ASSESSING THE IMPACT OF BUILT HERITAGE ON THE RURAL LANDSCAPE THROUGH THE INTEGRATION IN A GIS OF CARTOGRAPHIC INFORMATION AND REMOTE-SENSED DATA

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Abstract

Rural landscapes are the result of the interaction occurred over time between human activities and natural environment. Humanity has built constructions conceived to host farmers and biological productions, that have contributed to increase the level of agricultural productivity, meeting the food demand. This built heritage constitutes now a unique example - due to architectural and technical issues different from other building sectors - which plays indeed a central role in the formation of the rural landscape, as well as on relevant ecosystem services.

In this paper, the interactions between historical rural buildings and the surrounding landscape have been examined. A specific geo-database incorporating different datasets from topographical maps, aerial photos and satellite images has been implemented into a GIS. This approach has enabled to assess land dynamics around rural buildings, in terms of land cover and landscape indexes. A case study in an internal mountain area of Southern Italy has been considered. Thanks to a large-scale detailed spatial analysis, the relationships between some rural buildings and the surrounding landscape have been then assessed. This methodology allowed to implement a spatial system finalized to support solutions useful to public decision-makers, as well as to evaluate activities of protection and/or valorisation of the agro-forestry landscapes.

Key words: Rural built heritage; agro-forestry landscape; cartographic information; aerial photos; satellite images

Introduction

Agricultural activities have been the main driver for the characterization of the different historical rural landscapes (Agnoletti, 2012). However, the process of abandoning agricultural areas has led to a change from a socio-economic, ecological and landscape point of view, causing several impacts in Europe, with different consequences from a country to another (MacDonald et al., 2000; Picuno et al., 2017). This process is also leading to the abandonment of farm buildings, especially those related to traditional agricultural activities (Cillis et al., 2020). Therefore, considering the close relationship between landscape and buildings, it is necessary to implement methodologies for the evaluation of changes in the rural landscape, which include the built agricultural heritage as well. A multidisciplinary approach using different types of geodata (topographic maps, aerial photos, vector data, satellite images, etc.) is essential for these geospatial analyses (Statuto & Picuno, 2017). In this paper, an open source GIS approach, integrating remote sensed and other types of geodata, has been proposed to assess the relationship between rural landscape and farm buildings. Using a part of one protected landscape located in Southern Italy as a case study, a database of the rural built heritage currently present there has been created, including typical surveys of landscape studies as well. Hence, in order to investigate the possible connections between rural landscape and buildings, subsequent spatial analyses on a buffer area around each building have been conducted, focusing on the relevant land cover changes and landscape fragmentation that occurred over 62 years, from 1955 to 2017.

Materials and methods

The study area, which covers a total surface of 6705.8 ha, is located in the Basilicata Region (Southern Italy - Fig. 1). The boundaries include part of the *Vulture Regional Park*, an area of great naturalistic and cultural importance surrounding an old extinct volcano, that makes this landscape unique in Southern Italy. The main landmarks of this area, located in the territories of the municipalities of "Atella", "Rionero in Vulture" and "Melfi", are the Mount "Vulture" (1,326 metres) and the “Monticchio lakes”. Moreover, this is an area with a high agricultural suitability, both in terms of food production and rural heritage, sometimes restored for touristic purposes, for which it is therefore crucial to implement suitable integrated monitoring techniques useful for landscape planning.

