

Identifying areas suitable for wine tourism through the use of multi-criteria and geographic information system: the method and its application in the countryside around Mount Etna (Sicily)

Lara Riguccio, Giovanna Tomaselli, Laura Carullo, Danilo Verde, Patrizia Russo

Department of Agriculture, Food and Environment, University of Catania, Italy

Abstract

Vineyards are among the crops that shape quality landscapes. Many places in the world are famous for their unique wine landscapes which play an important role in the development of tourism in the rural areas. Among these, the wine landscape surrounding mount Etna (Sicily) emerges due to its undisputed value, as it is an important component of the territory recognised as a World Heritage Site by UNESCO. This work was conducted with that in mind, in order to identify the most suitable areas for wine tourism on the slopes of our volcano. The method used assigns a great importance to the quality of the landscape, an indispensable resource for encouraging wine tourism, and considers it to be of equal importance with the production of the wines themselves. The present work uses multi-criteria analysis in combination with geographic information system (GIS). Numerous indicators describing local resources were weighed and spatialized. The GIS analysis allowed for the development of various intermediate maps, which allowed to draw up the final suitability map for wine tourism, identifying areas larger than those of the actual vineyards. The value of these areas and the quality of their landscapes are closely connected to the production of the wines in the zone. It could be the target for specific plans and projects aimed at using the available resources, to develop wine tourism in rural areas. Although the study only covers a limited geographical area, the

methodology used has general validity and could be used in other contexts.

Introduction

The quality of the landscape plays an essential role in determining the quality of life of the local population, and thus maintaining this quality is both a social and institutional obligation (European Landscape Convention) (De Montis, 2014a; Carullo *et al.*, 2015; Riguccio *et al.*, 2016).

In most rural landscapes, quality is often associated with the presence of typical products and their production by traditional methods (Gullino and Larcher, 2013). *Typical agricultural methods* identify the landscape and thus assume the role of *cultural markers* for agricultural products. They can spur on improvements in the social and economic well being of the communities where they are present.

The vineyards are among those types of agriculture, which create high quality landscapes. There are many places in the world, which are famous precisely because their character is defined by vineyards, and this character is also closely connected to the specific rural area.

Wine tourism is also connected to quality vineyards. They are well known to have strong links with the rural landscape and rural life. Various authors and studies on wine tourism have suggested that the rural environment is a central element in wine tourism and its promotion (Getz and Brown, 2006). The rural landscape is an integral part of the wine tourism. Tourists visit the wineries on the basis of several factors (Charters and Ali-Knight, 2002), which may include: aesthetic appreciation of the natural environment, the cultural and historic context of the wine region (Mitchell *et al.*, 2012) and the traditional and innovative aspects of the production process (Corduas *et al.*, 2013). These factors are intrinsic and *visible* components of the wine growing areas in a region. However the landscape also consists of immaterial elements, which, by defining the unique and unrepeatable character of a particular social and geographical area, create the *spirit* of the place and are also what makes it potentially attractive. *Attractive* in this sense means the capacity of an area to attract and encourage new investments. This is linked to other goods and services and in particular to those connected with tourism, which depend on the quality of the landscape. All over the world many wine growing areas have today become international tourist attractions precisely because the local people have known how to take advantage of the areas' potential, of their material and immaterial resources, and have provided the areas with appropriate support services for wine tourism.

In Italy, and in Sicily in particular, although the current economic and political policies offer various opportunities for rural

Correspondence: Giovanna Tomaselli, Department of Agriculture, Food and Environment (Di3A), University of Catania, via S. Sofia 100, 95123 Catania, Italy.

Tel. +39.0957147573 - Fax +39.0957147600.

E-mail: gitomas@unicat.it

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development, with the strategic objective of improving the environment and the rural landscape (Siciliano, 2012), the large and important quality wine growing areas, as recognised by EU directives, are not given sufficient importance in the context of world tourism (Pomarici and Vecchio, 2014).

Research on the potential for land development through landscape enhancement (*i.e.*, enhancement of both tangible and intangible resources), in scientific terms, has been tackled by many researchers using multi-criteria evaluation (MCE) associated with a geographic information system (GIS) analysis. These procedures are now widely adopted in support of planning processes.

Multi-criteria techniques have been developed specifically for the purpose of addressing and representing conflicts that may arise from the use of land resources explicitly and with procedural transparency. The integration of multi-criteria analysis in a dedicated GIS, allows for the allocation of implemented analysis in space, the immediate verification of results on a territorial reference model, and the evaluation of different calibration of the model on the basis of planning purposes (Fichera *et al.*, 2015). Recently MCE-GIS integration has been used for the delimitation of *typical agricultural districts* (Riguccio *et al.*, 2015), for the development of rural areas through the implementation of cultural routes (Diti *et al.*, 2015), and to test soil suitability for the cultivation of autochthonous vines (Modica *et al.*, 2014). In these and other works (Chandrasekar *et al.*, 2009; Palmisano *et al.*, 2016) significant results were reached for the enhancement of rural landscapes. The MCE-GIS approach therefore is certainly still relevant and valuable. This work studies the area around Etna, highlighting the particular landscapes and countryside linked to wine production, in order to identify the most suitable areas for developing quality wine tourism. These could then be given added value by emphasising the relationship between the landscape and the product. Such a study requires particular attention being paid to the resources available and the skills in this field, which have developed over the centuries. This heritage is the result of the interactions between the local population, who shares the same awareness and values. Wine production is an expression of this: a *contextual awareness* which recognises the heritage of a specific local community and realises that this depends on the characteristics of the local production system (Becattini, 2000). In this work we produce maps that contain information which is useful for identifying the *quality objectives* for the components of the landscape, and which may assist in developing plans for the area. They may also help in putting into effect the principles of the European Landscape Convention, and in particular those of Article 1, which sets out strategic objectives, which are designed to protect, manage and plan the landscape.

The *Materials and methods* section is divided into three paragraphs. The first briefly describes the study area by highlighting the main geographical and socio-economic aspects. The second and third respectively describe the methodological aspects of the multi-criteria and GIS applications.

The *Results and discussion* section is divided into two paragraphs which quote, respectively, the results and the discussion of the multi-criteria and GIS applications. Finally, the *Conclusions* quote the considerations relating to the validity of the research from the methodological aspect and with regard to the specific local situation.

Materials and methods

The proposed method is based on multi-criteria analysis, using

multi-criteria decision aid, in conjunction with spatial elaboration using GIS (Murray and Tong, 2009).

