RESEARCH PAPER

QUANTIFYING LAND USE CHANGE DYNAMICS IN AGROTOURISM DESTINATIONS: A CASE STUDY FROM VENDA NOVA DO IMIGRANTE, BRAZIL

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ABSTRACT. Agrotourism is one of the main economic activities in the municipality of Venda Nova do Imigrante, located in the state of Espírito Santo, Brazil. The objective of this research was to analyse the landscape changes generated by this economic activity. The methodology's development through a stratified random selection, the thematic quality of the maps from the MAPBIOMAS platform was assessed. A confusion matrix was produced, and the kappa coefficient was calculated. Landscape metrics, Volunteered Geographic Information (VGI) from Instagram and Flickr Social Networks, satellite images and free Brazilian databases were used, along with the use of open source GIS software to analyse changes use and cover of land in the municipality generated over a period of 30 years and its relationship with agrotourism. In the results, it was obtained that the thematic quality of maps from the MAPBIOMAS platform was acceptable, the analysis of VGI in social networks was identified agrotourism farms located mainly in the south-east area of Venda Nova do Imigrante, the analysis of changes in land use and cover showed that the city had an increase in urban area around the Federal Highway BR-262 that cuts through the city and rural areas, as well as in the agrotourism farms evaluated, there was an increase in agricultural areas and planted forests.

KEYWORDS: rural tourism, space-temporal analysis, landscape metrics, volunteered geographic information, kappa coefficient, thematic quality maps

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INTRODUCTION

The agrotourism is an economic activity aimed to integrate tourists into agricultural communities, its main attraction is the agricultural landscape and the cultural customs of the locals (McGehee 2007; Phillip et al. 2010; Olivieri 2014). This type of tourism began in the 1960s, but gained popularity in the 80's and early 90's. In Brazil, agrotourism began to be explored at the end of the 1980s (Parra et al. 2006; Khairabadi et al. 2020), in the state of Espírito Santo, this activity began shortly after, in 1990. Due to its great impact in 1994, the Regional Development Center for Agrotourism was created in the municipality of Venda Nova do Imigrante. It was responsible for organizing agrotourism throughout the State of Espírito Santo. Currently, agrotourism is one of the main economic activities developed in the city, and its organization and touristic offer is recognized in the rest of the country, making it worthy of the title of National Agrotourism Capital (Pereira and Ribeiro 2011; Zandonadi 2013).

Agrotourism, in symmetry with other tourism segments in rural areas, promotes the conservation of natural formations necessary for the ecosystem balance together with traditional land use activities (Dublin et al. 2013; Towoliu et al. 2018), however, tourist activities can also have negative impacts on the environment (Almeida et al. 2022). In agrotourism the composition of the landscape (which are the present land uses) and the configuration of the landscape (how these land uses are distributed in space) are important characteristics because they are associated with positive and pleasant tourism experiences (Serenelli et al. 2017; Brandano et al. 2018). It is worth noting that the attractiveness of the tourism landscape in rural areas is the result of the consonance of attractions, structures, and services that allow the arrival, experiences, and permanence of the tourist (Towoliu et al. 2018).

Landscapes are dynamic and change over time, whether natural or cultural. To study these changes, one of the most used tools is landscape metrics, as they

allow us to quantify spatial structures and functions. Its initial application was in ecological studies, but due to its efficiency in evaluating land cover, especially in urban landscapes, it gained notoriety in different areas, becoming recognized in different areas of knowledge as well (Herold et al. 2005; Victorov 2012).

Landscape metrics can be used to monitor the development of tourist activity, as stated (Stankov et al. 2016) who used this type of measurement to quantify the variation in land use generated by the development of tourist activity in the municipality of Čajetina, Serbia. In the study developed by (Dimobe et al. 2017) landscape metrics were used to measure land use and land cover changes over 29 years in the tourist areas of the Nazinga Game Ranch Reserve in Burkina Faso. Another research on the tourist landscape was carried out on the island of Cos, Greece, where through the use of Geographic Information Systems (GIS) and landscape metrics, it was sought to quantitatively describe the spatial structure of the tourist landscape and to analyse the evolution of the terrain land use and occupation generated by the increase of this economic activity in the region (Gkoltsiou et al. 2013). Another similar and recent reference theme it has presented in (Wang et al. 2023) where the authors have applied remote sensing and GIS in Zhangjiajie, a famous mountain tourist city in China.

Due to the advances in connectivity that the internet has brought and the equipment of electronic devices with Global Positioning Systems (GPS), social networks have become a great source of georeferenced data (Hernández Magaña and Güiza Valverde 2016). This phenomenon brings up a term called Volunteered Geographic Information (VGI), which is defined as the information generated by human sensors, users of a platform, who voluntarily capture temporal space information that helps to understand the socioeconomic conditions and landscape of a given place (Goodchild 2007; Ramiro et al. 2016; Méndez-Quintero et al. 2022). This type of information is used in the landscape analysis of tourist sites. (Tieskens et al. 2018) proposes a methodology that uses photos from the social networks Flickr and Panoramio to estimate the correlation between the attributes of the landscape and the landscape preferences of tourists. Another research that addresses this issue is the one developed by (Payntar et al. 2021), who used artificial intelligence algorithms together with geotagged photographs obtained from the internet to identify travel patterns of an archaeological circuit in Cuzco, Peru, and in this way quantified the experiences that tourists had and the attractiveness of the landscape.

According to (Klimanova et al 2017), in the densely populated states of southern and south-eastern Brazil, the main changes in land use and land cover are related to agricultural development. The Brazilian municipality of Venda Nova do Imigante, which is well-known for its agricultural economy and its agrotourism model and is a national model, provided the soil for analysis in the current study. Given the importance of agrotourism development in Venda Nova do Imigrante, this research aims to analyse the changes in the city's landscape and its relationship with agrotourism activity. This research aims to answer the following question: what is the participation of agrotourism farms in the composition and dynamics change of land use and land cover in Venda Nova do Imigrante-ES, Brazil?

