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Landscape conservation and valorization by satellite imagery and historic maps. The case of Italian transhumance routes

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Abstract
In order to verify the potential use of old transhumance routes as tourist resource, the paper intends to illustrate a methodology to assess their conservation state, both in terms of track accessibility and viability, as well as in terms of heritage presence, and shows the results of a survey conducted on the Castel di Sangro - Lucera route (Molise region, Southern Italy). The methodology proposed represents a first step for integrated tourism planning as to the old transhumance routes in Southern Italy, starting from the digitization of the Custom Office historic maps and continuing on through an urgently needed program of conservation and restoration of the tracks supported by cartography and satellite imagery techniques.

Keywords: 17th-20th centuries historic maps, cultural landscape, GIS, Molise (Italy), satellite images, sustainable tourism.

Introduction
The importance of the cultural landscape in the Mediterranean area is greatly highlighted in the scientific literature and includes the relevant presence of the historic rural architecture, such as viability and routes, stone-made terraces and enclosures, traditional buildings [Moreira et al., 2006; Brown et al., 2007; Cullotta and Barbera, 2011; Petanidou et al., 2008]. Among them, the cultural landscapes of transhumance routes are important examples.
Transhumance is often associated with the collective seasonal migration of animals and shepherds between two distinct and physically distant pastures connected by special routes. The territorial morphology characterizing much of Mediterranean Europe determines a gradient in the vegetation growth which favours the movement between the mountain barrier of the Pyrenees-Alps-Carpathians and the Mediterranean coast [Braudel, 1949]. This practice is much more complex than we imagine [Grove and Rackham, 2001] and it has had great importance in human history with a high impact on the economic activities. It has also influenced the society and culture of the Mediterranean populations, particularly in Central and Southern Italy [Sprengel, 1971].

The transhumance routes have taken specific names in the language of the different regions: *tratturi* in Italy, *cañadas* in Spain, *carraires* in France and *drumul oierilor* in Romania, all of which have the same features and functions [Paone, 2006]. Despite the recent decline of transhumance, Mediterranean countries still retain significant traces of the tracks and the constructions built along them (taverns, fountains, churches etc.). The principle routes (*tratturi*) and the connecting tracks (*tratturelli*) appear to be the basic elements of transhumance, they are arranged in a meridians/parallels network and articulated in multiple sequences. A clear evidence of the central role played by transhumant routes in the history of the Italian peninsula can be seen in the urban and rural settlements which developed according to their direction and especially around intersections, such as in the case of Altilia in Molise[1] [Cialdea, 2007]. The length of routes was related to the distance between the pastures, while the width depended on the demand for the transhumant livestock. In fifteenth-century Southern Italy, for example, the tracks were brought to an amplitude of 60 Neapolitan feet, corresponding to approximately 111.60 meters, in order to adapt to the economic recovery plan of transhumance, thus representing a safe and solid pathway and, at the same time, ensuring the availability of meadows and pastures during livestock migration.

After the nineteenth century, the traditional transhumance was either replaced with a more modern and faster one by the use of trains and trucks, or was limited to very narrower stretches going from the mountains to the stables built downstream [Paone, 1987]. After the 30s, the *tratturi* were included in the enfranchisement law, which excluded only the four most important transhumant routes: L'Aquila-Foggia; Celano-Foggia; Castel di Sangro-Lucera; Pescasseroli-Candela. Agriculture thus began to occupy the space of the traditional green-ways which, until then, had been placed under protection by numerous regulations issued by state power [Russo, 2002]. In 1977, with the Presidential Decree n. 616 (Art. 66), routes and tracks passed under the authority of the regional governments, which began to operate decisions in perfect autonomy.

The paper intends to illustrate a method of analysis for the assessment of the conservation status of transhumance routes in a GIS environment and the cultural heritage associated with them, as well as their potential use for cultural tourism, through the recovery of historic sources and pre-geodetic maps in association with modern cartography and remote sensing techniques.

Study area

The extensive network of transhumance routes created in the past centuries, and involving many Southern Italy regions, has now almost completely disappeared. Nowadays, Molise is the region with the broadest historic traces of transhumance landscape, also because it was the only one to be almost fully crossed by these routes [Avram, 2009].