The GIS ArcMap 9.2 from ArcGis 9 was used for the latter, while Adobe and AutoCad software were used for editing the graphics.

Area of the study

Italy was the largest wine producer in the world, with 40.8 million hectolitres, and in Sicily more land than in any other region was used for wine production, a total of 1127.3 km², which is equivalent to more than 17% of all Italian land used for wine production (data 2011 from IRVOS - the Sicilian institute for wine and oil). In Sicily various areas are recognised as producers of certified quality wines. The area around Mount Etna, now a UNESCO World Heritage Site, produces the Etna DOC [*Denominazione di Origine Controllata* - Controlled Designation of Origin (CDO)] wines in a unique landscape, but unfortunately this is not sufficiently appreciated (Caniglia *et al.*, 2008). Here the vineyards could play an important role in developing and revitalising the area and its natural and cultural heritage. Highlighting the strong social and cultural links between wine production and the area has a vital role to play in developing the local economy and protecting the rural landscape.

The study area is bounded to the north by the Alcantara River, which is currently a regional river park, to the east by the Ionian sea and to the west and south by the Simeto River. The area is located in landscaped area number 13 (Etna's volcanic cone) of the Territorial Landscape Plan of the Sicilian region and covers approximately 1369 km² (Figure 1).

In this area there are vast quality vineyards. The predominant grape cultivar is the *Nerello Mascalese*, which characterises the DOC area of the north east volcanic slope with its typical sapling shape. This vine covers about 93% of the surface area dedicated to grape vine cultivations in the province of Catania (32 km²).

The production of DOC wines makes up approximately 38% of wine production in the province and uses only 17.8% of the land dedicated to grape vine plantations in the province [data 2011 from CCIAA (Chamber of Commerce of Catania)].

Mount Etna, apart from the vineyards, contains various material and immaterial resources. To give a brief description, there are the various lava flows, extensive woods, caves and many other natural features. All of these make Etna unique and explain why it is a regional park and the home to some *Sites of Community Importance* and *Special Protection Areas*. Agriculture is practiced

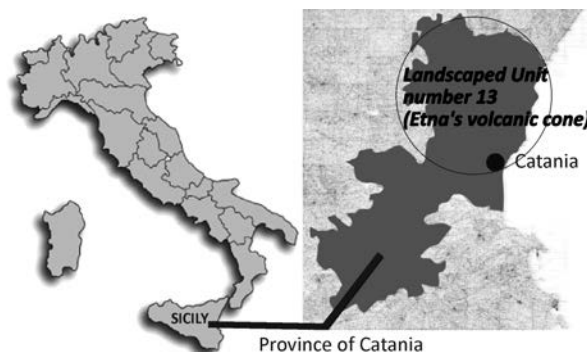


Figure 1. Location of study area.

below 1500 m a.s.l.. As well as the vineyards there are also typical fruit orchards, pistachio, cherry and chestnut groves and also stands of Indian figs (Strano *et al.*, 2012). Buildings form an important element of the landscape, and in particular the large villas and wineries built since 1400. There are many historic towns and villages, archaeological and cultural sites and typical historic buildings (Riguccio *et al.*, 2013). There are many museums, markets and popular festivals and these are an important part of the immaterial heritage of the area. Grape growing and wine production on Mount Etna have very ancient roots. This can be seen from the presence of ancient wineries (structures for pressing the grapes were originally excavated in the rocks), which date from 1200 B.C.. Before the spread of Phylloxera at the end of the 19th century, most of the slopes of Mount Etna between 500 m and 1500 m a.s.l. were used for vineyards, as can be seen from the historical ordinance survey maps from 1866. Today the area used for vineyards is markedly less than it was in the middle of the 19th century, but modernisation of the cultivation system means that vineyards are still the most important form of agriculture around Mount Etna. The specific identity of the wines produced comes from their strong links with the local area, which makes them irreproducible elsewhere: the wines from Etna are unique, both because of their chemical, physical and organoleptic characteristics (which come from the natural resources of the area, and in particular the particular soil and climate and the local genetic resources for the grapes), and as a result of the knowledge of and experience in wine-making which has matured in the area over the passage of time.

From the integration of different sources, particularly from the WEB, from CCIAA [data 2011 from CCIAA (Chamber of Commerce of Catania)] in Catania - and from a direct recognition, we have found 98 farms on Etna volcano that grow wine grapes and they are also wine producers, of which nearly 60% is concentrated in the territory of Castiglione di Sicilia town (30 farms), Randazzo town (18) and Linguaglossa town (8). Forty-eight farms (mainly located between Randazzo and Linguaglossa) offer tastings and tours. Of these 48 farms, twenty-two are equipped for catering, eleven also offer hospitality for the night, two have set up wine museums, four are also educational farms, one is equipped with an amphitheater and other attractions (Figure 2A).

Five wineries only join the group of Etna Wine Road and twelve adhere to the Wine Tourism Movement circuit. As for the accommodation capacity in the area, the Catania province statistics office in 2011 recorded the presence of: 57 agritourism and rural tourism farms, for a total of 922 lodgings; 282 bed & breakfasts, cottages, shelters, parks camping, *etc.*, for a total of 2544 accommodations. There are fifty-five hotels all over the area, including thirteen four-star, thirty three-star, seven two-star and three one star, for a total of 5938 beds. The highest concentration of rural accommodations is registered in Castiglione di Sicilia and Linguaglossa towns (Figure 2B).

The private and public initiatives dedicated to the enhancement of the local wine heritage are multiplying throughout the area, with projects that are intended to promote and market the Etna wines, even outside of the local environment and offer an opportunity for comparison with other national and international producers, among them: *ViniMilo* Milo, *Contradas Etna* and *Sicily En Primeur* in Castiglione di Sicilia, *EnoEtna* in Santa Venerina, *VinEtna* in Randazzo, *Wine glasses of stars* in the Cities of wine (Castiglione Di Sicilia and Zafferana Etna). Moreover, in all the municipalities of the Etna area, they organise festivals and events dedicated to the grape-harvest and to the local products.

Multi-criteria analysis

Multi-criteria analysis was used to evaluate the attributes, the criteria and the sub-criteria. This was done in order to identify the areas, which were most suitable for wine tourism.