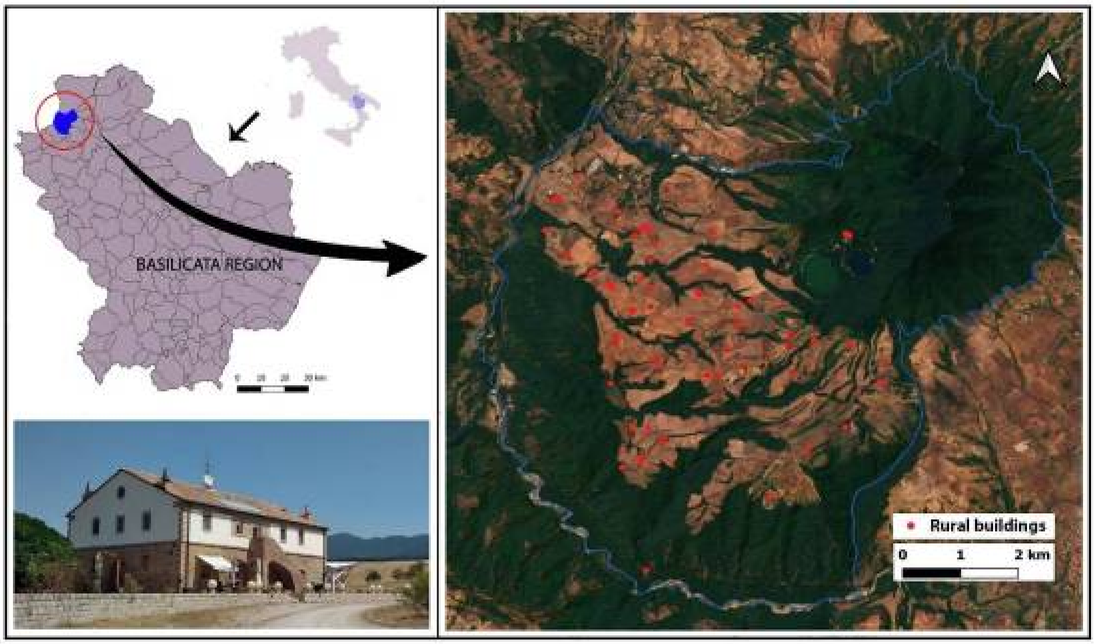

Fig. 1: Location of the study area and an example of a rural building restored for touristic purposes, named "Masseria Giannini"

The assessment has been structured in three different phases performed in a GIS environment (QGIS 3.10). In the first step, the land cover datasets and then a database of rural building heritage has been elaborated. Through the high number of open data of the Basilicata region (Cillis et al., 2018), rural buildings have been identified. The land cover classes dataset, in vector format, have been created by digitizing different types of remote-sensed data included in a square buffer area that spans 25 hectares around each rural building. For the year 1955, cartographic information and aerial photos have been used, for 1988 the relevant orthophotos, while for 2017 the orthophotos were integrated with Sentinel 2-L2A data (Statuto et al., 2019). Landscape fragmentation was calculated for each buffer area and for the same year using the landscape metric parameter *Effective Mesh Size* (Jaeger, 2000), expressed in hectares. The lower value is constrained by the pixel size of land cover raster and it is achieved when the landscape is maximally subdivided; that is, when every pixel is a separate patch. The value is maximum when the landscape consists of a single patch. The higher the value, the lower the degree of fragmentation of the landscape of the analysed area (Fig. 2). The values have been mapped using a "*moving window approach*" through the FRAGSTATS software.

Results and Discussion

A preliminary analysis of the land cover data during the 62 years of analysis (Tab. 1) shows that in the buffer areas around the farms building, the landscape was mainly characterized by agricultural land (values above 70% in all the three years of analysis). Compared to other inland mountain region of the Mediterranean zone, in this area the decrease of agricultural land is not very evident (Picuno et al., 2020). If the agricultural areas remained more or less constant, the built-up areas ranged from 1.35 ha in the year 1955 to 23.5 ha in 2017. This is mainly due to the construction of new roads and the increase of buildings around the main historical rural settlements (Olišarová et al, 2018). The other important dynamic that emerges from this analysis concerns the land cover classes related to natural areas. Broad-leaved forests have increased in fact by about 15 ha since the years 1955 to 2017, grasslands doubled (up to almost 6% of the total buffer area) due to the abandonment of some agricultural areas, while transitional woodland-shrubs were reduced by almost 1% of the total buffer area. On the other hand, broad-leaved forests increased by about 15%, in line with what happens in the rest of the territory (Cillis et al., 2019; Statuto et al., 2013). Hence, in general, a certain stability in terms of land cover in the areas around the farms may be deduced.