To obtain the answer to the investigation, the objectives that defined the scientific rigor for the space analysis were established, as follows:

- Validate the accuracy of the thematic maps for the years 1988 and 2018, obtained from Brazilian databases.
- List landscape metrics that make it possible to understand the change of land use between selected years.
- Access the change in land use and land cover in the municipality and selected agrotourism farms.

MATERIALS AND METHODS

Although the analysis was carried out for a Brazilian municipality, the approach proposed in this article, including a methodology that can be replicated in several case studies (Fig. 1), the applicability and potential use of landscape metrics associated with remote sensing for the analysis of agrotourism, can be relevant for the development of the activity in countries with fragile/dependent and/or developing economies.

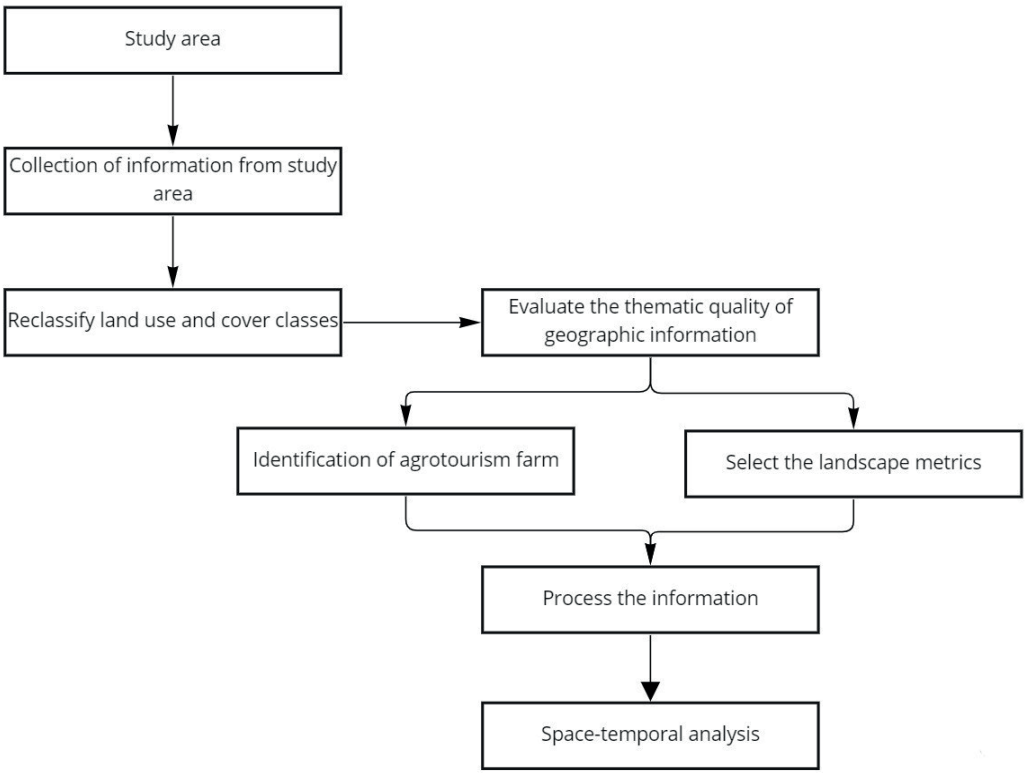

Fig. 1. Methodology flowchart

The first step was to collect thematic maps of land use and land cover and this information was reclassified according to the research objectives. Subsequently, the thematic quality of the maps was evaluated and the agrotourism farms were identified with the help of volunteer geographic information from social networks. The metrics for quantitative description of landscape were selected according to the consulted bibliography. Finally, the geographic information was processed and the space temporal analysis was carried.

Study Area

The municipality of Venda Nova do Imigrante is located in the mountainous region of the Brazilian state of Espírito Santo (Fig. 2), 106 km from Vitória the state capital. It has a land area of 188.9 km^2. Initially, it was populated by Portuguese coffee growers, but in 1892 it received a large wave of Italian immigrants, mainly from the Veneto region. The municipality area was emancipated from the municipality of Conceição do Castelo on May 10, 1988, by Decree-Law No. 4,069 / 88, obtaining its status as a municipality and current name (PVNI, 2021.)

The municipality has a strong Italian ethnic identity and the local economy is based on agriculture, especially coffee growing, fruit and vegetables on a small and medium scale as well. In recent decades, agrotourism has gained prominence as one of the main income sources. (Nogueira 2006; Zandonadi 2013).

The landscapes, in their physical dimension, were conditioned by the association of geological and geomorphological events that provided peculiar characteristics, such as the rugged relief. The lithological framework is mainly composed of metamorphic (gneiss) and magmatic (granite) rocks and thrust fault structures, typical of the Serra da Mantiqueira, due to neotectonics. The lithological framework underwent new reactivations due to the separation of the Afro-Brazilian plate (Saadim 1991; Sgarbi and Dardenne 1996; Marques Neto 2017). Weathering and denudational agents were responsible for sculpting the convex mountains, jagged valleys, and a vast river network that conditions the heterogeneity of the landscape. Also, the action of weathering in the formation of structured soils, suitable for agricultural activities, is highlighted. The original biome of Espírito Santo is the Atlantic Forest, which is characterized by semideciduous and rainforest forests (IBGE, 2004). The existence of high-altitude fields on the mountain summits is significant in addition to these phytological characteristics.