Our research has addressed the Castel di Sangro-Lucera transhumance route, which almost entirely falls within the Molise administrative limits and is considered the best preserved track of the original network [Petrocelli, 1999]. It originates from the route Pescasseroli-Candela, more precisely from the Zittola Bridge and the Vallesalice Tavern in the territories of Castel di Sangro (Abruzzo), and ends in Lucera (Apulia) where it joins the Celano-Foggia route. Figure 1 shows the path of the route, almost completely falling within the territory of Molise.

The interest for this route also derives from its characterization as a symbol of the transhumance civilization, thanks to the occurrence of many examples of environmental and cultural heritage [Carnevale, 2005].

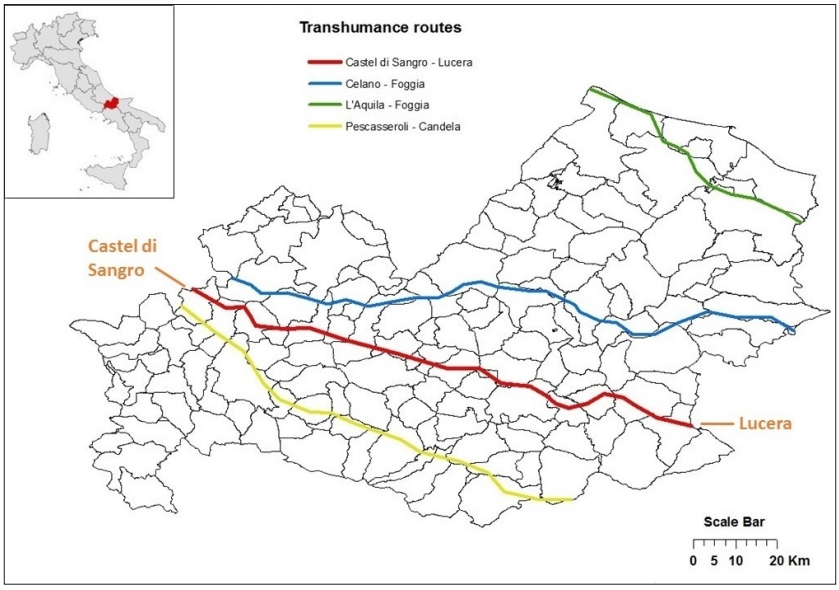

Figure 1 - The Castel di Sangro - Lucera route in the transhumance network of Molise region (Southern Italy).

The aim of this research is to test the possibility to map this legacy along the Molisian route of the sheep track, thus identifying the parts of greater interest in terms of heritage preserved and landscape fruition. The requalification of the tracks, at least part of them, may make sense if it leads to a tourist product structured so as to meet the new demands of itinerant tourism linked to the rediscovery of the ancient paths, as well as to the cultural heritage found along these roads which recall our historical memory.

Cartographic data sources

The present study is based on the recovery of historic sources and pre-geodetic maps in association with modern cartography and remote sensing techniques.

As for the historical maps, the focus was on the Capecelatro Atlas, a very detailed and accurate document in relation to the time of production[2]. The mapping operations began in 1651 and ended in 1652. It is the first reintegration document involving the whole Southern Italy transhumance system with a consistent production of maps, as well as a detailed description of the routes. The Capecelatro Atlas comprises 552 maps measuring 350 X 240 mm (164 mm back); inside, preceded by two indexes (one contemporary, the other of the nineteenth century), there are reports on the reintegrations of the various tracks followed by their monochromatic drawings. The maps are signed by Giuseppe De Falco, who is supposed to be a designer specifically instructed to draw up the tables of the Atlas. The

technique used is rich in details and landscape representation. The reason for which he chooses such a basic illustration lies in the necessity to respond to administrative needs and to draw pictures which are even recognizable by people with little expertise. In this regard, the representation focuses mainly on the pathway, while the remaining elements function as reference points for orientation ensuring better reading and interpretation of the track. The purpose is to return an essential vision of the transhumance route, easy to read through an elementary abstraction of reality based on analogy and with a simple sketch of the localities crossed by the track. The maps are also characterized by a rich toponymy: place names recur for each location, wood, river, infrastructure or any other feature designed.

Although no metric scale appears, the regular distance of the two lines which delimit the track allows to assume the use of a fixed measure. Often, the lines of demarcation are joined by a dotted line showing the width of the track as 60 feet, while on the top margin the limit stones are reproduced, bearing the letters T and R (that means *Tratturo Regio*). The length is shown in the upper part of the pathway between fixed points, while a dirt trail is shown in the central part, where passage of flocks is presumed to be concentrated, in order to give an idea of the concavity of the route. The representation of waterways is interesting, as they are made with full design; the buildings and inhabited places are also represented by very simple pictures from a frontal perspective view or, in rare cases, from a bird's-eye view.

