The use of satellite images to characterise winescapes

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Wine tourism is not just about the consumption of wine. Wine tourism fosters close experiences with winescapes, which are defined as the cultural context of wine production and viticulture. This paper proposes an end product database applying Geographical Information Systems (GIS) and remote sensing imagery to characterise the cultural landscape of wine tourism. The current literature shows a gap in prior research, therefore this study uses geotechnology as a tool in managing wine tourism destinations. São Joaquim, a Brazilian destination, has been changing due to new economic dynamics, driven mainly by the production of high-altitude wines and wine tourism. The cultural landscape analysis in this study provides an understanding of the processes of economic activities. The case of São Joaquim was considered as it is a wine tourism destination in the early stage of development and because of its singular geophysical landforms. Our research methodology includes the identification of land cover and the classification of land use and addresses the intersection between primary and secondary data. QGIS software was used for the intersection between the data from satellite imagens processing and secondary data. The results showed that remote sensing and the use of GIS were viable resources in carrying out a preliminary analysis of a cultural landscape, especially a winescape, providing a database useful in territorial planning. The main contribution of this research is the possibility of applying remote sensing and GIS to the territorial planning of tourism in wine regions. This study also contributes to research about winescapes and their territorial certification processes, and it can be used for emerging tourism segments and sustainable territorial planning.
**Keywords:** cultural landscape; Geographical Information System; remote sensing; winescape; wine tourism; Brazil.

**Introduction**

Since the 1990s, wine tourism has become relevant to a tourism niche segment where tourists and visitors interact with the cultural landscape. These cultural features, linked to the rural environment, form a new way to integrate tourists and farms (Ferreira & Hunter, 2017). Beyond a single geographical delimitation, the cultural landscape is a territory produced as a combined interaction between labour, nature, and social relations. Wine tourism involves not only the consumption of wine but also incorporates a close experience involving wine production and viticulture. Wine tourism is related to the culture and technique of wine production, from its elaboration, history, and expertise, to aspects that are intrinsically part of wine production activities, all of which are encapsulated in the concept of winescape.

Grape growing and wine production are significant economic activities, recognised as modifiers at a landscape level. Considering the uneven spatial distribution of activities such as grape growing and wine production, geotechnology is a useful way of studying their spatial distribution, as these technologies can integrate physical, cultural, and economic variables. In addition to Geographical Information Systems (GIS), remote sensing imagery in particular, enables research to be undertaken which is integral to the landscape and which provides helpful, up-to-date accounts of changes (Dougherty, 2012; Johnson et al., 2012).

The research presented in this paper proposes an end product database making use of GIS and remote sensing imagery to characterise the cultural landscape of wine tourism, so that it can be used to manage and plan the development of vineyard landscapes. It provides a more robust basis for decision making for the territorial
planning of tourism in rural areas. This tool promotes sustainable land use as recommended by UNESCO regarding vineyards' cultural landscapes. The winescape in a southern Brazilian location, São Joaquim, was used as a case study. While gathering scattered GIS data from different sources for this particular area, the tool proposed is replicable to any grape culture around the world. It can in fact be deployed to other agricultural areas where tourism activities coexist. The main advantage of this tool is the low cost required to deploy hardware and software, along with more user-friendly interfaces and secure systems, making this technology broadly available (Green, 2012).

The research steps include a bibliographic review, the identification of land use and land cover classes from the selected case study, and the intersection between land use and land cover maps, with primary and secondary data from the GIS data. These images were generated to enable analysis of the winescape.

**Literature review**

**Cultural landscape and winescape**

Different areas of knowledge and theoretical approaches have sought to study geographical landscapes in a broad sense. From a cultural perspective, the concept of landscape asserted itself within the Berkeley School in California (USA) in the early 20th century. The term emerged from Carl Sauer’s article "The Morphology of Landscape" published in 1925, which proposed the concept of the landscape as a new context in geographic science. Santos (2002, p. 103) proposed that the landscape is a set of forms that, at a given moment, express the inheritances from successive relationships located between man and nature. Several authors (e.g., Santos, 2002; Besse, 2014) have advanced the traditional analysis of geographical landscape, stating that this concept cannot be described objectively, being a phenomenon with subjectivity and
intentionality, similar to a language. The approaches proposed by these authors show the dynamic and evolutionary character of the landscape, referring to the past and proposing object future perspectives, becoming an essential tool for research and analysis.