Standardization of Information and Assessment of the Quality of Geographic Information

The first step to fulfil the purposes of the research was to use thematic maps that would allow the perception of changes in land use and land cover classes. In this context, thematic maps were selected from the collection 5 available in the MAPBIOMAS Project, corresponding to the years 1988 and 2018 (Mapbiomas 2021). The raster files of the selected maps were reclassified generating 6 final classes, using the Dinamica Ego 5 software (CSR/UFMG, 2021), namely: native forest, planted forest, agriculture area, urban area, water bodies, and others.

To access the quality geographic information available on the Mapbiomas platform, a stratified random sampling with the information of the year 2018 was chosen because this year there is a larger size of agricultural and urban coverage, which allowed for standardization in the number

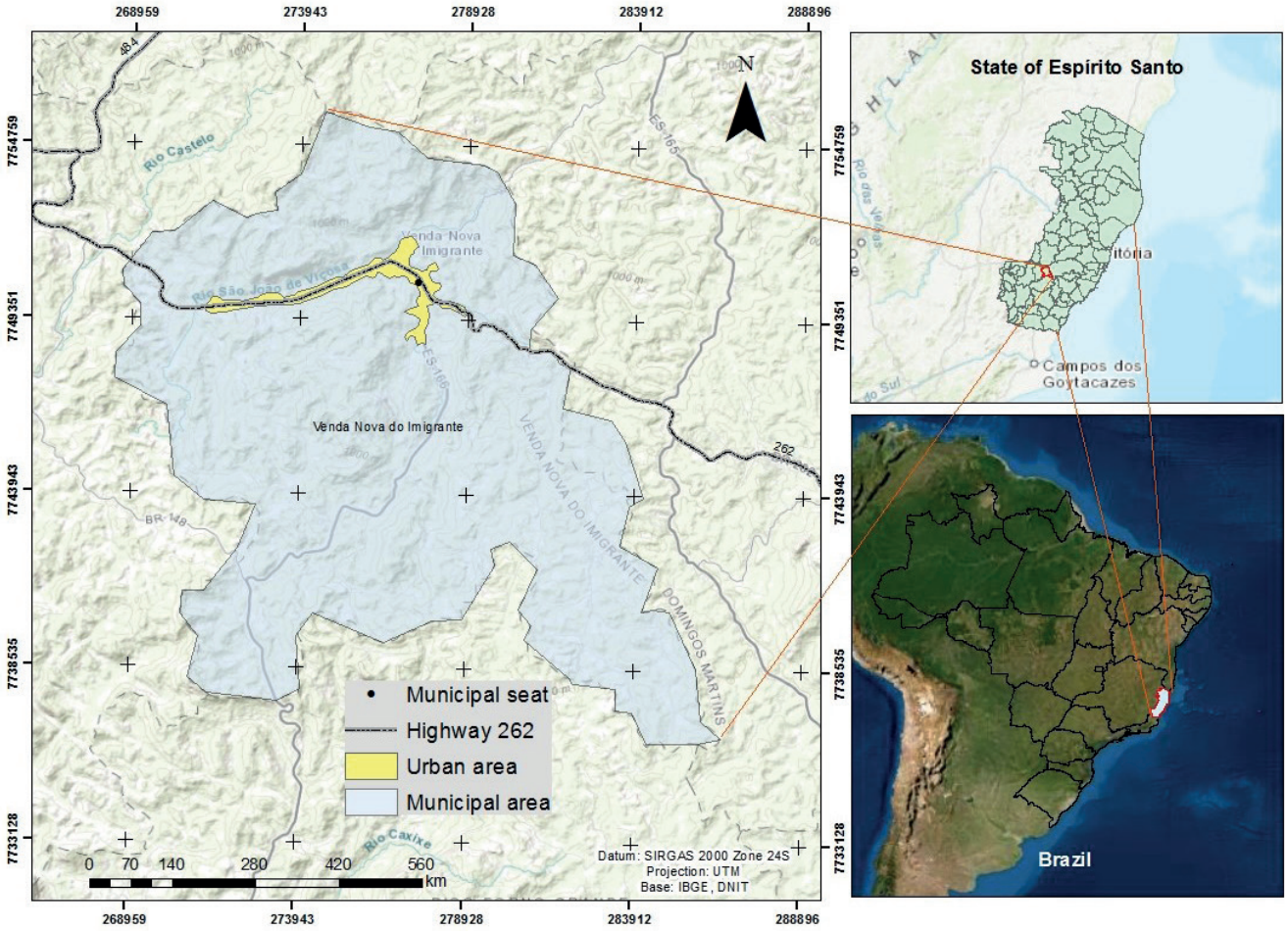

Fig. 2. Location municipality Venda Nova do Imigrante

of samples for the two years studied. Stratified random sampling allows to obtain a representation of each class of land use and occupation in proportion to the territory (FAO 2016), according to (Equation 1).

$$n = \left(Z_{\alpha/2}\right)^2 * p * q / e^2 \quad (1)$$

Equation 1 presents the calculation of the number of samples (n) defined by the multiplication of the square of the desired degree of confidence (critical value = Z(α/2)) by the expected probability of a hit (p) and by the resulting conscious result of 1 minus a probability (1-p). This value will still be divided by the squared error (e).

The geographic information of the Mapbiomas platform, for the year 1988 was compared with a Landsat 5 satellite image with a resolution of 30 meters, obtained from the database of the Earth Explorer (USGS 2021). Regarding the MAPBIOMAS information corresponding to the year 2018, a comparison was made with the CBERS 4 satellite image, with a resolution of 10 meters, obtained from the platform of the National Institute for Space Research (INPE 2021). Additionally, for a better match between the land cover obtained in MAPBIOMAS and reality, images from the Google Earth satellite and the Esri satellite were also analyzed for two time periods. The evaluation of the thematic quality of information from the MAPBIOMAS platform for mapping was carried out in the QGIS 3.18.1 software (QGIS. org, 2021), with the help of the AcATaMA plugin (Llano 2022), in order to obtain a confusion matrix for each year.