Table 1 shows the hierarchical database model of the problem. The analytic hierarchy process (AHP) (Saaty, 1990), was used to do this. This is based on constructing square matrices, with the elements to be hierarchically ordered found in both the lines and columns. Every element x_{mn} is the result of the comparison between indicator m on the line and indicator n in the column, in relationship with the objective which one wishes to achieve. Saaty's numerical linguistic scale (Saaty, 1990) was used for this comparison. The AHP helps one to understand in a simple but decisive way the quantitative and qualitative aspects of a decision and thus reducing distortions in the decision making process.

The ultimate objective of our multi-criteria analysis was to distinguish between different areas of Mount Etna in terms of their suitability for wine tourism. A scale of values was defined which was deduced from integrated evaluation of the components of the hierarchical problem. This was structured on four levels: criteria, sub-criteria, attributes and indicators.

The criteria at the first hierarchical level are: i) classifying the areas according to the quality of the landscape; ii) classifying the areas according to the quality of the wine tourism.

For the first of the above criteria, the corresponding sub-crite-

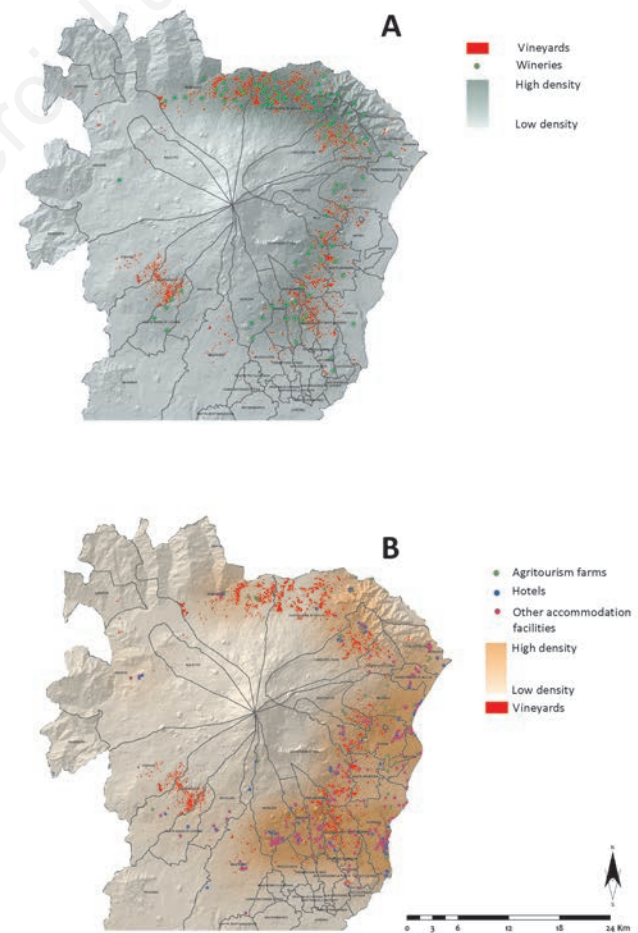


Figure 2. Localisation of the main wineries (A) and accommodation facilities (B).

ria, which are themselves divided hierarchically, based on their attributes and the indicators, are as follows:

- A) Evaluating the system of development, taking into consideration historic information and in particular: a) changes in the landscape, deduced from comparing the historic use of the land (1866) with that today (2010), with no change being given a null value, reversible changes a medium value (changes in agricultural practices), and irreversible ones such as urbanisation a high value; b) the presence of historic vineyards; c) the presence of historic rural settlements; d) the presence of a historic road network;
- B) Evaluation of the structural system, taking into consideration: e) the urban centres and their infrastructure; f) the use of the land and in particular the area of land used for vineyards; g) the isolated assets, such as farms and farmhouses inside the vineyards or inside buffer zones of 6 km; h) areas of natural importance such as woods and Natura 2000 sites and areas of importance for the local wildlife; i) the traditional farming practices and in particular the areas dedicated to the cultivation of olives, Indian figs, pistachio *etc.*;
- C) Evaluation of the system for viewing the area, taking into consideration the roads and panoramic viewpoints (l).

For the second of the above criteria (classifying the areas according to the quality of the wine tourism), the sub-criteria is:

- D) Agro-cultural system which have the following attributes and indicators: m) presence of modern vineyards or wineries; n) tourist structures, such as hotels, BandBs, agritourism establishments, campsites *etc.*; o) historic cultural heritage, such as historic or archaeological sites, historic town centres, museums, *etc.*; p) different types of infrastructure.

The multi-criteria analyses were developed by constructing the relevant matrices for pairwise comparison for each hierarchical level. The weightings come from qualitative judgments based on the literature and present policies in this sector (Cullotta and Barbera, 2011; De Montis, 2013; De Montis, 2014b; De Montis *et al.*, 2014), using Saaty's scale (1-Equal importance, 3-Moderate importance of one over another; 5-Essential or strong importance; 7-Very strong importance; 9-Extreme importance). Thus the matrices were constructed in a way which was coherent with the hierarchical structure shown in Table 1, and the consistency of each of them was verified. All the matrices were found to be consistent and so the weightings given to them were acceptable.

A spreadsheet (EXCEL software) was prepared allowing for the verification of the sensitivity of hierarchical application to changes in the weighting of the components of the problem. In particular, the sensitivity of the hierarchic order obtained by the percent variation of indicator weightings with changes in the weighting of the *quality of the landscape* and *quality of the wine tourism* criteria was established, as these affect all lower hierarchical levels.

Spatial analysis and geographic information system mapping

Spatial analysis and GIS mapping have been carried out in two phases. In the first phase the data were harmonised and were digitized and transferred into a GIS setting. In the second phase the data were elaborated in a GIS setting, with the basic indicators given their relative weightings and creating the weighted maps for each hierarchical level.

First phase

The basic 1:25,000 scale topographic map in raster format and

geo-referenced using Monte Mario/Italy zone 2 coordinates (EPSG: 3004), was integrated with the thematic maps local Landscape Plan. This was supplied by the Supervisory board for the Ministry of Cultural Heritage and activities for the Province of Catania. The information which described the following indicators was used: c₁ e₀₁ (traditional agricultural landscape), c₂, g₁ e₀₂ (types of rural settlement), e₁, p₁, p₂, p₃, p₄, p₅ (viability), e₂ (historic towns and villages), e₃ (residential areas), l₁ (panoramic viewing points), l₂ (panoramic roads), all the indicators of attributes f (use of the soil), h (natural areas) and i (traditional agriculture).

Historic data, were extracted from the topographical maps in raster format of the historic IGM series. These had a scale of 1:25,000 and 1:50,000, and covered the period from about 1866 to 1940. The information extracted described vineyards and other farming practices at the time in particular, as well as the infrastructure. In addition appropriate questioning had highlighted the following indicators: all those related to these attributes a (transformation of the landscape), b (durability and survival of the vineyards), d (durability and survival of the infrastructure).