The latter representations make use of two methods of reproduction which blend and in some way remedy the poor technique, giving essential but effective information. The first method consists in a representation of the path from the perspective of those traveling; the landscape elements hold their positions on the map in relation to the orientation of the track. The second method is to orient the main prospect of significant buildings along the track or the skyline of the towns situated nearby towards the reader; in this way, the main façades of the buildings are turned towards the observer of the map, therefore modifying the actual position compared to that which it is in reality. The map in Figure 2 shows both imaging techniques. To give the idea of the traveler's point of view, the towns are placed in consideration of their original position with respect to the track: coming from Castel di Sangro and going towards Lucera, the towns of Civitanova del Sannio and Civitavecchia (the present Duronia) are on the left (at the top of the track), while St. Benedict monastery is on the right (at the bottom of the track). On the same map, the second representation technique is also clear; the buildings are represented frontally with respect to whom is observing the map, as well as the bridge, so as to allow the illustration of its arches and consent to easily interpret the types of architecture.

The effectiveness of details in the maps produced by De Falco can also be seen in the illustration of the structures temporarily used by shepherds and farmers. The simplicity of the representation is moreover evidenced by the symbols used: for example, the tree for the woods, the tufts of grass for pasture, while relief depiction - such as the uplands on which villages, forts and places of worship stand - is rendered mainly by means of hill profiles. The attention to details, as to what is set along the track and in the immediate neighborhood, is an essential source for an appraisal of long-lasting landscape elements as well as for virtual representation, centuries later, of sites and material evidence which no longer exist [Iazzetti, 1993].

In order to localize the route in detail, the latest edition of the topographic map of the Italian Military Geographic Institute[3] was used, providing information about the sheep tracks as

well as the facilities and structures connected to it, at least those still existing at the date of survey. These maps are the result of a photogrammetric survey and photo plans with Gauss conformal representation framed in the Italian geodetic system (Rome Monte Mario) and Universal Transverse Mercator projection.

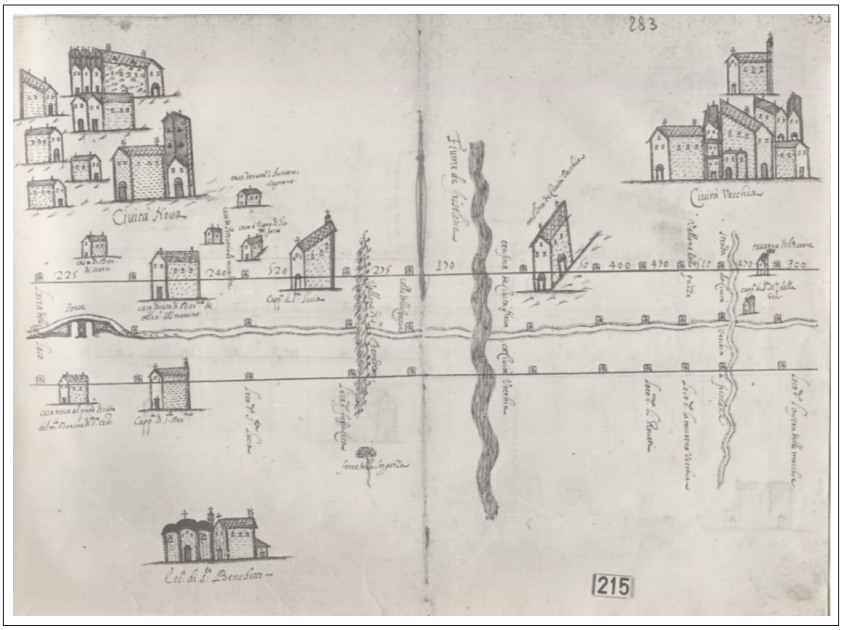

Figure 2 - One of the 552 maps in the Capecelatro Atlas (17th century) showing the track between the towns of Civitanova del Sannio and Duronia (Molise, Italy).

Moreover, the use of the so-called "basemaps" from ArcGIS 10.0 online has proved an effective tool for the detection of the track limits, the comparison with those reported in the topographic map and historical cartography, and finally the analysis of the current state of conservation[4].

Methods

The techniques of digitization of historic maps associated with those of remote sensing combined in a geographic information system [Azzari, 2002; D'Ascenzo, 2011] allowed the recognition of the route and the analysis of its state of conservation in terms of accessibility and usability. Below, the stages of the study carried out until now will be illustrated.