From the evaluation of the samples by the classes, the confusion matrices or error matrices for the years in question were produced, 1988 and 2018. The confusion matrix is the tool that allows us to weigh the accuracy between the sensing and the thematic map (Ariza-López et al. 2019; Alba-Fernández et al. 2020, Alba-Fernández 2021). Through the confusion matrix, different indices can be estimated, including the global accuracy and the kappa index (coefficient) used in this study (Foody 2004).

Global accuracy is a calculation that considers the summation of the number of correct answers in the classes divided by the number of samples. The value obtained allows a first comparative analysis between the mapped content, although, when considering only the diagonal of the confusion matrix, this index does not capture chance between the classes (Brites et al. 1996). Global accuracy is expressed by Equation 2.

$$G = \sum_{i=1}^{c} x_{ii} / n \quad (2)$$

Where:

$\sum_{i=1}^{c} x_{ii}$ corresponds to the summation of the diagonal of the confusion matrix and n = the total number of samples

The kappa index established by (Cohen 1960), has a wide applicability in space statistical studies, although some authors suggest variances for greater numerical veracity. Kappa gives an example of how flawless a class is. It brings innovation about the global index, as the kappa considers both the results of the main diagonal and the other values contained in columns and rows (Brites et al. 1996). Among the algebraic deductions, the kappa index with stratified random sampling was considered for the research, represented by (Equation 3).

$$K = n \sum_{i=1}^{c} X_{ii} - n \sum_{i=1}^{c} X_i + X_{+i} / n^2 - \sum_{i=1}^{c} X_i + X_{+i} \quad (3)$$

Where:

$\sum_{i=1}^{c} X_{ii}$ Matrix diagonal summary.

$\sum_{i=1}^{c} X_i + X_{+i}$ Sum of the product of the sums of the row (xi+) by the column (x+i).

n^2 Number of samples squared.

The kappa index values range from 0 to 1, with values close to zero showing that the class or category has a high level of error about remote sensing. On the other hand, values close to one have a higher degree of accuracy. It is important to emphasize the interpretation and the possibilities of analysis of the Kappa index applied by the various authors, the concepts and classification scales presented by (Fleiss et al. 1969), (Landis and Koch 1977), (Monserud and Leemans 1992) is demonstrated by (Foody 2020) (Fig. 3).

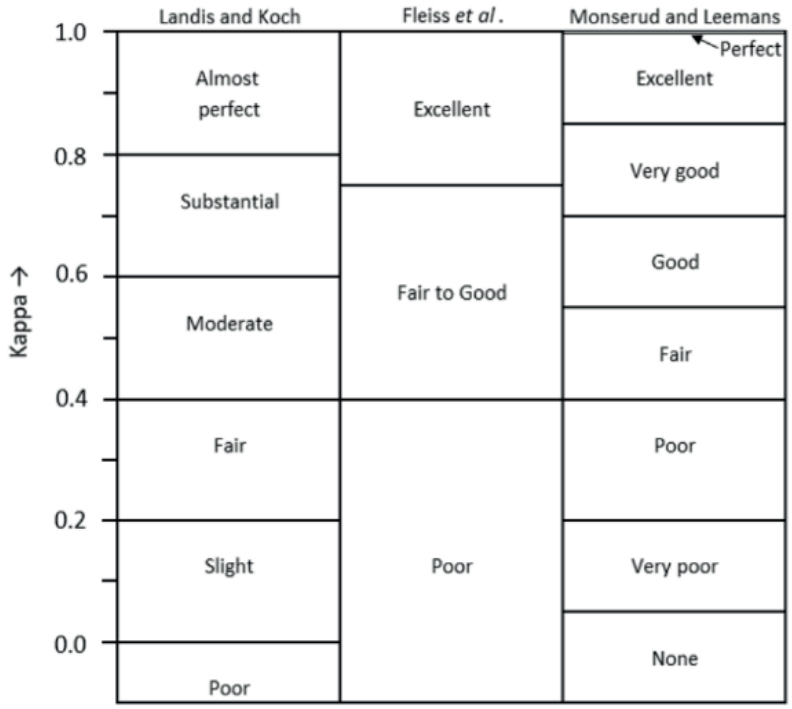

Fig. 3. Kappa index classification (Foody 2020)

Identification of agrotourism farms.

To identify the agrotourism farms in the municipality of Venda Nova do Imigrante-ES, Brazil, the geotagged photographs published between February 1, 2017 and February 1, 2021 with the location of the municipality and posted on the networks social Instagram and Flickr were consulted. The criteria for selecting the photographs were those that show agrotourism farms where tourist activities related to traditional agriculture on a family scale were prioritized. Once the farms had been identified, their location and coordinates were verified on Google Maps, and the boundary area of the properties was defined with the help of the Rural Environmental Registry (CAR) made available by the municipal management in shapefile format (PVNI, 2021).

Landscape metrics

To identify landscape changes over the 30 years analyzed, landscape metrics were selected based on the consulted bibliography (Table 1). Subsequently, the MAPBIOMAS images corresponding to the years 1988 and 2018 were analysed in the Fragstats 4.2 software (McGarigal et al. 2015).