Finally, information was integrated in digital form from various specialised websites, registered with and authorised by the relevant local authorities (Councils, Chambers of Commerce, wine roads, farmer's associations, *etc.*). This information was related to attributes m (vineyards and winery businesses) and n (tourist accommodation).

The information from this phase was used to create the basic thematic maps.

Second phase

The results of the IV level of the hierarchical analysis, *i.e.* the values of the weightings of the indicators, were linked to their corresponding spatial areas in a GIS environment and weighed with the vector values of the weightings at the higher hierarchical levels, previously multiplying them with a numeric constant equal to 100. This last weighting is necessary in order to obtain whole numbers whose products return the true weightings of the factors. It was thus possible to map the values of the attributes, the sub-criteria, the criteria, and finally the suitability of the area for wine tourism. On all maps we have highlighted the vineyards. The buffer areas of 2, 4, and 6 km are shown in Figure 3, only to highlight the traditional crops in adherence to the vineyards,

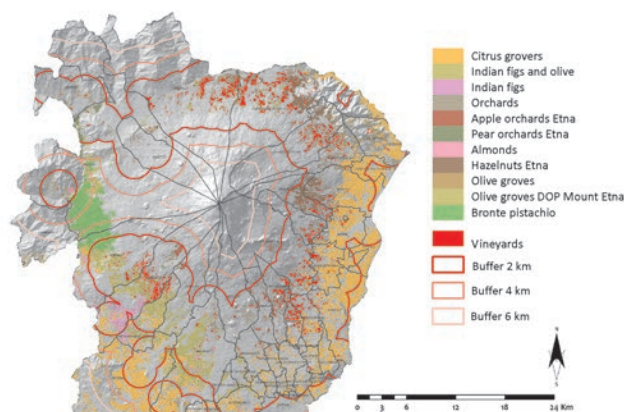


Figure 3. Territorial distribution of traditional agriculture.

Table 1. Hierarchical structure and weightings.

Objective	I Hierarchical level Criteria	W*	II Hierarchical level Sub-criteria	W*	III Hierarchical level Attributes	W*	IV Hierarchical level Indicators	W*	
Suitability for wine tourism	Quality of the landscape 33								
	A. Development system 20								
		a. Changes in the landscape landscape	6			a1. Survival of traditional agriculture		90	
					a2. Change from traditional agriculture to other forms of agriculture		6		
					a3. Change from traditional agriculture to built up areas		4		
		b. Vineyards	65		b1. Survival of the vineyards		80		
					b2. Change from historic vineyards to other field crops		10		
					b3. Change from historic vineyards woodland		10		
					b4. Change from historic vineyards to built up areas		8		
		c. Historic and cultural heritage	10		c1. Traditional agricultural landscape		50		
					c2. Rural settlements		50		
		d. Historical ability to survive	19		d1. Ability of the historic infrastructure to survive		100		
		B. Structural system 40							
		e. Local settlements and infrastructure	33		e1. Viability		75		
					e2. Historic centres		7		
					e3. Residential centres		18		
		f. Land use	26		f1. Citrus groves		6		
					f2. Shrub land and woods		20		
					f3. Built up areas		2		
					f4. Bodies of water		15		
					f5. Forestry		7		
					f6. Horticulture		5		
					f7. Grazing and fallow land		6		
				f8. Arable land		5			
				f9. Wooded arable land		6			
				f10. Greenhouses		2			
				f11. Vineyards		26			
	g. Isolated historic sites	24		g1. Rural settlements		100			
	h. Areas of natural interest	7		h1. Woods		66			
				h2. SCIs and SPAs		16			
				h3. Areas of interest for the wildlife		19			
	i. Traditional agriculture	10		i1. Vineyards		60			
				i2. Typical fruit orchards and fruit growing areas (Indian figs, almonds hazelnuts, pistachio, etc.)		30			
				i3. Citrus groves		10			
	C. Visual system 40								
	l. Panoramic roads and viewing points	100		l1. Viewing points		50			
				l2. Panoramic roads		50			
	Quality of the wine tourism 67								
	D. Agro-cultural system 1								
	m. Wineries and vineyards	51		m1. Farms		100			
	n. Tourist structures	26		n1. Farms open to tourists		60			
				n2. Hotels and B&Bs		20			
				n3. Campsites		20			
	o. Historic cultural heritage	8		o1. Traditional agricultural landscape		50			
				o2. Rural settlements		50			
	p. Infrastructure	15		p1. Motorways		20			
				p2. Main roads		20			
				p3. Provincial roads		20			
				p4. Other roads		20			
				p5. Railways		20			

*Weightings. SCIs, sites of community importance; SPAs, special protection areas.

graduating their proximity to these (in adherence in the 2 km buffer, distant in the buffer on average between 2 and 4 km, more distant from 4 to 6 km.