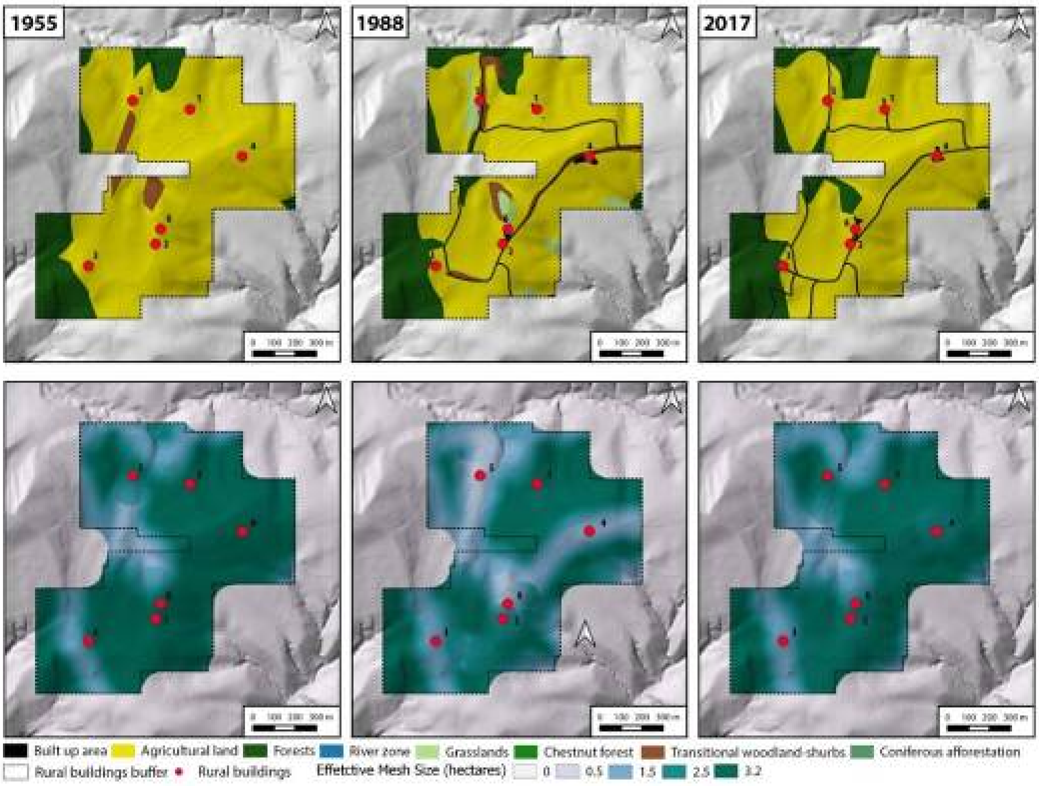

Fig. 2: Extract of the cover mapping for ground (top) and Effective Mesh Size (bottom). The numbers are the identifiers of the buildings described in Table 2.

Tab. 1: Quantification of land cover for the three years of analysis, expressed in hectares and as a percentage of the total buffer area.