Berque (1998) thoroughly explored the set of temporal relations of the landscape. For him, the landscape assumes a simultaneity between brand landscape and matrix landscape. Brand landscape refers to an expression of collective work, and the matrix landscape refers to schemes of perception, design and action that channel relationships with space and nature. In the same context, Besse (2014) problematised contemporary landscape issues, discussing five ways to understand the landscape: 1) as a cultural and social representation; 2) as inhabited and manufactured territory; 3) as a natural and living environment for human societies; 4) as an aesthetic and functional project; 5) as a phenomenological experience of the surrounding space.

The context of the landscape cannot be decontextualised from tourists’ experiences. The classic literature on travel experience deals with the landscape from the perspective of visual determinism, either through the "look of the tourist" (Urry, 1990) or through a "staged authenticity" (Maccanell, 1973). In his publication, The Tourist Gaze 2.0, Urry (2002) highlighted the importance of conducting studies on sensory landscapes such as soundscapes, smellscapes and tastescapes, thus highlighting the intimate, conceptual and empirical relationship between landscape, sensory perception and tourism. This is precisely the context in which this research emerges, the landscape as a geographical category in itself. (Besse, 2014; Claval, 1998, 2014).

Among the various neologisms in landscape studies, one is of particular interest to this research. The winescapes is a concept proposed by Peters (1997), and it refers to the context of wine production and its associated experiences. The wine landscape, or
viticultural landscape, refers to the agricultural scenario where grape culture is predominant, with other crops being cultivated on a smaller scale (Peters, 1997). The term winescape refers to a broad understanding of the geography of a wine producing region and is not limited to the landscape, but also includes an appreciation of the colours, smells and flavours of wine. All of these also configure the widespread notion of terroir. Patriquin (2005, p. 1) described a winescape as "a spatial realm that integrates winemaking and wine tourism within a vinicultural setting". The vineyard landscapes are considered by Elías (2014) as heritage assets, which must be preserved to build a wine-growing memory, as they are the product of generations of work, endowed with knowledge and techniques linked to the territories. For the author, the vineyard landscape "explains the culture of a territory as a geographical manifestation of the lives of the people who transform it" (Elías, 2014, p. 141).

A winescape is a vast cultural system, with features relating to know-how, beliefs and knowledge about the different ways of adapting a vineyard’s topography and capturing the correct amount of sunshine. Winescape features include tunnels which have been excavated to provide cold temperatures for the fermentation and ageing of wine. As Gabardo and Valduga (2019) analysed, some specificities of the viticultural landscape provide inherently cultural systems and resources for wine tourism.

**Perspectives in Wine Tourism**

Wine tourism is a consolidated tourism segment throughout many wine regions worldwide. Ricolfe et al. (2010) identified key motivations for wine tourism: purchasing wine, wine tasting at the winery, learning about the wine and its manufacturing process, visiting the winery and the vineyard, participating in wine fairs or parties, having a meal at the winery, and visiting a wine museum or natural sites in the region, among others.
Fundamental analysis of the profile of tourist demand was carried out by Charters and Ali-Knight (2002). In their innovative investigation about the habit of wine tourism in the context of Australian wineries, the authors proposed four levels of tourists based on their interests and knowledge about wines: novices, interested, wine lovers and connoisseurs. Charters and Ali-Knight (2002) identified that, regardless of their level of involvement with wine, most wine tourists value the winery's environment or "scenery" and the acquisition of new knowledge during a visit, and in this context the winescape emerges.

In a comprehensive study of the motivation and satisfaction of visitors to a wine festival, Gálvez, Fernández and López-Guzmán (2015) found that the degree of visitor satisfaction increased among those with a particular interest in enjoying the flavours of regional enogastronomy. In their analysis of winery visitors’ photographs, taken from visits to a large sample of wineries, Lavandoski and Lanzer (2008) found that the vineyard holds strong interest among wine tourists' experiences. Therefore, the vineyard landscape constitutes a critical element of the wine tourism experience.

The literature on wine tourism has revealed its different contexts. Some analysis has attempted to draw a relation between the territory, cooperation and heritage of wine (Alonso, Sheridan & Scherres, 2008; Privitera, 2010; Alonso & Liu, 2011; Valduga, 2014; Girini, 2017; Cañizares & Pulpón, 2018). Other studies emphasised the perspective of travellers’ routes, tourism destinations, planning and development (Fuller, 1997; Getz, 2000; Hall & Mitchell, 2001; Hall, 2002; Bruwer, 2003; Escolar & Morueco, 2011; Sartori, Mottironi & Corigliano, 2012). Analysis from the perspectives of demand, management of organisations and marketing in wine tourism are also topics related to wine tourism studies (Leiper & Carlsen, 1998; Getz et al., 1999; Hall et al., 2004; Brown & Getz, 2005; Bruwer & Alant, 2009; Hall, 2009; Quadri-Felitti & Fiore,
2012). A further study on issues relating to sustainability and the role of wine tourism in regional development was conducted by Baird, Hall and Castka (2018).