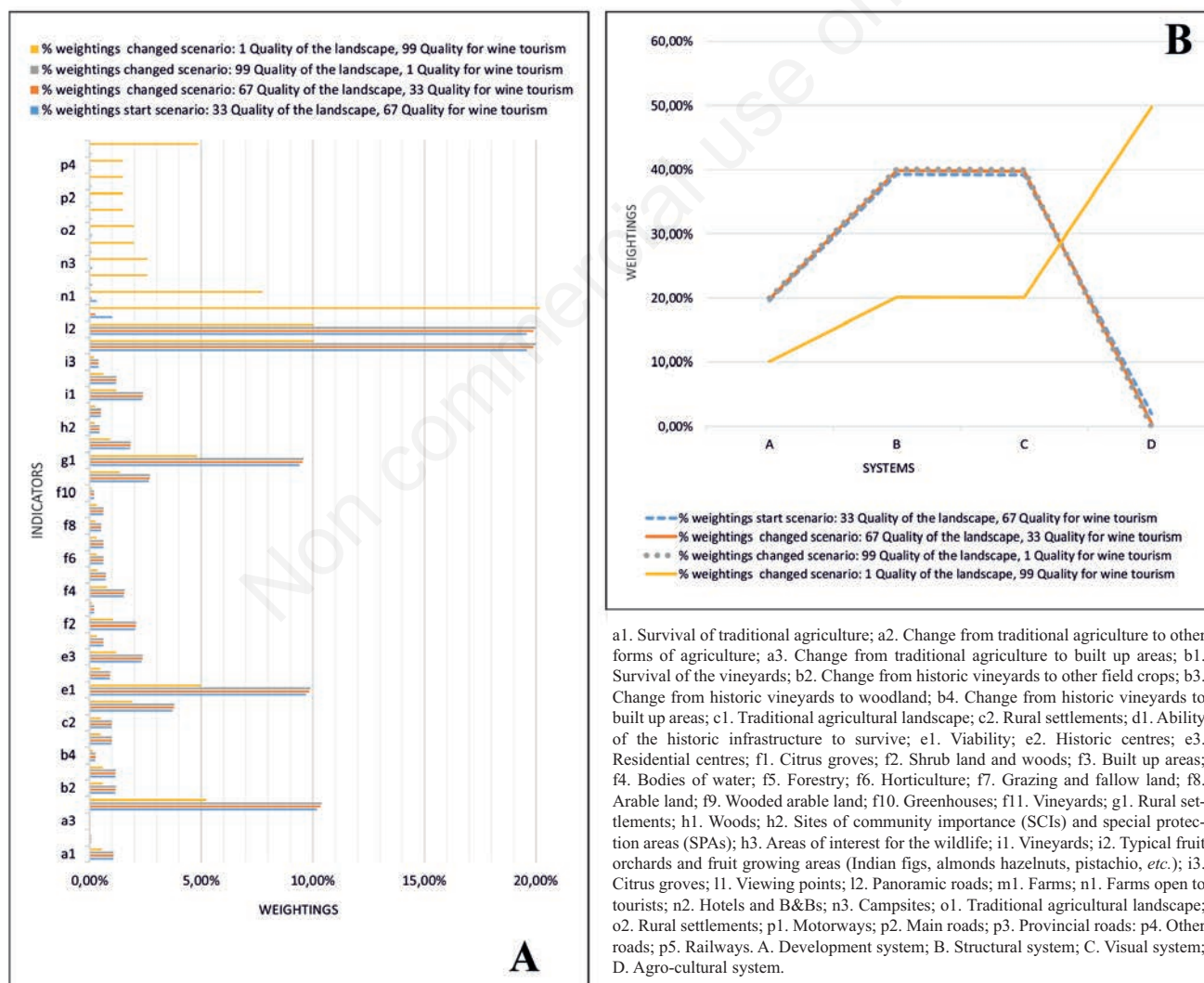
Results and discussion

Multi-criteria analysis

The goal was to classify the area around Mount Etna in terms of its suitability for wine tourism. This was done by a hierarchical analysis, which was based on constructing a pairwise comparison matrix for each of the four hierarchical levels. The results of the multi-criteria calculations, which are to say the values of the vectors of the weightings multiplied by the constant of 100, are shown in Table 1. The pairwise comparison matrix for the first hierarchical level showed that the potential for wine tourism, with a weighting of 67, was more important than the quality of the landscape.

The matrix for the second hierarchical level established the

order of importance of the landscape systems, which describe the quality of the landscape. Pairwise comparison showed that the structural system and the visual aspects were equally important, with weightings of 40, while the system of development was less important, with a weight of 20. The matrices for the third hierarchical level provided the weightings for putting the attributes related to the different systems (sub-criteria) in order of importance. They were also useful for weighing the values of the descriptive indicators for each attribute. For the development system (A) the historic vineyards (b) had the highest weight (65), especially when there was no change in their use from 1866 or from 1940 (b₁). This attribute contributed greatly to identifying the quality of the landscape. The historic roads (d) (weighting 19) were also of marked importance. This was described by a single indicator, the permanence of the infrastructure (d₁). The historic heritage attributes cultural (c) (weighting 10) and transformation of the landscape (a) (weighting 6), are described, respectively, by two (c₁ and c₂) and three (a₁, a₂ and a₃) indicators. The indicator with the highest weighting was again that for no change in the landscape (a₁) (weighting 90). Thus where there are historic vineyards there is no



a1. Survival of traditional agriculture; a2. Change from traditional agriculture to other forms of agriculture; a3. Change from traditional agriculture to built up areas; b1. Survival of the vineyards; b2. Change from historic vineyards to other field crops; b3. Change from historic vineyards to woodland; b4. Change from historic vineyards to built up areas; c1. Traditional agricultural landscape; c2. Rural settlements; d1. Ability of the historic infrastructure to survive; e1. Viability; e2. Historic centres; e3. Residential centres; f1. Citrus groves; f2. Shrub land and woods; f3. Built up areas; f4. Bodies of water; f5. Forestry; f6. Horticulture; f7. Grazing and fallow land; f8. Arable land; f9. Wooded arable land; f10. Greenhouses; f11. Vineyards; g1. Rural settlements; h1. Woods; h2. Sites of community importance (SCIs) and special protection areas (SPAs); h3. Areas of interest for the wildlife; i1. Vineyards; i2. Typical fruit orchards and fruit growing areas (Indian figs, almonds hazelnuts, pistachio, etc.); i3. Citrus groves; i1. Viewing points; i2. Panoramic roads; m1. Farms; n1. Farms open to tourists; n2. Hotels and B&Bs; n3. Campsites; o1. Traditional agricultural landscape; o2. Rural settlements; p1. Motorways; p2. Main roads; p3. Provincial roads; p4. Other roads; p5. Railways. A. Development system; B. Structural system; C. Visual system; D. Agro-cultural system.

transformation of the landscape. These vineyards are most certainly in DOC wine areas, and thus it is evident without doubt that their historic character is an important component of the quality of the landscape, even though the development system only has a 20% value when defining the quality of the landscape. For the structural system (B) the attributes with constant weightings are those for the settlements and the infrastructure (e) (weighting 33), the use of the soil (f) (weighting 26) and isolated historic sites (g) (weighting 24), while nature areas (h) (weighting 7) and traditional agriculture (i) (weighting 10) have little importance. The distribution of the values of the respective indicators shows that those, which contribute greatly to determining the quality of the landscape, are the various types of infrastructure (e₁) (weighting 75). This is even more pronounced when they coincide with the survival of the historic infrastructure (d₁) (weighting 100). Once more it becomes clear that the vineyards play a noteworthy role in this (f₁₁) (weighting 26), even in the context of the structural system. The quality of the landscape is also undoubtedly influenced by the presence of woods (f₁, weighting 20; h₁, weighting 66).

The visual system (C) is described by two indicators: panoramic viewing points (l₁) and panoramic roads (l₂). These have equal weightings of 50 in determining the quality of the landscape. If the panoramic roads are also roads of historic importance then this makes them particularly important.