Table 1. Landscape metrics implemented in the project (based on McGarigal and Marks 1994; Dimobe et al. 2017; Urrutia et al. 2020)

METRIC	ABBREVIATION	DESCRIPTION	ANALYSIS LEVEL	INTERPRETATION OF RESULTS
Class Area	CA	It quantifies how much a given land-use class occupies in the landscape. Values close to 0 demonstrate that the class occupies a small area concerning the total area.	Patcher	CA > 0, without limit.
Percent of Landscape	PLAND	Corresponds to the percentage of the class in the landscape.	Patcher	0 < PLAND ≤ 100
Number of Patches	NP	Number of fragments or patchers in a class.	Patcher	NP ≥ 1, without limit.
Mean area	AREA_MN	Corresponds to the average area in hectares of each class within the landscape.	Patcher	AREA_MN > 0, without limit.
Standard deviation area	AREA_SD	Informs the standard deviation from the mean area. It can thus be verified whether class sizes were maintained over time or whether significant outliers were produced.	Patcher	AREA_SD> 0, without limit.
Average distance from neighbors	ENN_MN	It exposes the average distance between the nearest neighbors (fragments), it is a metric of structural connectivity.	Patcher	ENN_MN> 0, without limit.
Standard deviation of neighbors mean	ENN_SD	Informs the variation of values, concerning the average of the distances between the closest neighbors.	Patcher	ENN_SD> 0, without limit.
Mean Shape Index	SHAPE_MN	Quantifies the shape of fragments and allows you to assess how much a class is exposed to the edge effect. Values closer to 1 mean that the shapes are more similar to the circle or square (isodiametric). On the contrary, values close to 0 demonstrate complex shapes and are more susceptible to external interference.	Patcher	MSI ≥ 1, without limit. MSI = 1 when the patch is circular (vector) or square (raster).
Patch Richness	PR	Class diversity index in the landscape. It is based on the hypothesis that the greater the number of classes in a landscape, the greater the possibility of having different species, which in turn informs the composition of classes in the landscape.	Class	PR ≥ 1, without limit
Patch Richness Density	PRD	Quantifies the density of the number of classes. While the PR informs variation in the number of classes in the landscape, the PRD measures the intensity of these classes, in turn, the size of the patches in each class will influence. The calculation is made considering the classes present in an area of 100 ha. Ranges from 1, when there is only one class per area, to infinity.	Class	PRD > 0, without limit
Shannon's Diversity Index	SHID	The Shannon Index expresses values related to landscape diversity. It increases proportionally with the richness of the blob classes in the landscape, when the landscape has only one class, they will have a value of 0. On the other hand, in landscapes with varied land use, the index will increase until reaching the maximum value of 1.	Class	SHDI = 0 when the landscape contains only 1 patch

The selected landscape metrics allow characterizing the agricultural matrix in terms of area, density, border, shape, isolation, proximity, intercalation and diversity, they are also used to analyze the development of tourist activities and the influence they have on the landscape (Dimobe et al. 2017; Urrutia et al. 2020).

RESULTS AND DISCUSSION

Reclassification of use and cover land

The thematic maps of land use and land cover obtained from the MAPBIOMAS platform were reclassified into 6 classes: native forest, planted forest, agricultural area, urban area, water bodies, and others. Fig. 4 shows the configuration of land use and land cover that the municipality had in 1988 and 2018.

Determining the number of samples for thematic quality assessment

To determine the quality of geographic information in thematic maps, the "Native Forest area" class and the "Planted Forest area" class were unified due to the difficulty of differentiating them separately in satellite images. In obtaining the number of samples, the parameter of the areas of the land use classes of the year 2018 was used. Statistically, we chose to obtain a probability of correctness of 95%. In turn, the Z(α/2) has a value of 1.96; p=0.95; q=0.05 and the error=0.025, as it is a two-tailed test. The number of samples required was 292 achieved through Equation 1 with the values expressed here. Subsequently, this number was stratified into the classes of the thematic land cover and use map (Table 2).