Taking into account the tourist experience, relevant studies by Pine II and Gilmore (1998) were based on the so-called Economy of Experience. Some researchers have turned to the emotional perspective of the wine tourism demand, to plan experiences, sensations, creativity and innovation (Ali-Knight & Carlsen, 2003; Carmichael, 2005; Quadri-Felitti & Fiore, 2012).

In Brazil, wine tourism dates back to the first half of the 20th century and is connected to the Italian immigration process which started in the late 19th century in the state of Rio Grande do Sul (Valduga, 2011). Recently, around the late 20th century, new wine regions have emerged and, consequently, case studies began to emerge.

**Geotechnologies applied to viticulture regions**

Mapping and monitoring tools and techniques are well developed and widely used to study the environment (Johnson et al., 2012). In recent years, there has been an increasing number of tools which support geotechnologies, providing more accurate and faster results, and reducing the operational costs of projects (Viel et al., 2019). In the case of this research, land use and land cover are not only about the physical variables, but also about those associated with social dimensions and changes that occur in a given territory. Thus, the patterns of land cover and land use provide a broader perspective on the dynamics of occupation and economic evolution, combining both physical and social variables (Viel, Rosa, Hoff, & Moura, 2019).

Global Position System (GPS), remote sensing and GIS have changed the way the earth’s surface is visualised, analysed and monitored (Johnson et al., 2012). In general, geospatial tools involve GPS for data collection. Remote sensing is often used for monitoring and mapping, with GIS being deployed across multiple uses, including
spatial data processing, analysis, modelling and mapping environmental databases for data storage and retrieval (Green, 2012). Maps can also be integrated with GIS databases to better understand the environment and its elements (Johnson et al., 2012). Land use and land cover studies have evolved through the use of geotechnologies, mainly by deploying remote sensing and GIS (Viel et al., 2019).

Using remote sensing and GIS, researchers have been able to successfully apply geotechnologies at an agricultural and horticultural farm level. By their very spatial nature (Smith & Whigham 1999), these technologies can be utilised for data collection, positioning, analysis, display, visualisation and communication for the monitoring, mapping and management of a wide range of agricultural and horticultural crops (Green, 2012). In horticulture, especially in vineyards, data collected by field research can be combined with background images. These practical applications lead to greatly improved efficiency and effectiveness in the day to day operations of vineyards and, ultimately, the impact upon improved fruit quantity, quality and wine production (Green, 2012). In this sense, Precision Viticulture (PV) is an increasing trend in the USA and in Australia, as already documented by Proffit et al. (2006). PV opens up new opportunities to use and display spatial information and to form a basis for constructing local (geospatial-based) information systems for vineyards (Green, 2012).

The use of remote sensing by satellite imagens or aircraft is increasing as a viticultural production tool, a useful resource used to update land cover and land use maps. According to Johnson et al., (2012, p. 214) “orbital systems are particularly well-suited for regional mapping due to their frequent update and large field-of-view”. This view is supported by Hay (1974), whose early study explored the potential use of Landsat Multispectral Scanner imagery (80 m resolution) as a complement to aerial
photography for the US Department of Agriculture’s (USDA) crop inventory in California’s San Joaquin Valley.

During the last 20 years, different methods have improved automated image classification, aiming to automatically categorise all image pixels into land cover and land use classes. Most research on remote sensing has utilised “spectral pattern recognition which assigns cover types based on their inherent reflectance properties within the spectral range of the sensor” (Johnson et al., 2012). In this approach, the classes of interest are predefined by the researcher, with representative samples to train the classification.