The most important attribute for determining the potential of an area for wine tourism is the type of farm (m) (weighting 50) and the presence of vineyards and wineries (m₁) (weighting 100). The available tourist facilities (n) are very important (weighting 26), especially when those are found in the same vineyards and wineries (n₁) (weighting 60). Once again the historic environment, and the influence of the use of traditional agricultural methods in defining this, is of great importance (o₁) (weighting 50), as is the presence historic rural settlements (o₂) (weighting 50) (Caliandro *et al.*, 2014). Ultimately, the indicators which determine whether an area is most suitable for wine tourism are: the historic environment of the area and the types of agriculture, above all the vineyards; the traditional and typical nature of the types of agriculture practiced; a good infrastructure, the presence of historic rural settlements; the presence of vineyards and wineries which are ready to exploit the possibilities of wine tourism.

The sensitivity analysis shows that the hierarchic ordering obtained is solid, as it allows for a wide variation in the criteria weightings (quality of the landscape and quality of the wine tourism) without the ordering itself changing.

In fact Figure 4A and B show that neither the percentage values of the indicators nor the ordering of the systems change significantly when criteria weightings are switched, but perhaps more significantly they do not change when *quality of the landscape* is assigned a weighting of 99 and *quality of the wine tourism* of 1. The model is sensitive if 1 is assigned to the first criterion and 99 to the second, however this would require assigning no importance to the quality of the landscape, which is inadmissible given the aim of the problem.

Spatial analysis and geographic information system mapping

The first phase of GIS implementation involved digitizing and harmonising the acquired data. The data were organised in topological layers, depending on their type. It is well-known that the GIS, when constructed from basic data, allows one to obtain various types of maps, such as, for example, those which simply visualise the spatial information, or the results of overlay maps, or the

numeric elaboration of the values of different records or fields of information (Tortora *et al.*, 2015).

The potentials of GIS have been used here for developing the second phase, the construction and visualisation of the maps associated with multi-criteria issues. There are many maps of the fourth hierarchical level. These show the various indicators in their respective geographical areas. Some of these are particularly important for determining whether or not the countryside is suitable for wine tourism.

The map of the changes in the historic vineyards shows that only a few have not changed their use since 1866, with some 5.8%, or 15.46 km² of the original area (235.21 km²) used for vineyards at that date, still being used today. These make up 38% of the area (40.59 km²) presently used for vineyards (Figure 5), and are mainly found north and southeast of the volcano. The fourth level map of traditional farming methods (Figure 3) shows that there has been a marked diversification in farming practices on all the slopes of Mount Etna, with the exception of a limited area to the northwest. The agricultural landscape inside a buffer zone of two km around the vineyards is characterised by the presence of woods and orchards, mainly hazelnut woods and olive groves. Citrus groves are mainly found to the east, where the climatic conditions close to the sea are ideal for this kind of cultivation. Other fourth level maps, not reported here for reasons of brevity, show the great suitability of the infrastructure and services to the northeast and southeast of the volcano. The motorway runs north to south to the east of Etna, and there are many wineries and wine cellars, which are open to visitors. There is a good tourist infrastructure and almost all the roads in the area have good views of the landscape. At the third hierarchical level there are fourteen weighted maps, which show the spatial distribution of the multi-criteria evaluations at this level. Once again certain maps are of particular importance, such as the ones that show: the changes in the landscape, the historical and cultural heritage, the settlements and the infrastructure, and the areas of particular natural interest (Figure 6). The landscape changes map shows that in general there have been few changes in the landscape since 1866, especially in the higher altitudes of the slopes of the volcano where the land is rocky and covered by woods. The *medium change* areas, quite extensive among cultivated areas, are areas where a reversible change in use has occurred, and especially a change in the type of agriculture. There are almost

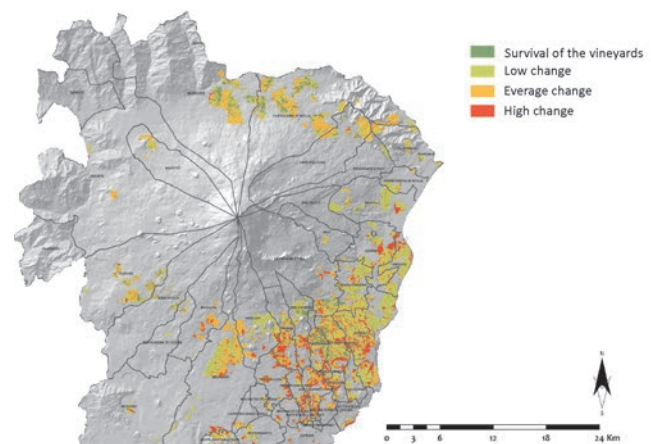


Figure 5. Changes in the historic vineyards.

no irreversible changes (Figure 6A). The areas of high or medium historic or cultural value are quite limited, and they are found in the historic centres around the wine growing areas (Figure 6B). This is of particular importance when one is considering the possibility of exploiting these areas for tourism. The areas with the highest values for infrastructure and settlement are almost all found spread out uniformly on the North East and South slopes of the mountain. The eastern slopes in particular have uniformly high values. This is because of the density of towns and villages and the excellent road network (Figure 6C). The areas with the highest natural values are mainly the wooded ones. These are found northwest of Etna, where there are no vineyards, and also, but to a lesser extent, on the fringes of the vineyards to the northeast of the mountain. These areas are, however, reasonably accessible from the wine growing areas and are thus a valuable component of the landscape (Figure 6D).

The second hierarchical level is described in three weighted maps (Figure 7).

The first shows the values of the system of development (Figure 7A). The largest areas with the highest values are those with quality wine production, as these reflect the historic character of the vineyards and the surrounding areas. These are found on the northern and south-eastern slopes of the volcano. There are also small high value areas to the southwest of Etna. The second map shows the structural system (Figure 7B). The areas with the highest values are found all around the crown of Mount Etna, with the largest areas on the eastern slopes. This shows that there is an

excellent infrastructure in the latter areas, and that this plays a fundamental role in establishing which areas are suitable for wine tourism.

The third map shows the values of the visible system (Figure 7C). Once again the highest values are found concentrated on the northern and eastern slopes of the mountain. Most of the roads are, indeed, found north of the mountain. They give access to views over the Alcantara river (a regional river park), while to the east of Etna the roads and motorway offer views of the coast and seascape, as well as of the vineyards and citrus groves on the slopes of the mountain.

