an area of montana dense ombrophylous forest and alluvial community, the Una River and its tributaries, lakes, and urban and rural ponds, which include marginal strips of 30 meters for hydrography and 50 meters for springs, in addition to areas with slope higher than 45 degrees. These areas are in a slope between 0 to 164%, altitude between 850 and 1,130 m, and shading between 0 and 254 luminosity levels. In Latosol areas, there is a predominance of clay loam texture in alluvial communities with a greater water retention, in line with their phytogeographic and clay loam characteristics in forest fragments, with organic matter around 68%. Vegetative biomass is considered good (NDVI between 0.50 and 0.77), the photochemical reflectance is moderate (sPRI between 0.41 and 0.59), and the carbon flux is regular (CO ₂ Flux between 0.20 and 0.40). The birds inventory in fragment areas identified 147 species (46 families and 20 orders), with an abundance of 9,025 individuals.
Objectives	Preservation of wet areas and riparian forest; Preservation of fragments of montana dense ombrophylous forest and species that reside in it; Conservation of local hydrography.
Environmental conflicts	Proximity to anthropic influence activity throughout the entire area.
Allowed Uses	Development of scientific research, as long as authorized by the proper environmental agency. Studies focused on environmental education
Potentialities	Preservation of natural resources and maintenance of wet and forested areas seeking the quality of PPAs and their surroundings.
Management Actions	Inspection and monitoring of areas to avoid use and exploitation; Sensitization of the ecological functions of permanent preservation areas; Sensitizing the population regarding the ecological functions of wetlands and forests; Restriction on occupation in the area's territory. Water quality monitoring studies;
Legislation	Constitution of the Federative Republic of Brazil Law no. 6,938/1981 - National Environment Policy Law no. 7,663/1991 - State Water Resources Policy of the State of São Paulo Law no. 9,433/1997 - National Water Resources Policy State Law no. 9,509/1997 - São Paulo State Environmental Policy Decree no. 4,297/2002 - Criteria for the Ecological-Economic Zoning of Brazil Law 12,651 / 2012 - Brazilian Forest Code Ibiúna Urban Master Plan

CONSOLIDATED RESIDENTIAL ZONE	
Characteristics	Zone with built area and consolidated road networks, where trade activities, hotel chains, and residences are intensified in the basin area. The zone is at altitudes between 850 and 986 m, well lit, with a slope between 0 and 93%, and relief between plane to wavy. The social insertion index varies between good and excellent, with favorable conditions for educational level, income, and households. The housing quality index is between regular and excellent, with satisfactory basic sanitation infrastructure, resulting in an environmental quality indicator ranging from good to excellent.
Objectives	Sustainable use of the residential area aiming at consolidating urban, commercial, and tourist areas and preserving the sociocultural values of the population.
Environmental conflicts	Degradation of water resources in the residential area; Garbage disposal on residential roads; Noise pollution;
Allowed Uses	Civil construction, provided that there are environmental impact studies when potentially

	degrading. Development and improvement of the main road network with access to residential areas. Diversified trade and services in line with the conservation of natural resources.
Potentialities	Consolidation of the urban and tourist area with quality goods and services; Development of a tourism and urban management system in partnership with the city hall, entrepreneurs, and the civil society aiming to improve the leisure conditions of the population and tourists; Creation of cooperatives with the local population, encouraging the generation of jobs and income; Development of a quality program for green areas in residential areas. Development or improvement of the municipal selective waste collection program. Programs to encourage, develop, and improve the educational and cultural quality of the population.
Management Actions	Monitoring of the residential area aiming to minimize the suppression of vegetation in these areas; Monitoring, evaluation, and expansion of the basic sanitation system when necessary; Development of sociocultural actions and environmental activities in residential areas.
Legislation	Constitution of the Federative Republic of Brazil Law no. 6,938/1981 - National Environment Policy Law no. 7,663/1991 - State Water Resources Policy of the State of São Paulo Law no. 9,433/1997 - National Water Resources Policy Decree no. 4,297/2002 - Criteria for the Ecological-Economic Zoning of Brazil State Law No. 12,300/2006 - State Policy on Solid Waste Ibiúna Urban Master Plan

UNCONSOLIDATED RESIDENTIAL ZONE	
Characteristics	Zone with built area and secondary road networks without paving and low basic sanitation, education level, and home infrastructure. It also has processing facilities, transportation, and cultivation of agricultural products. The zone is at altitudes between 850 and 1,068 m, well lit, with a slope between 0 and 79%, and relief between plane to gently wavy. The social insertion index of buildings varies from regular to good, with low education levels and income rates in households. The housing quality index is between bad and good, with basic sanitation rates considered precarious, resulting in an indicator of environmental quality between bad and good.
Objectives	Regularization of the residential area aiming at consolidating urban or rural, commercial, and tourist areas and preserving the sociocultural values of the population.
Environmental conflicts	Degradation of water resources close to the residential areas; Discharge of domestic effluents and garbage in water resources areas and paved roads; Fires; Suppression of vegetation areas around buildings.
Allowed Uses	Development of the road network with access to the most distant neighborhoods; Implementation of water supply and sewage treatment systems to meet the demands of the local population. Civil construction, provided that they meet the municipal requirements for regularity of properties; Diversified trade and services in line with the conservation of natural resources.
Potentialities	Consolidation of the residential area and of commercial activities; Development of an urban management system aiming to characterize and consolidate residential areas; Creation of cooperatives with the local population, encouraging the generation of jobs and income; Development of a quality program of green areas for residential areas. Development or improvement of the municipal selective waste collection program. Subsequent incorporation of areas with consolidated residential characteristics into the consolidated residential area. Programs to encourage, develop, and improve the educational and cultural quality of the population.
Management	Monitoring of domestic effluent discharges, with notification of the irregularity to the