The maximum likelihood classifier, which occurs when a classification of pixels is made based on a sample of a training area, is another common approach. Trolier et al. (1989) mapped early and late seasons in vineyards in New York. Similarly, Lanjeri, Degarra and Melia (2004) compared and monitored land cover changes in a dry-farmed vineyard in Spain. Coutinho et al. (2019) proposed a remote sensing methodology to collect data from vineyards through a Normalised Difference Vegetation Index (NDVI) resulting in a database of vineyards in the Vale do Rio do Peixe, in Brazil. The remote sensing classification can also be based on automated recognition and analysis of an image’s spatial or textural patterns rather than on spectral content (Johnson et al., 2012). Through this approach, textures and spatial patterns can be explored and associated with vineyards, but require very precise spatial resolution. Relevant research was developed by Warner and Steinmaus (2005), who analysed spatial autocorrelation in panchromatic IKONOS satellite imagery (one metre) to detect row structure in vineyards in the state of Washington, USA.

More recent attention has focused on mapping vineyard attributes, such as defining and plotting the vineyard boundary, row positions and blocks and vineyard
infrastructure, mostly in those vineyards operating on a commercial scale (Merenlender, 2000). By monitoring vineyards with GIS, managers can quickly develop a detailed spatial database containing consistent data to monitor spatial patterns over time (Vianna et al., 2019b). As noted by Bonfante et al. (2015), GIS is useful for processing high-resolution topographic data and precision soil data, and is also useful for vineyard management at a microscale of the terroir zoning.

Viel (2018) proposed an evaluation of the relevance of geomorphology to manage and monitor areas for the geographical indication of wines and sparkling wines. In his case study, he combined remote sensed data and GIS by analysing the Digital Elevation Model, and then associating it with land use and land cover pattern data for Vale dos Vinhedos, a protected designation origin region in Brazil.

More recently, geotechnologies have been merged with mobile technologies, and mobile GIS software has appeared as a new tool. All of these advances make it even more possible to gather, process and display information while working in the field (Green, 2012).

**Methodology**

This study makes use of a wide range of data collection. In the early stages, bibliographical and documental data were deployed. Documental sources contributed to a better understanding of aspects related to land cover, land use and occupation, topographic maps, and statistical data on socioeconomic aspects of the study area (see Fig. 1).
The generation of land cover and land use maps was based on images from the multispectral instrument (MSI) – Sentinel-2A satellite, acquired in August 2019, from the European Space Agency image bank (ESA) (https://scihub.copernicus.eu). Centroids of the vineyards were obtained from data generated by the Vineyard Register, supplied by the Agricultural Research and Rural Extension Company of the State of Santa Catarina (EPAGRI). The data collected had a standardised system of coordinate systems and references. The WGS 84 reference system was chosen as it is the official reference system used by GPS and the Universal Transverse Mercator (UTM) coordinate system for calculation purposes.

The QGIS software was used for mapping the land cover and the land use, which was divided into six classes: a) Native Forest (NF), b) Non-forest Native Vegetation (NV), c) Planted Forest (PF), d) Agricultural Zone (AZ), d) Urban Zone.
(UZ), e) Water Bodies (WB), f) Vineyards (V) (Table 1). The composition of bands eight (infrared), four (red), and three (green) was used to classify the image. This composition allowed for better identification of the targets present in the study area with a spatial resolution of ten metres.

Table 1. Description of the supervised classification classes.

<table>
<thead>
<tr>
<th>Classes</th>
<th>Description</th>
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<tbody>
<tr>
<td>Native Forest (NF)</td>
<td>Dense, open and mixed ombrophilous forest and semi-deciduous seasonal forest and pioneer tree formation</td>
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<tr>
<td></td>
<td>Environmental protection areas</td>
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<td></td>
<td>Reforested areas</td>
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<tr>
<td>Non-forest Native Vegetation (NV)</td>
<td>Area with native shrub vegetation</td>
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<tr>
<td>Planted Forest (PF)</td>
<td>Tree species planted for commercial purposes (e.g., eucalyptus, pine)</td>
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<tr>
<td>Agricultural Zone (AZ)</td>
<td>Areas predominantly occupied with annual crops</td>
</tr>
<tr>
<td></td>
<td>Areas for agricultural use where it was not possible to distinguish between pasture and agriculture</td>
</tr>
<tr>
<td></td>
<td>Livestock areas</td>
</tr>
<tr>
<td></td>
<td>Landscaping</td>
</tr>
<tr>
<td>Vineyards</td>
<td>Grape plantation areas</td>
</tr>
<tr>
<td>Urban Zone (UZ)</td>
<td>Urbanised areas with a predominance of non-vegetated surfaces, including roads and buildings</td>
</tr>
<tr>
<td>Water Bodies (WB)</td>
<td>Rivers, lakes, dams, reservoirs and other bodies of water</td>
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<td></td>
<td>Area related to artificial lakes</td>
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Source: adapted from Mapbiomas (2019).