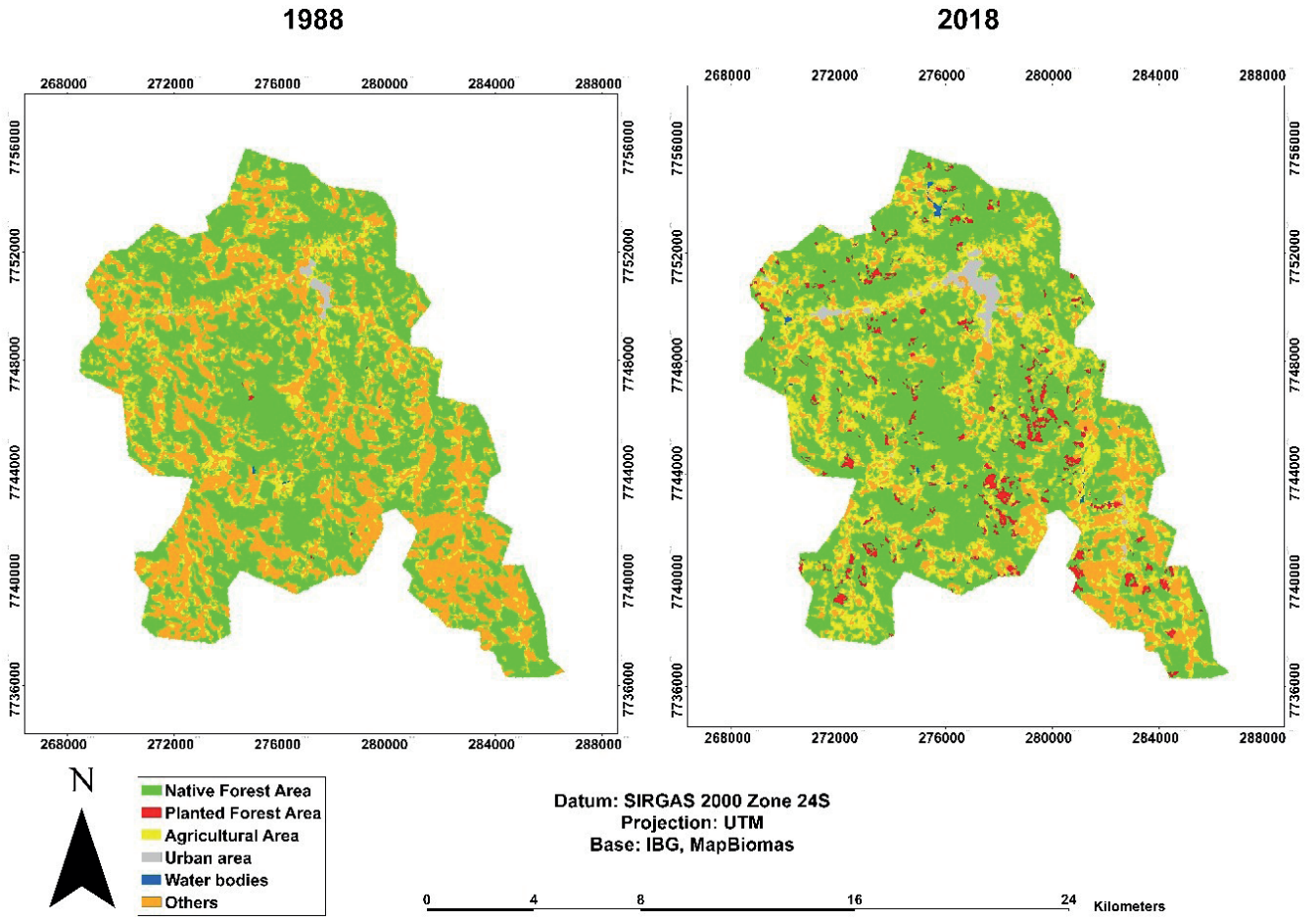

Fig. 4. Land use and land occupation Venda Nova do Imigrante in 1988 and 2018

Table 2. Proportion of samples by classes

Name of the classes	Classes area (ha)	proportion of the class	Number of samples
Native and Planted Forest	11391.12	0.603	166
Agricultural area	4451.22	0.236	69
Urban area	304.65	0.016	10
Water bodies	36.45	0.002	5
Others	2702.07	0.143	42
Total	18885.51	1	292

The forest class obtained 176 samples, while the urban class and water bodies accounted for 5 and 0 respectively. Thus, for adequate representation of the classes, 10 forest samples were reduced and distributed equally between the urban and water bodies classes.

Confusion matrix, global accuracy, and kappa index

The confusion matrix for the year 1988 (Table 3) and year 2018 (Table 4) were generated from the comparison of images obtained from the Landsat 5 and CBERS 4 satellites respectively with the thematic maps of the MAPBIOMAS platform through the AcATaMA plugin, available in QGIS.

The global accuracy value obtained with the help of the AcATaMA plugin was 0.82 and the kappa index value 0.67, these values are acceptable in thematic quality, according to the scales of the different authors (Table 4).

For the year 2018, the global precision value was 0.85 and the kappa index was 0.75, which allows reliability in the thematic map.

Selection and identification of agrotourism farms

A total of 15,420 photographs of the municipality of Venda Nova do Imigrante were analyzed on the Instagram social network corresponding to the period of time determined in the methodology, of which 23 complied with the specification of the research, in relation to the social network Flicker, it was analyzed 509 photographs and only 6 met the selection parameter. From the photographs that met the parameters, a total of 6 farms were identified and their coordinates were consulted on google maps (Table 5).

In relation to the selected photographs, it was observed that in the social network Instagram the photos published mainly reflected tourists and the activities they carried out, allowing to analyze the relationship between the tourist and the place, while in the social network Flickr, the photographs were focused on landscapes, allowing to analyze the attractions of tourist sites and agricultural places. Although the social network Instagram had a greater number of photographs, most of these photographs were of commercial products and selfies, on the other hand, the social network Flicker in most of its photographs were of rural and municipality landscapes and a small portion corresponded to cultural events. The identified agrotourism farms were situated in the municipal area's south-eastern region (Figure 5).

Description of the landscape of Venda Nova do Imigrante

With the help of the FRAGSTATS 4.2 software, the selected landscape metrics for the municipality area corresponding to the years 1988 and 2018 were analyzed (Table 6).

Table 3. Confusion Matrix for the Year 1988

Thematic raster classes	Native and Planted Forest	Agricultural area	Urban area	Water bodies	Others	**Total**
Native and Planted Forest	147	3	0	1	15	166
Agricultural area	16	42	0	1	10	69
Urban area	0	0	10	0	0	10
Water bodies	3	0	0	2	0	5
Others	7	6	0	1	34	42
Total	173	45	10	5	59	292

Table 4. Confusion Matrix for the Year 2018

Thematic raster classes	Native and Planted Forest	Agricultural area	Urban area	Water bodies	Others	**Total**
Native and Planted Forest	146	15	0	0	5	166
Agricultural area	9	51	0	0	9	69
Urban area	0	2	8	0	0	10
Water bodies	0	0	0	5	0	5
Others	0	5	0	0	37	42
Total	155	73	8	5	51	292

Table 5. Agrotourism farms selected for the study and geographic coordinates in decimal degree

FARMS	LATITUDE	LONGITUDE
Agroturismo Familia Brioschi	-20,377697	-41,132806
Família Busato Agroturismo	-20,371011	-41,128060
Pousada Bela Aurora	-20,417500	-41,130765
Carnielli	-20,365476	-41,125312
Vinhos Tonole	-20,362892	-41,118941
Fazenda Saúde	-20,370351	-41,112043