A database containing data as in the Capecelatro Atlas was built. A comparison between these data and those collected by Georg Liebetanz during his journey along the same track (years 1989-1990) was made with reference to the landscape of transhumance as in the IGM topographic maps of 1957. In this way, it was possible to carry out an initial systematic comparison of the route in the seventeenth and in the twentieth centuries, also highlighting the material elements that are identifiable as historic legacy of great value and potential enhancement.

To assess the degree of conservation of the human landscape along the route and the relevance of the associated cultural value, reference was made to the Capecelatro Atlas with a precise identification of those material elements which are still present and can be considered today as cultural heritage. Therefore, the analysis focused not only on the trail but also on the landscape along the route, or the material elements of the landscape traversed by it and due to the economy of transhumance: taverns, farms, churches, limit stones. In this regard, both the descriptions of Capecelatro [1651] and Liebetanz [1999] were compared and processed; then the elements mentioned were geo-referenced taking as a basis the IGM topographic maps. Subsequently, the historic maps were implemented in the GIS as iconographic information material.

The first phase of the research has therefore been dedicated to the creation of a database with the collection and classification of basic information such as:

a) municipalities crossed by the route;
b) distances in Neapolitan feet with the relative conversion in meters[5];
c) place names of the localities crossed;
d) infrastructures (roads, bridges), buildings (churches, farms, villas, taverns), limit stones;
e) text descriptions of both the track and the material evidences that there insist;
f) historic iconography of the landscapes traversed.

The second phase included the use of IGM topographic maps in three different fields and in the following sequence (Fig. 3):

I) checking and georeferencing of POIs (Points Of Interest, related to buildings, infrastructures, localities, limit stones) based on the correspondent information found on the IGM maps;
II) positioning of the POIs detected in the Capecelatro Atlas which do not have any correspondence on the IGM maps through the measurements and transposition in meters from definite reference points;
III) creation of a feature called "transhumance route limits" representing the path indicated on the IGM maps.

This geographical information system allowed, through the overlaying of IGM maps and satellite images, to define and trace which original route is free, and therefore viable. By a careful observation of satellite images, it is possible to observe the role of the cultivated fields and/or natural vegetation as borders, and to identify the course and limit of the track even if these were not marked in the topographic map (Fig. 4).

The analysis of the conservation state and usability has been dealt with. It is important to specify that the concept of accessibility has been applied in a double meaning: internal and external accessibility. Internal accessibility means the present viability in a perspective of slow tourism, that is a type of sustainable tourism very close to the concepts of eco- and geo-tourism: tourists are encouraged to visit locations where it is possible to establish a true relationship with the landscape and the local community, so the routes are then covered by walking, cycling or horse riding. External accessibility refers to the possibility to increase the access points by major communication routes and fast means of transport, in order to integrate the local slow mobility with the long-haul tourist circulation. This latter measure has been evaluated by means of transport system indicators, such as infrastructure capacity and ranking, average time of transportation, intermodal options.

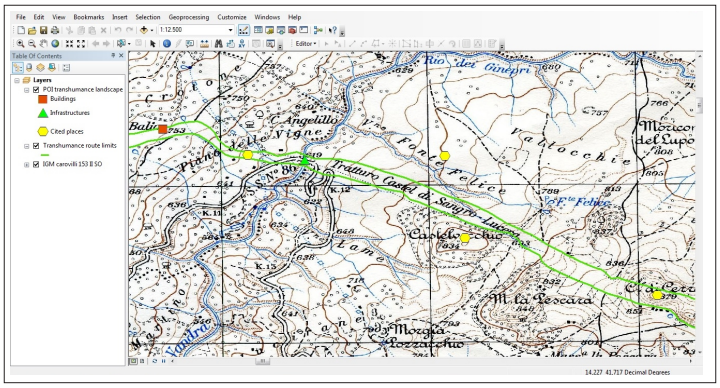

Figure 3 - GIS view with IGM topographic map, transhumance route limits (green lines) and POIs (orange square for buildings, yellow exagon for cited places, and green triangle for infrastructures).