In each satellite image, the bounding corresponding to the geographical delimitation of São Joaquim was identified. Thus, in the QGIS environment, a supervised image classification was performed and executed using the Dzetsaka tool.

Using as ground truths (information collected on location by EPAGRI) the positions of the centroids of the vineyards located in São Joaquim, training polygons were generated for each of the land use and cover classes proposed in this research. These polygons are the basis for the supervised pixel classification procedure. Some land cover has a predominant characteristic, such as urban, grassland and forest areas, while in other areas the predominant characteristic depends on the size of the principal target, such as country houses surrounded by trees and various crops (Cruz et al., 2007).
The Maximum Likelihood algorithm was deployed to perform image processing, a classification of pixel by pixel using algorithms for the recognition of spectral patterns of the image based on a training area. The training areas are areas of the image that the researcher identifies as representative of each class, a homogeneous sample of the respective class. Pixel classification of satellite images is a method of grouping pixels based on their similarities, using classes determined or not by the researcher. Therefore, object-oriented classification is a process in which the first step is image segmentation, the parts of which are used as samples so that the rules assigned in the semantic network generate hypotheses and materialise as objects for a given class. This classification also simulates visual interpretation techniques through knowledge modelling for feature identification, based on the description of identifying patterns such as colour, texture, metric and context (Cruz et al., 2007).

The raster data (matrix form) from the pixels of each class resulting from processing in the QGIS environment was transformed to vector data (polygonal shape). This procedure allows the calculation of the sum of all polygons for each class of interest using the field calculator tool. Thus, the surface area in square kilometres (km²) of each class of interest was estimated.

Besides the land cover and land use maps, information about vineyard altitude was also processed based on the Digital Elevation Model (DEM) SRTM/NASA, resulting in the average height for each vineyard polygon. Along with calculations estimating the area of the vineyards, it was possible to analyse the winescape features for the study case area.

**Background to the Case Study**

From the turn of the 20th century in Brazil, a certificate in Geographical Indications and Denominations of Origin became recognised and began to be awarded.
This recognition began with wine production and expanded to include meat, fruit, rum and coffee, among other products. In order to gain recognition of this type of certification, a series of land use and coverage studies are necessary, in addition to research into territorial and historical aspects. However tourism, and specifically wine tourism in this case, are not included in the study protocols involving certification. Applying to a region that has neither a Geographical Indication nor a Denomination of Origin, in this context this study proposes to contribute so that the recognition protocols in the country can incorporate aspects of tourist territorialities, which, as in the case studied, anticipate certification recognition processes.

São Joaquim, in the southern state of Santa Catarina, is a Brazilian city that has been changing due to the development of new economic dynamics (see Fig. 2). Tourism and grape culture has driven recent socioeconomic changes. After the breakdown of the wood extraction industry, the city invested in agriculture, especially in horticulture and more recently in grape culture. Along with grape culture, the city began the production of high-altitude wines, a promising activity that allied with tourism, turning wine tourism into an economic development alternative. As a new wine-producing region, São Joaquim has been studied for its high altitude, situated at 1,360m above sea level, and its favourable environmental characteristics for the production of fine wines (Vianna et al., 2019a). Its edaphoclimatic characteristics\(^1\) proved to be unique for the production of quality wines (Cordeiro, 2006) and the success of wine producers has attracted tourists to the area. São Joaquim is in the South Plateau, in the mountainous

\(^{1}\) Edaphoclimatic characteristics altitude, slope, orientation, average annual temperature, average daily thermal amplitude, average annual rainfall, average of the total annual hours of sunshine and soils (Viana et al., 2016).
region of the state of Santa Catarina, which has an approximate area of 1,886 km² and a population of 26,763 inhabitants (IBGE, 2019).

Santa Catarina currently has 269.2 km² of grape culture distributed among 525 vineyards, with an altitude higher than 900m above sea level (Vianna et al., 2019a). In three regions (i.e., Vale do Rio do Peixe, Campo Belo do Sul and Serra Catarinense – see Fig. 2), 26 wineries produce wines, and 14 of them offer opportunities for wine tourism activities. Noteworthy are the opportunities for visiting and tasting products, with retail and commercialisation, together with accommodation options in the wineries and the Harvest Festival which is held annually during the harvest season (Valduga & Minasse, 2018).