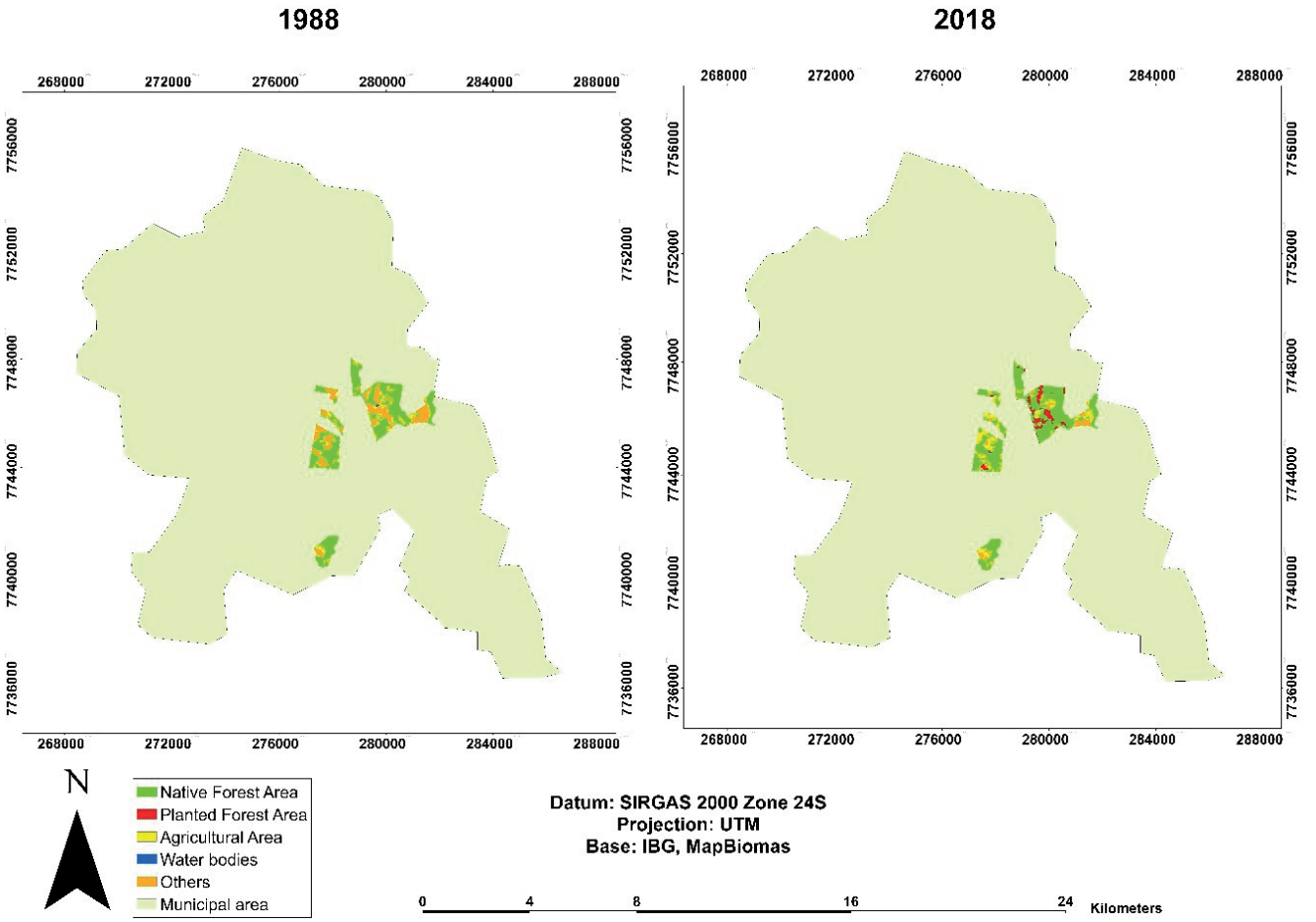

Fig. 5. Location of the agrotourism farms selected for the study

Table 6. Results of the landscape metrics of Venda Nova do Imigrante in 1988 and 2018

LANDSCAPE METRICS	USE AND COVERAGE LAND											
	Native Forest Area		Planted Forest Area		Agricultural Area		Urban area		Water bodies		Others	
	1988	2018	1998	2018	1988	2018	1988	2018	1988	2018	1988	2018
CA (ha)	9986.85	10682.28	5.94	708.84	2470.32	4451.22	81.18	304.65	4.95	36.45	6336.27	2702.07
PLAND (%)	52.88	56.56	0.03	3.75	13.08	23.57	0.43	1.61	0.03	0.193	33.55	14.31
NP	289	264	5	277	1531	895	5	19	4	17	381	510
AREA_MN (ha)	34.56	40.46	1.19	2.56	1.61	4.97	16.24	16.03	1.24	2.14	16.63	5.30
AREA_SD (ha)	272.50	400.11	0.94	3.74	3.39	19.03	19.75	44.03	0.89	3.16	87.39	18.17
SHAPE_MN	1.76	1.66	1.31	1.54	1.59	1.84	1.82	1.57	1.20	1.45	1.57	1.50
ENN_MN (m)	87.24	79.84	1612.22	203.92	88.98	80.38	193.03	231.38	1360.09	1234.48	120.29	132.25
ENN_SD (m)	45.65	31.99	1370.30	228.36	50.32	38.60	74.69	244.09	1723.40	1317.46	78.14	99.89

	1988	2018
PR	6	6
PRD	0.03	0.03
SHDI	1	1.14

It can be observed that in 30 years the municipality had an increase in the size of the native forest, planted forest, agriculture area, urban area and water bodies classes, and a reduction in the area of the other class. The number of patches (NP) in the forest and agriculture classes decreased but had increase in the average area value (AREA_MN), which suggests that there was a greater connectivity in these classes. But the standard deviation (AREA_SD) in these same classes also increased, inferring the presence of areas of different sizes.

Shape is an important metric to identify the edge effect on natural formations. The higher its value, the greater the interference (negative effect) of neighboring classes on the ecosystem. When comparing this metric (SHAPE_MN) between years, it was found that there was a reduction in pressure on the formation of natural forests. On the other hand, in local agriculture, largely associated with agroforestry, the increase in the average shape should be considered positive, as the plantations are interspersed with natural formations and thus demonstrate the permanence of the practice of sustainable cultivation over the years.