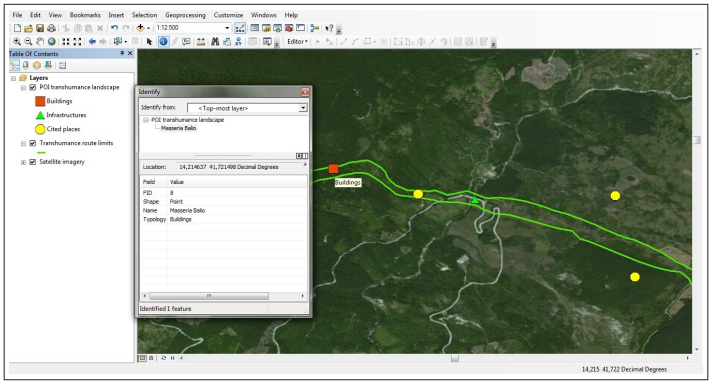

Figure 4 - GIS view with satellite imagery, transhumance route limits (green lines) and info on the POIs.

The conservation analysis was made according to the method proposed by Meini et al. [2013a,b] in using a vegetation index into a sample area of the sheep track. Since its wide use with very good results in remote sensing researches [see e.g., Iamonico, 2008; Sternberg et al., 2010; Duringon et al. 2012; Alphan and Derse, 2013; Schucknecht et al., 2013] the Normalized Difference Vegetation Index (NDVI) was chosen. It is a standardized index which generates an image displaying greenness (relative biomass). It is based on a combination of reflectance measurements in two or more spectral ranges and it is linked to the level of coverage and state of wealth of vegetation because photosynthetic pigments, above all chlorophyll, absorb in a selective manner the incidental electromagnetic radiation exploiting energy in the range of wave length of the visibility.
The NDVI is calculated as:

$$\mathrm{NDVI} = \left[(\mathrm{IR} - \mathrm{R}) / (\mathrm{IR} + \mathrm{R}) \right] \quad [1]$$

with
IR = pixel values from the infrared band;
R = pixel values from the red band.
The index outputs values ranges between -1.0 and 1.0, where the negative values represent clouds, water, and snow, and values near zero represent rocks and bare soils. Moderate values represent shrub and grassland (0.2 to 0.3), while high values indicate temperate and tropical rainforests (0.6 to 0.8). The GIS equation used to generate the output is as follows:

$$NDVI = \left[(IR - R) / (IR + R) \right] * 100 + 100 \qquad [2]$$

Where *100 + 100 is used to return values in a range of 0-200 and fit within an 8-bit structure, obtaining a more detailed analysis.
In order to highlight the current state of conservation, the calculation was limited to the track area. It was, therefore, necessary to extract this area from the satellite imagery by means of the clip tool, which works through the overlapping of two information layers: the satellite image and the polygon shapefile of the sheep track. The result is a new raster layer of the track (Fig. 5). At this point it was possible to proceed with the NDVI calculation [2] which returned the path with the spectral responses of the surface coverage (Fig. 6).
The new information layer shows the coverage of the track by means of a different color, in particular the cemented areas or roads are shown in shades of purple, grassy areas in shades of light green, the areas with dense vegetation in shades of dark green. In this way, it has been possible to identify the traits which have been better preserved and on which the visits can be focused. As an ultimate step, field surveys will be carried out in order to verify the degree of conservation.

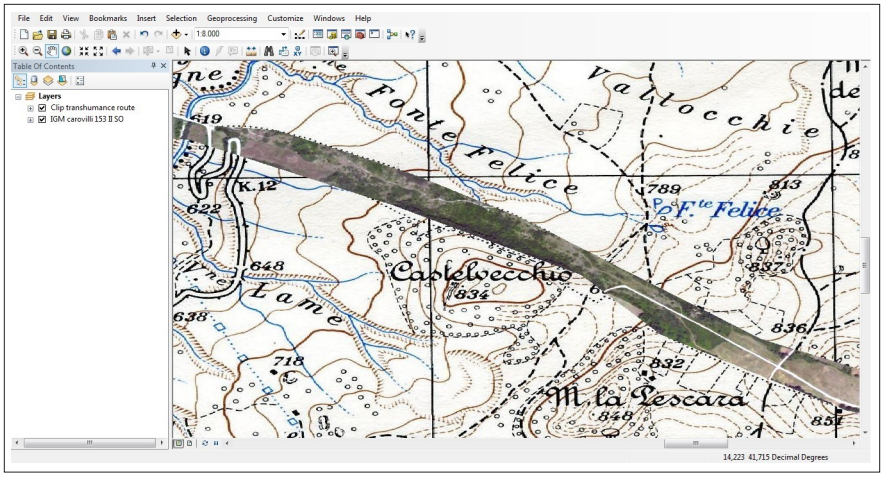

Figure 5 - Clip of the satellite imagery raster shapefile with reference to the track.