Figure 2. The geographical distribution of viticulture in the state of Santa Catarina.
Studies on other Brazilian wine-growing regions demonstrate that the development process responded to an inverse logic to that which occurred in the state of Rio Grande do Sul. In Rio Grande do Sul, wine-producing has been proven to induce regional development and wine tourism. In other regions, wine tourism is presented as the central strategy for the development of a new wine-producing region and for reframing the rural space (Ferreira & Hunter, 2017; Fountain, Charters, & Cogan-Marie, 2020), as observed in Serra Catarinense (Losso, 2010), the broader region where São Joaquim is located.

Economic cycles attributed mainly to four economic activities (i.e., livestock, extractivism, agriculture and tourism) marked the process of formation of São Joaquim in the late nineteenth century. After a decline in logging, agricultural cultivation, especially pomiculture, gained a place in the local economy (Losso & Pereira, 2011). The municipality is known for its apple cultivation which began in the 1970s. The successful cultivation of apple trees facilitated the emergence of viniculture, whose phytosanitary treatment is similar. Viticulture has emerged as an additional factor in the economic development of the region.

Tourism activity develops along three axes: winter tourism, due to the high altitude climate with an expectation of snow precipitation and low temperatures; rural tourism, linked to livestock activity and former farms; and wine tourism, driven by viticulture with the production of altitude wines (Losso, 2010; Nodari & Frank, 2019). Endorsed by EPAGRI, it was conventionally considered that altitude wines were those which originated in vineyards located between 900 metres and 1450 metres above sea level (Sobrinho, 2017; Vianna et al., 2019b)
Altitude viticulture has emerged as a new potential for tourism, given the unique landscape characteristics of the producing regions. The changes in the global and national wine markets in production, marketing and consumption, have all favoured the insertion of new products, and new producing regions (Losso, 2010).

Results

The results show that the natural land cover classes were divided into 50.2% non-forest natural vegetation, 37.5% natural forest. Natural vegetation types dominate the land cover in São Joaquim, corresponding in total (NF and NV) to over 87.2% of the area. Land cover related to anthropic activities comprised 12.3% of the territory, including agricultural zones, planted forest and built-up areas. Small dams used for water storage and a few non-commercial fish farms represent the water bodies class. This class of land cover corresponds to 0.3% of the area (see Fig. 3). The study area contains small water bodies, but due to their small surface area, they are hard to visualise on the map.

Figure 3. Spatial distribution of land use and land cover classes in São Joaquim, Brazil.
In terms of land use, the urban zone (UZ) takes up only 0.2% of the territory. UZ is stable in São Joaquim due to the small population and a low population growth rate. The land use also involves rural zoning types which are predominant, with over 8.6% of the land being zoned for agriculture, and 3.5% for planted forest. In São Joaquim the main focus is horticulture, with a highlight on apple tree plantations. The mountain region of Santa Catarina concentrates 51.0% of the national production of apples, with São Joaquim representing 31.0% of this contribution (Guimarães & Oshita, 2019). Overall, 0.1% of the land use is for vineyards which consists of a total of 2,367,401 m². Considering all agriculture zones, only 1.5% corresponds to grape culture.

The sizes of the vineyards range from 730 m² (or less) to 125,760 m², with a median size area of 14,978 m² (see Fig.4). There is a clear predominance of small

Source: adapted by the authors (2020).
vineyard properties, and the most significant area is concentrated in São Joaquin, with a *vitis vinifera* plantation in Santa Catarina (Nodari & Frank, 2019).

Figure 4. Vineyard area in São Joaquin, Brazil

![Vineyard area in São Joaquin, Brazil](image)

Source: adapted by the authors, (2020).

Vineyards are planted at elevations ranging from 1,059m to 1,427m, with an average elevation of 1,238m (see Fig. 5). The largest number of vineyards, 46.0% (74 properties), are concentrated at altitudes between 1,228m and 1,281m. These aspects vary over cardinal directions, where the highest altitudes are concentrated in the south, followed by high altitudes in the northwest portion of São Joaquin.

Figure 5. Vineyard altimetry in São Joaquin, Brazil
The highest and the lowest altitudes are the ones with the smaller number of vineyards. Only five properties are situated between 1,016m and 1,069m, representing the lowest places. Three vineyards are located between the highest points, 1,387m to 1,440m above sea level.