Actions	competent government agency; Monitoring the deposition of household, industrial, and hospital waste along residential roads, with notification of the irregularity to the competent government agency; Development of sociocultural actions and environmental activities in unconsolidated residential areas aiming to raise public awareness of the occupation of areas at risk, pollution, and basic sanitation.
Legislation and Documents	Constitution of the Federative Republic of Brazil Law no. 6,938/1981 - National Environment Policy Law no. 7,663/1991 - State Water Resources Policy of the State of São Paulo Law no. 9,433/1997 - National Water Resources Policy Decree no. 4,297/2002 - Criteria for the Ecological-Economic Zoning of Brazil State Law No. 12,300/2006 - State Policy on Solid Waste Ibiúna Urban Master Plan

PRIMARY AGRICULTURAL ZONE

Characteristics	Zone composed of temporary agricultural crops, forestry, and livestock in predominantly illuminated relief, with developed road networks, and proximity to the SP250 Bunjiro Nakao state highway. Cultivation areas are on a slope between 0 and 99%, with relief between flat to gently wavy, altitude between 850 and 1,109 m. Crops predominate in Latosols (163 ha in Argisols), with a predominant clayey texture and up to 63% of organic matter. Pasture areas are on a slope between 0 and 82%, with relief between flat to gently wavy, and altitude between 850 and 1,090 m. Having only clay soils, the areas vary between clayey and sandy clayey, and the organic matter content may reach 57%. The forestry areas represented by <i>Eucalyptus</i> sp. and <i>Pinus</i> sp. are on a slope between 0 and 98%, with a relief between flat to gently wavy, and altitude between 865 and 1,105 m. With a predominance of Latosols, these areas have a texture between clayey and sandy clayey. Only 46 ha of forestry areas are in Argisols, and the organic matter content reaches 70%.
Objectives	Develop and consolidate crops with botanical and physiological characteristics for high luminosity rates, fostering the local and regional economy through agropastoral production using sustainable practices and conservation of water, soil, and the health of the population.
Environmental conflicts	Degradation and contamination of water resources; Introduction of exotic species; Agricultural practices using pesticides and burning; Vegetable suppression for the formation of pasture areas; Soil erosion and leaching.
Allowed Uses	Production of diversified temporary crops, silviculture for timber extraction, and livestock of small, medium, and large animals.
Potentialities	Consolidation of the agricultural economy in the municipality of Ibiúna; Creation of jobs and increase in local income through the link between producer and population; Consolidation and incentive to family farming; Implementation of sustainable agricultural development policies;
Management Actions	Inspection and monitoring of the use of pesticides and fires; Guidance for soil analysis at least three months before planting; Periodically evaluate the soil organic matter seeking a positive influence of density, porosity, release and fixation of nutrients, pH regulation, and food source for microorganisms; Periodic assessment of the quality and contamination of water resources by pesticides; Adequacy of agricultural activities to environmental legislation with adjustment terms of conduct or an equivalent legal instrument whenever necessary; Orientation and development of training for small, medium, and large producers on sustainable agricultural practices; Encouragement and strengthening of the local agroecological production chain seeking partnerships with NGOs, basin committees, the city hall, and the civil society; Indication for assessing soil fertility and plant nutrition. The use of the free <i>software</i> FERTI-UFV and NUTRI-UFV is recommended (http://www.agrosistemas.ufv.br/); Guide to the use of water in periods of irrigation considering the evapotranspiration of the crop. It is suggested to use the Technical Bulletin no. 196 of the Agronomic Institute of Campinas;

	<p>In Latosols: Recommendation for the production of annual and perennial crops, pastures, and reforestation. Guide the need for soil corrections regarding acidity and low fertility; Guide the unfeasibility of using fires and the excessive trampling of animals in pasture areas seeking to avoid exposed soil and dryness; Indicate that in Latosols with high sand contents, there is a greater susceptibility to erosion and leaching of nutrients, requiring conservationist treatments and careful management, since Latosols and Argisols are susceptible to erosion even after preparation for planting. In clayey Latosols, indicate fact that when intensely mechanized their porosity is reduced and forms a compacted layer (20-30 cm), making it difficult for plants to establish roots and for water to infiltrate.</p> <p>In Argisols: Indicate the strong occurrence of erosion in areas of crops with abrupt transitions of particle size textures associated with the increase in slope; Indicate the use of soil conservation practices to avoid losses of fertilizers and corrective agents due to erosion in dystrophic and alic Argisols. In soils with high fertility, production aiming family farming is indicated when there is no investment of capital; In soils with intermediate fertility, more intensive production and perennial crops are indicated.</p>
Legislation	<p>Constitution of the Federative Republic of Brazil Law no. 7,63/1991 - State Water Resources Policy of the State of São Paulo Law no. 9,433/1997 - National Water Resources Policy State Law no. 9,509/1997 - São Paulo State Environmental Policy Decree no. 4,297/2002 - Criteria for the Ecological-Economic Zoning of Brazil State Law No. 12,300/2006 - State Policy on Solid Waste Ibiúna Urban Master Plan</p>