There are two maps of the first hierarchical level: the quality of the landscape map (Figure 7E) and the quality of the wine tourism map (Figure 7D). The latter is more important. The landscape is, indeed, of high quality in almost all the area surrounding the volcano, while the most suitable areas for wine tourism are concentrated only in the areas to the north and southeast of the mountain. This clearly indicates which areas are most suitable for the development of wine tourism (Figure 7F). Most of the crown of the volcano, from about 200 m to 1500 m a.s.l., has medium values. Low values are found only in the most impervious rocky areas, with few services. Five environments were found to be those most suitable for wine tourism. The first two of these included productive vineyards, while the other three environments did not. These results are of great importance in helping in the creation of a detailed plan aimed at improving and giving value to the available resources of the area. It could, for example, be useful to diver-

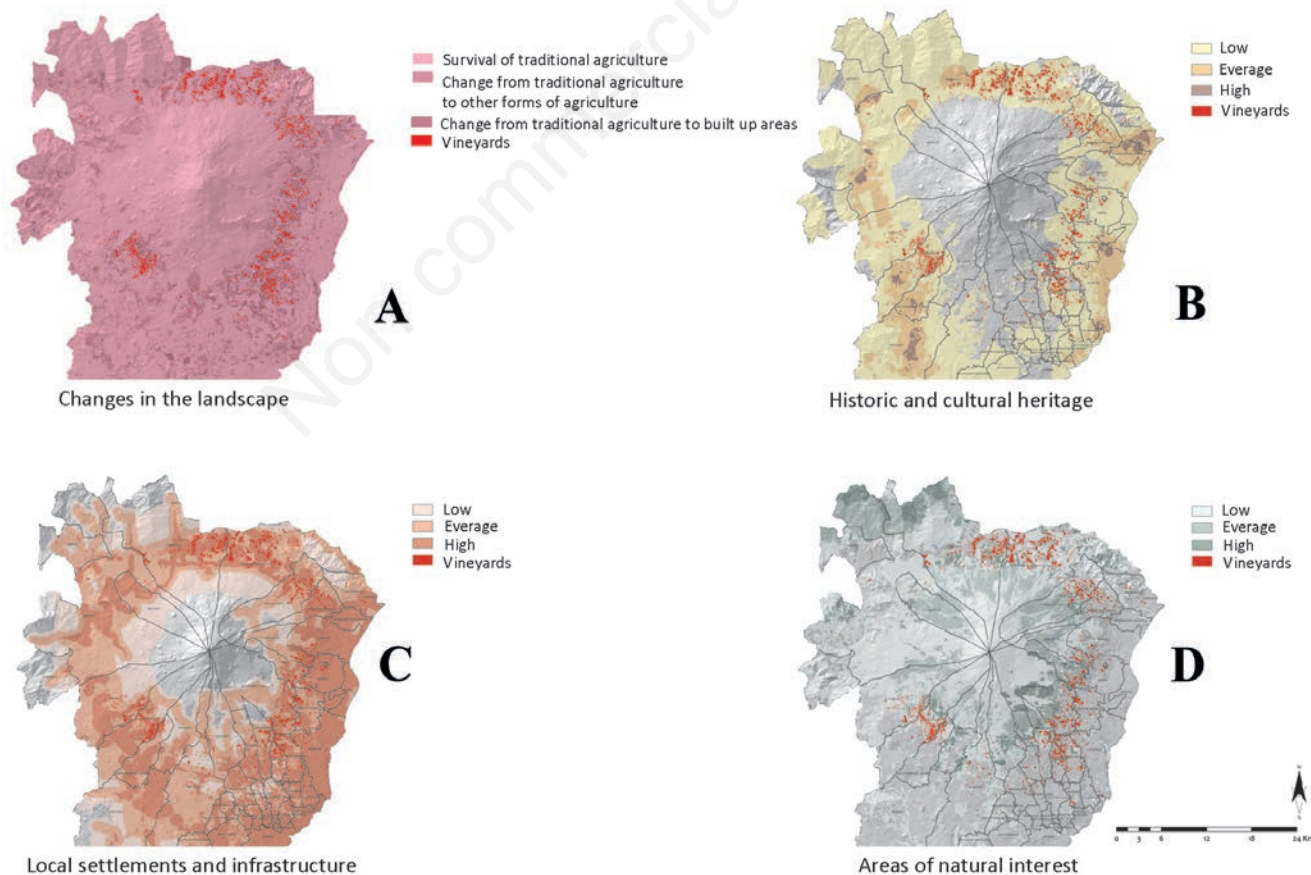
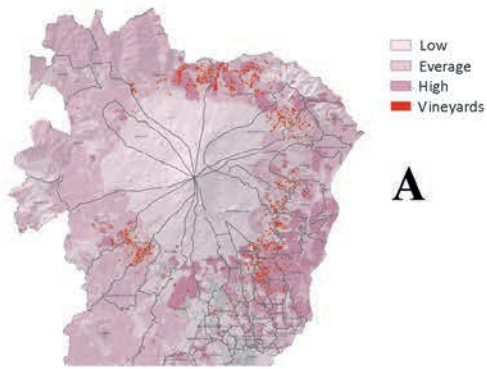
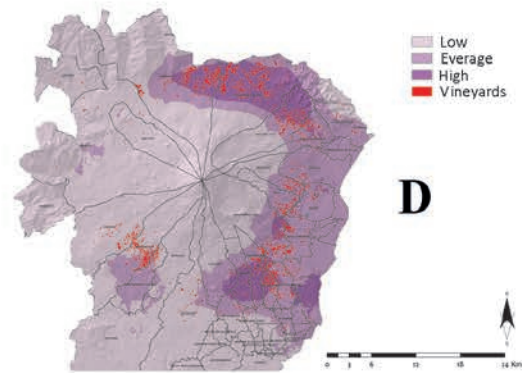


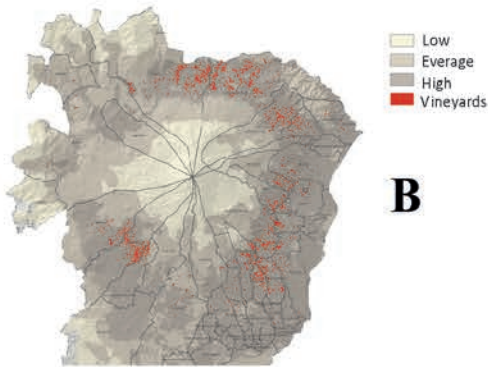
Figure 6. Some maps related to the third hierarchical level.