	1955		1988		2017	
	ha	*%*	*ha*	*%*	*ha*	*%*
Built up area	1.35	0.13	23.98	2.37	23.50	2.32
Agricultural land	799.96	79.02	738.72	72.97	748.30	73.92
Coniferous afforestation	4.14	0.41	4.35	0.43	4.20	0.41
Broad-leaved forests	126.39	12.48	135.23	13.36	142.23	14.05
Chestnut forest	11.42	1.13	9.23	0.91	3.13	0.31
River zone	1.41	0.14	1.41	0.14	1.42	0.14
Grasslands	27.78	2.74	53.23	5.26	60.25	5.95
Transitional woodland-shurbs	39.91	3.94	46.21	4.56	29.32	2.90
Tot	**1012.35**	**100**	**1012.35**	**100**	**1012.35**	**100**

As regards the mapping of the Effective Mesh Size, the processing was carried out by calculating for the three different years of analysis the mean value and the standard deviation (SD) and, finally, the difference between the average values between 1955-1988 and 1988-2017 for the buffer area around each rural building. Table 2 shows an extract of the analysis related to the maps and buildings shown in Figure 2. What emerges is that in the period 1955-1988 there is an overall reduction of the average values of the effective mesh size (expressed in hectares) in all rural buildings. On the other hand, in the period 1988-2017 there is an increase in the average value in all farm buildings that, from an ecological point of view, can be considered as a decrease of the fragmentation of the territory. Finally, for a general assessment, the table 2 shows that the year 1955 was the time period in which the level of fragmentation was lowest (demonstrating a greater homogeneity of land cover), while the year 1988 was the most fragmented year, since it historically represented the period with the highest dynamics of land transformation. Fragmentation is a concept that is very much linked to biodiversity (Fahring, 2003). Thus, this preliminary analysis can provide useful indications for subsequent surveys related to how biodiversity can change around rural buildings over time.

Tab. 2: Effective mesh size values (in hectares), expressed in terms of average and standard deviation, extracted by elaboration of data related to buildings shown in figure 2.

Rural Building	1955		1988		2017		1955-1988	1988-2017
	Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*		
1	2.75	0.55	2.49	0.75	2.68	0.52	-0.26	+0.19
2	3.00	0.33	2.33	0.64	2.74	0.46	-0.68	+0.41
3	2.73	0.57	2.59	0.56	2.64	0.58	-0.14	+0.04
4	3.09	0.22	2.35	0.74	2.94	0.24	-0.74	+0.59
5	2.34	0.61	1.81	0.72	2.31	0.58	-0.53	+0.50
6	2.87	0.52	2.22	0.68	2.65	0.58	-0.65	+0.42

Conclusion

This preliminary methodology, which has been applied on a small scale in this study, may prove useful in identifying how the landscape around farms has been transformed. In particular, it is possible to identify how farms can play an important ecological role within the rural landscape by linking land use data, geostatistical surveys and landscape metrics. The use of a GIS tool to integrate the different types of geodata is fundamental, starting from the cataloguing phase of rural buildings and land cover data, then using them as a basis for more complex spatial analysis. In particular, the implementation into a GIS of both cartographic information and remote-sensed data (aerial images; satellite data; etc.) has enabled important advantages, since it allowed a more accurate classification of the land cover, thanks to the integration of multi-temporal information, as well as the merging of different techniques. This approach would reveal therefore an appropriate tool for possible future application in the analysis, planning and management of the rural landscape, since it enables to assess the role and impact of these farm buildings in the surrounding rural context. This methodology, being usable in other similar case studies, is also suitable to collect several types of data, as well as to support public decision-makers to assess monitoring activities finalised to the protection and valorisation of high value landscape.

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Souhrn
V tomto článku byly zkoumány interakce mezi historickými zemědělskými budovami a okolní krajinou. Do GIS byla implementována specifická geo-databáze obsahující různé datové soubory z topografických map, leteckých snímků a satelitních snímků s cílem posoudit dynamiku půdy kolem venkovských budov z hlediska krajinného pokryvu a indexů krajiny. Případová studie se týká vnitřní horské oblasti jižní Itálie, v níž byly díky pordrobné rozsáhlé prostorové analýze vyhodnoceny vztahy mezi venkovskými budovami a okolní krajinou. Tato metodika umožnila implementaci prostorového systému dokončeného na podporu veřejných činitelů s rozhodováním při hodnocení činností ochrany a / nebo valorizace venkovské krajiny.

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