SECONDARY AGRICULTURAL ZONE

Characteristics	<p>The zone presents exclusively areas of temporary agricultural crops in predominantly shaded relief, with developed road networks, and proximity to the SP250 Bunjiro Nakao state highway. The areas are on a slope between 0 and 98%, with relief between flat and gently wavy, and altitude between 850 and 1,115 m. Located exclusively in Latosols, the cultivation areas have a clayey texture in the north, a clay loam in the center, and clayey in the south. The contents of organic matter may reach 70%.</p>
Objectives	<p>Develop and consolidate crops with botanical and physiological characteristics for low luminosity rates, fostering the local and regional economy through agricultural production using sustainable practices and conservation of water, soil, and the health of the population.</p>
Environmental conflicts	<p>Degradation and contamination of water resources; Introduction of exotic species; Agricultural practices using pesticides and burning; Vegetable suppression for the formation of pasture areas; Soil erosion and leaching.</p>
Allowed Uses	<p>Production of diversified temporary crops.</p>
Potentialities	<p>Consolidation of the agricultural economy in the municipality of Ibiúna; Creation of jobs and increase in local income through the link between producer and population; Consolidation and incentive to family farming; Implementation of sustainable agricultural development policies.</p>
Management Actions	<p>Inspection and monitoring of the use of pesticides and fires; Guidance for soil analysis at least three months before planting; Periodically evaluate the soil organic matter seeking to assess its positive influence of density, porosity, release and fixation of nutrients, pH regulation, and food source for microorganisms; Periodic assessment of the quality and contamination of water resources by pesticides; Adequacy of agricultural activities to environmental legislation with adjustment terms of conduct or an equivalent legal instrument whenever necessary; Orientation and development of training for small, medium, and large producers on sustainable agricultural practices; Encouragement and strengthening of the local agroecological production chain seeking</p>

	<p>partnerships with NGOs, basin committees, the city hall, and the civil society; Indication for assessing soil fertility and plant nutrition. The use of the free <i>software</i> FERTI-UFV and NUTRI-UFV is recommended (http://www.agrosistemas.ufv.br/); Indicate the use of water in periods of irrigation considering the evapotranspiration of the crop. It is suggested to use the Technical Bulletin no. 196 of the Agronomic Institute of Campinas; In Latosols: Recommendation for the production of annual and perennial crops, pastures, and reforestation. Indicate the need for soil corrections regarding acidity and low fertility; Indicate the unfeasibility of using fires and the excessive trampling of animals in pasture areas seeking to avoid exposed soil and dryness; Indicate that in Latosols with high sand contents, there is a greater susceptibility to erosion and leaching of nutrients, requiring conservationist treatments and a careful management. Clayey Latosols are susceptible to erosion even after preparation for planting. In clayey Latosols, indicate fact that when intensely mechanized their porosity is reduced and forms a compacted layer (20-30 cm), making it difficult for plants to establish roots and for rainwater to infiltrate.</p>
Legislation and Documents	<p>Constitution of the Federative Republic of Brazil Law no. 7,663/1991 - State Water Resources Policy of the State of São Paulo Law no. 9,433/1997 - National Water Resources Policy State Law no. 9,509/1997 - São Paulo State Environmental Policy Decree no. 4,297/2002 - Criteria for the Ecological-Economic Zoning of Brazil Law no. 11,428/2006 - Atlantic Forest Law Ibiúna Urban Master Plan</p>

Conclusions

The zoning proposed here is an instrument with eight management zones that allow action and monitoring for the Una River hydrographic basin and its eleven sub-basins. The segmentation of the zoning in sub-basins encourages a localized management model, with easy detection and resolution of environmental problems.

The agricultural zones sum the largest territorial area, while the delimitation of conservation and permanent preservation zones make actions effective for the protection of 36.38% of the territory. The monitoring and recovery zones encourage environmental control. The sub-basin 8 has the highest anthropic activity and, consequently, management zones with immediate actions for the conservation of water resources.

The EEZ proposal considers the principles of utility and simplicity, facilitates the implementation of limits and restrictions by the government, and fosters the understanding by citizens, and protection, conservation, and recovery of natural resources, according to the Decree no. 4,297 of June 10, 2002.

The methodological process shows the possibility of integrated studies on the reality of the territory in a hydrographic basin. Therefore, the method assists in and benefits the

development of the EEZ with less complexity and allows its replication to other hydrographic basins. It is therefore an instrument for the management of natural resources with a view to implementing actions that minimize problems and environmental conflicts.

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