**Discussion**

The vegetation cover and water bodies comprise important elements in a tourism landscape. During the years of the 2000s, the search for a new relationship with nature, and particularly the need for identity and for characterising places of value, has meant that an increasing number of people have ventured to the countryside (Privitera, 2010). Thus, the rural landscape offers a resource for tourism development (Girini, 2017).
The quality of the landscape afforded by the picturesque natural vegetation within the territory of São Joaquim places it in a privileged position as a tourist destination for wine tourism. Aspects such as protection and enhancement of the landscape, including rural architecture, the local society’s culture, its uses, and the cultural landscape as a whole, are a source of comparative advantage that cannot be reproduced elsewhere. The cultural landscape shows the identity of a region, and regarding the tourist supply, is one of the leading resources for wine tourism (Girini, 2017). This landscape which is associated with wine production and wine tourism provides a path to socio-economic development (Ferreira & Hunter, 2017).

Both the cultural landscape and the winescape hold particular symbolism. Although there is a reduced area of vineyards in São Joaquim because the area supports other land uses, the region is characterised as a winescape. Even with the recognition of the landscape as being an essential element of wine tourism, there is still no clear awareness about the vulnerability of this resource. There must be a concern for continuing management and sustainability, as takes place in similar well-known wine-producing areas throughout the world. Into the future, we must recognise this territory as being of great heritage value. We must protect the wine producing landscape, especially considering that tourism in rural areas has a progressive dominant role in change and control (Saarinen & Rogerson, 2014). In this sense, there has been growing interest in the registration and recognition of landscapes for preservation and tourism promotion (Girini, 2017).

São Joaquim is a low-density location with approximately 13 inhabitants per sq. km (IBGE, 2019), and this characteristic complements tourism development, as it targets tourism in low-density areas. Since it involves the experience of the place where
it develops from the perception of the cultural landscape and its elements, this low density is strongly related to wine tourism.

We can highlight two points. Firstly, a territory with low human occupation (built-up areas) tends to be an area with a predominance of vegetal land cover, a natural endemic cultivated area, or a mix of both. Regardless, it has appeal as a landscape, an essential element for the development of wine tourism. As Getz (2000) states, this segment is effectively associated with natural landscapes, low rates of tourist development and low population density. Secondly, wine tourism as a tourism segment typical of low-density regions has its development associated with landscape preservation. According to UNESCO (2019), the protection of winescapes has value related to the conservation of natural heritage and cultural manifestations. It is not just a matter of transforming the landscape into a frame, but of including regulatory preservation in landscape management, guaranteeing the continuity of economic activities and their transmission to future generations (UNESCO, 2019).

As part of the winescape, since 2007, an increase in vineyard areas in São Joaquim, ranging from 1.4 km² to 1.9 km² (Nodari & Frank, 2019) has taken place. Vianna et al. (2016) argued that between 2009 and 2013 São Joaquim had the most significant increase (14.0%) in the planted area among the other high-altitude wine-producing locations in Santa Catarina. Unlike other wine-producing regions in Brazil, viticulture in São Joaquim is not associated with Italian immigration. Rather than having a historical heritage, it was the high altitudes in the region that differentiated this area from other areas. The geographical location favours the production of wines with a particular composition, such as a high concentration of polyphenols (Sobrinho, 2017).

As Ferreira and Hunter (2017, p. 6) highlighted regarding aesthetic appeal in the case of South Africa, the winelands offer a range of topographical pleasures such as
high mountains. The high altitude of São Joaquim also influences the climate, and the region experiences the lowest temperatures throughout Brazil. The São Joaquim wine region has significant potential, demonstrated by a climate that differentiates it from all other regions in the country. It has four well-defined seasons, and its high point is the winter, when it can even snow, a rare phenomenon in a tropical country like Brazil (Losso & Pereira, 2011). This particularity arouses interest in wine tourism in the region. The climate associated with the vineyards increases tourism activity, reflecting a higher flow of tourists in other tourist infrastructure services such as accommodation and food supply.

Figure 6. Winescape in São Joaquim, SC.

Carlsen’s (2004) study showed that the wine regions recognise that the benefits of wine tourism extend beyond the vineyards. It is a segment that involves and affects all areas of the regional economy (Girini, 2017; Baird, Hall & Castka, 2018). According to Fountais et al. (2017) wine tourism is seen as an option in achieving regional development. The wine tourist wants to know the origin of the product and also wants to learn about the local environment (Escolar & Morueco, 2011).