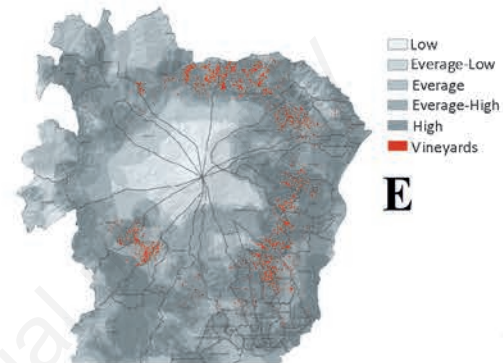
Second hierarchical level: Development system



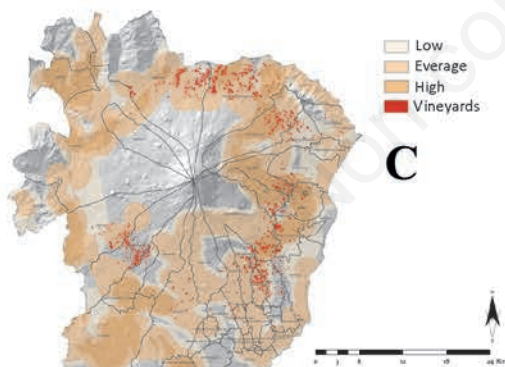
Second hierarchical level: Agro-cultural system
First hierarchical level: Quality of the wine tourism



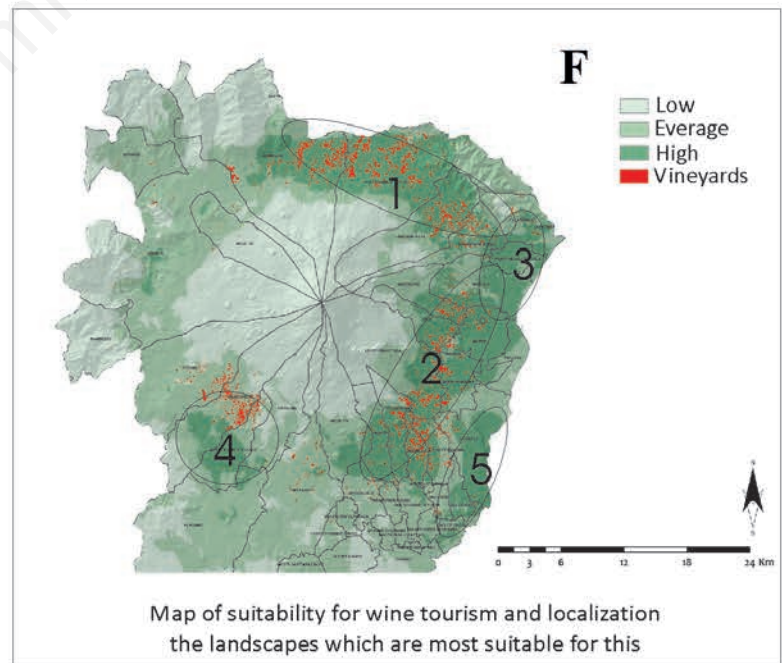
Second hierarchical level: Structural system



First hierarchical level: Quality of the landscape



Second hierarchical level: Visual system



Map of suitability for wine tourism and localization the landscapes which are most suitable for this

Figure 7. Maps related to the second hierarchical level, the first hierarchical level and Map of suitability for wine tourism.

sify the functions of each territorial environment, with the aim of reciprocal integration of the resources of the different areas. This would create an efficient and sustainable system of wine tourism, based on cooperation between the farmers and the tourist authorities, reduction of the duplication of identical services, fewer changes in the agricultural and natural landscape, *etc.*

Conclusions

The aim of the research was to identify which parts of the particular area are suitable for wine tourism. In order to do this a hierarchical analysis in a GIS environment was developed for the 13th landscape environment of the Sicilian Regional Landscape Plan (PTPR), or, in other words, the area around Volcano Etna.

Multi-criteria analysis, in conjunction with GIS, is widely used in land planning and many scientific works have shown that it is both versatile and valuable (Russo *et al.*, 2014). We show that the synergy created suits to the achievement of our objectives.

The used method issued does, indeed, allow identifying the most suitable areas for wine tourism, taking into account the different components of the area. The landscape plays a significant role in identifying which areas are suitable for wine tourism. Although of course the presence of wineries and their associated vineyards are obviously of great importance for identifying the most suitable areas, it is also important to bear in mind the surrounding landscape, above all when there are historic vineyards and other cultural artefacts. Doing so allows the identification of suitable areas that are larger than those actually used for vineyards and compared to the areas where the wine tourism is currently practiced.

Thus the aim of the research was to identify those areas where a landscape plan could be created which was aimed at developing the area through giving added integrated value to existing resources (wine production and the quality of the landscape) (Russo *et al.*, 2011; De Montis *et al.*, 2016).

This suggests a different planning approach from that one used for the PTPR: an approach that pursues the promotion of the area by using the potential and synergies of the different landscape components and not the promotion or protection of the individual *components* as the PTPR guidelines indicate. The latter, in fact, although in the general guidelines reaffirm the *promotion of the identity and of the peculiarities of the regional landscape, both as a single unit and in its various specific configurations*, quote the planning guidelines only for the *systems and components*, and so for the vineyards landscape (anthropogenic system component) it is suggested the compatible maintaining with the general landscape and environment safeguard criteria. In particular, we tend to preserve the traditional sapling plant and it is recommended to ensure the functionality of crops and landscape, preserving the plants on terracing.

Other guidelines for the maintenance of landscape and functional qualities are dictated for many other landscape components, such as the traditional rural structures, the historical paths system, the typical crops, giving no indication about the strategic integration of the recognised landscape values. The results obtained with the presented methodological application, have allowed identifying some areas where we hope to introduce or to increase the activities related to wine tourism, based on the constitution of a cultural, social, economic, network system. The identified areas, in addition to those forming the triangle of Randazzo - Castiglione di Sicilia - Linguaglossa (Zone 1 and 2), in which area the wine tourism is

already well established, are the areas south of Etna (zones 3, 4, and 5), where the tourism exists today is mainly linked to the historicity of the urban centres and to the local folkloristic events and not to the entire landscape value. The results of this study have been sent to the Sicily Region's Agriculture Inspectorate, hoping that it can be a useful support to the future and more detailed planning actions.

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