The planted forest showed an increase of approximately 703 ha between years, accounting for 3.75% of the vegetation cover in 2018. The growth in the number of fragments demonstrates that these plantations were spread throughout the territory, with the average area of the surrounding class of 2.6 ha.

The urban patch, in 1988, the year of its political and territorial emancipation, occupied 81 ha (0.43%) with the presence of 5 fragments with an average area of 16 ha. In 2018 the urban area came to represent 304.65 ha (1.6%) with an increase in the number of fragments to 19, maintaining its average area of 16 ha. These values are explained by the expansion of the urban center along 262 Highway and the formation of small villages.

The water bodies in the first year accounted for 4 fragments with a total area of 4.95 ha, 0.03% of the territory. In the second year, there were 17 fragments with an area of 36.45 ha (0.19%). The increase in water bodies is related to artificial damming for sport fishing and leisure.

At the landscape level, when comparing the Patch Richness (PR) between 1988 and 2018, it was found that there was an increase only in the planted forest class, which did not cause a significant change in the PR. Another metric that corroborates the configuration of classes between the years evaluated was the Patch Richness Density (PRD), which quantifies the number of classes per 100 hectares that also remained constant.

In the landscape category, it was found that the municipality in both years had a good indicator of the Shannon Diversity Index (SHDI), and in 1988 the SHDI = 0.99, and in the year 2018 SHDI = 1.14. In a way, it can be said that the Shannon in both remained close to the value of 1. It should be noted that the SHDI is calculated using the weighted geometric mean of the landscape classes. In turn, its alteration may occur due to variation in Patch Richness (PR) or Class Percentage (PLAND). As explained above, the PR remained constant over the years and responsible for the small variation was the PLAND with the increase in the classes of forest (from 52.88% to 56.56%) and agriculture (from 13.08% to 23.57%) in detriment to the reduction of the other class (from 33.55% to 14.31%) which includes: exposed soil, mining, and other unidentified coverage.

Analysis of landscape metrics on selected farms

With the help of the FRAGSTATS 4.2 software, the landscape metrics selected for the area of the chosen farms, corresponding to the years 1988 and 2018, were also analyzed (Table 7).

Interesting information on soil cover was provided by the analyzed farms. In 1988, the forests had 28 fragments that corresponded to 58% of their coverage, with an average area of 12.3 ha. Agriculture had 77 fragments responsible for 12% of occupation with an average area of

Table 7. Results of landscape metrics of agrotourism farms in Venda Nova do Imigrante in 1988 and 2018

LANDSCAPE METRICS	USE AND COVERAGE LAND									
	Native Forest Area		Planted Forest Area		Agricultural Area		Water bodies		Others	
	1988	2018	1998	2018	1988	2018	1988	2018	1988	2018
CA (ha)	344.07	388.17	0	49.50	72	112.77	0.63	1.17	175.59	40.68
PLAND (%)	58.09	65.54	0	8.36	12,16	19.04	0.11	0.20	29.65	6.87
NP	28	19	0	22	77	52	1	1	36	19
AREA_MN (ha)	12.29	20.43	0	2.25	0,94	2.17	0.63	1.17	4.88	2.14
AREA_SD (ha)	21.63	46.20	0	3.13	0,87	4.32	0.00	0	8.04	3.47
SHAPE_MN	1.69	2.01	0	1.41	1.47	1.54	1.17	1.63	1.35	1.40
ENN_MN (m)	112.94	226.42	0	222.38	100.52	111.90	N/A	N/A	142.50	302.99
ENN_SD (m)	77.14	566.40	0	226.42	99.06	126.98	N/A	N/A	143.85	207.49

	1988	2018
PR	4	5
PRD	0.68	0.84
SHDI	0.94	1

0.94 ha. The class "other" covered farms, with 36 fragments that together accounted for 29% with an average area of 4.88 ha.

Compared to the values for the years 2018, it can be seen that part of the class "other" has been replaced by both native and planted forests and by agriculture. The class "other" reduced to 19 fragments and occupied 6.87% and its average area became 2 ha; native forest increased to 64.53% with 19 fragments. Agriculture also increased to 19% with 52 fragments and its average area increased to 2.17 ha. It is also observed that the planted forest class became present in 2018. They now represent 8.36% of the total of selected farms, with the number of 22 fragments with an average area of 2.25 ha.

Regarding the landscape category, the PR, PRD and SHDI metrics showed an increase between the years. The expansion of the forest and agriculture classes and the emergence of the planted forest class took place over the other class, which represented on farms, mainly exposed soil. Its reduction became a gain in diversity due to the recovery of degraded areas for forest restoration and crop planting.

CONCLUSIONS

The systematization and analysis of the data allowed for the quantification of the content and structure of the landscape as well as its temporal history. It was found that the municipality of Venda Nova do Imigrante had a significant growth in agricultural and urban areas together with a reduction in the class other constituted mainly by exposed land. The recovery of soil through reforestation and agricultural production is one of the points where agrotourism farms play a part in the dynamics of change in land use and cover.

The methodology presented in this study allowed to satisfactorily identify and analyze changes in land use in agrotourism places and at the same time allowed to evaluate the quality of the maps used. In relation to the sources of information and the software used, they are free, which allows lower costs in this type of spatial analysis.

It was concluded that the Mapbiomas platform is adequate for land use and cover land change studies, however, the thematic quality of the oldest maps is difficult to validate due to the limited supply of high space resolution images at the time.

The social networks Instagram and Flickr showed a large volume of VGI of the municipality; however, the volume was low for the analysis of agrotourism places. This shows a low efficiency in capturing information on this type of tourism.

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