The vineyards comprise a region and therefore can offer wine tourism as a regional product. Escolar and Morueco (2011) pointed out that the optimal way to organise wine tourism is to create integrated itineraries between the producing areas. In this sense, offering tourists the opportunity to discover natural, cultural and historical elements that characterise the territory, therefore the winescape. Also, the concentration of vineyards close to urban areas and roads is an advantage in establishing wine routes. In the creation of routes, it is necessary to articulate and enhance the tourist infrastructure; this means accommodation, gastronomy, and other leisure activities.

In developing wine tourism, the approach and commitment of all public and private economic agents are fundamental. It is essential that local, provincial, and national governments support tourism activities (Ferreira & Hunter, 2017). Wine tourism occurs in a particular territory that will be uniquely positioned locally and globally so the perceptions and actions of local stakeholders will differ, influencing the form wine tourism takes (Fountain et al., 2020).

Wine tourism should be considered as a sustainable development associated with knowledge, technology and the enhancement and preservation of the cultural landscape (Patriquin, 2005). The potential of the winescape lies in its economic efficiency, which supports tourism activities in addition to wine production (Cañizares & Pulpón, 2018). To provide sustainable development, territorial planning is essential.
and the first step is to have a database that supports decision makers with solid and truthful information, as is emphasised by this research methodology and findings.

In this sense, wine tourism, a segment capable of promoting the development of rural regions, is a promising segment in São Joaquim, although it is still in a very early stage. Geographical Indications and Denominations of Origin recognition require a series of land use and coverage studies, in addition to territorial and historical aspects. However tourism, and specifically wine tourism in this case, are not included in the study protocols involving certifications. In this context, applied to a region that does not have a Geographical Indication or Denomination of Origin, this study proposes to contribute so that the recognition protocols in the country can incorporate aspects of tourist territorialities. As in the case studied, this will provide the anticipated certification recognition processes.

Conclusions

This paper showed that the data obtained from the remote sensing of satellite images and provided by EPAGRI allowed analysis of the physical characteristics of the winescape of São Joaquim. The results showed a predominance of natural vegetation integrated into a mosaic of vineyards and other agricultural areas. Also shown was the predominance of small and medium-sized vineyards at high altitude which are highly productive.

One of the essential components of wine tourism is the landscape of each region, which is distinguished by its particularities and its identity. Thus, the wine-producing regions have advanced in protecting their landscapes with different mechanisms, for example, UNESCO’s landscape protection as world heritage, Geographical Indication or Denomination of Origin, and levels (local, national or international) of protection in terms of natural, historical and cultural assets. Although still underdeveloped,
conditions for wine tourism are favourable in the study area, causing it to be prominent in regional tourist activity. The social and natural elements, which together create a vulnerability in the landscape, make it necessary to develop in-depth and interdisciplinary studies allowing the identification of resources, potentialities, and difficulties. The methodology presented in this paper acknowledges the creation of instruments to manage and monitor the territory. Besides, there is a need to establish a protection mechanism so that these landscapes remain as resources for tourism, and also socio-economic development considering the benefits (jobs, taxes, income, etc.) of economic activity. The methodological approach chosen for this research has proven to be a viable and affordable way for the preliminary characterisation of the cultural landscape and winescape by integrating remote sensing, geoprocessing, and secondary data. The capacity to gather data from different sources, and the speed and volume of data collected is possible only with field research. The information gathered by this method helps to identify problems, plan the expansion of cultivation, and manage the native vegetation areas and the built-up area. This combination of findings provides some support for discussing the relationship between winescape, land use and cover, and its relationship with tourism.

In terms of practical application, this study is a data base for territorial planning in the region, and it is a replicable asset. This type of information can also help in establishing a geographical indication of origin for high altitude wines. Furthermore, it makes it possible to map wine production spaces and to understand the multifunctionality of rural areas. In tourism, practical applications can be used for the territorial planning of tourism, mainly regarding the distribution of infrastructure and tourist attractions. Also, it provides initial data for setting tourist itineraries between the vineyards, for example, developing a GIS for tourist infrastructure.
As it was limited to an one-year analysis, this study lacks a time series which would allow a comparison of the evolution of land cover and land use as well as territorial monitoring of the increase in the number of vineyards and growth of new plantation areas. Another issue that was not addressed in this study was whether regions with similar historical background have similar findings in terms of land cover, land use and vineyard area size.

Further research could investigate the evolution of land use and land cover in a wine tourism territory from a historical series of satellite images from the beginning of grape culture to the current time. Additional studies are needed to develop a full picture of the winescape by analysing the sensorial aspects beyond the physical elements of the winescape.

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