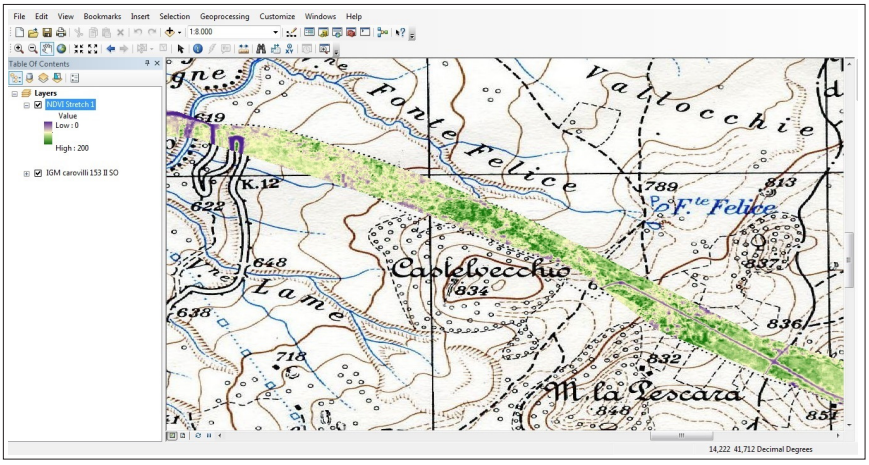

Figure 6 - The result of the NDVI analysis made on the Castel di Sangro - Lucera track.

Results

The GIS project allowed to define exactly the Castel di Sangro-Lucera track as in the original transhumance route and to delimit the track which is currently open and viable. The abandonment of transhumance practice has resulted in a progressive reduction of the track amplitude, both for the spontaneous growth of vegetation and for the misappropriation of collective space (private or public uses), as demonstrated by the presence of asphalt roads, factories or soccer fields right on the path of the previous sheep track. In some cases, therefore, the satellite images show a completely transformed landscape, as in Figure 7.

Figure 7 - The track delimitation shows that some roads and a soccer field (see arrow) were built within the transhumance route near the village of Torella del Sannio (Molise, Italy).

Generally, however, the use of remote sensing images has proved to be effective for the identification of the existing tracks, especially where the abandonment of the land produced a growth of the wooded area, and the limits of the transhumance route are not recognizable in the landscape by field survey but only through vertical photo interpretation of the biomass of different ages.
In many cases, the image interpretation provides information that are not available using the topographic map and it allowed to delimit the original route which was not even designed in the IGM so-called "tavolette".
There are several cases of interest detected through satellite images. Near Roccasicura, the identification of the track was made difficult both because of the infrastructure works and of the complete state of abandonment, due to the absence of maintenance of the "demanio" (government property) and to the absence of human activity. Another significant case is the Commune of Rionero Sannitico: here the path is not identifiable by the IGM topographic map, while it is clear using a high resolution satellite image (it is also possible to identify the part of the track partially covered by dense vegetation). The Commune of Duronia is a specific example of said phenomenon, where the trail seems to get lost near Faito, but the photo interpretation has made it possible to track it down, one may infer, by subtraction: i.e. on the basis of the presence of the fields placed at the edge of the track.
Besides the route delimitation, the analysis has also affected the cultural landscape visible along the tracks, more precisely the material elements of the landscape traversed by these and linked to the economy of transhumance: taverns, churches, limit stones and so on. For an assessment of the relevance of the elements which still exist today - a sign of conservation of the landscape and the cultural heritage associated with it - recourse was made to the seventeenth century Custom survey, with a precise identification of the elements which today represent the legacy to be preserved, protected and enhanced. Thus we came to a mapping of the cultural heritage present along the Castel di Sangro - Lucera route in the region of Molise, identifying the traits of greatest interest in terms of heritage preserved and enjoyment of the landscape traversed.

Conclusive remarks and future perspectives

The analysis and interpretation of the landscape needs multi-criteria approaches; especially when tools are requested for management needs. The present paper verify the potential use of old transhumance routes as tourist resources, through a combined methodological approach, using historical cartographic data sources as well as recent satellite images. Thus, transhumance routes are assessed according to the conservation state, the track accessibility and viability, the importance of still present material heritage elements.
The use of historic maps represents a focal aspect of this paper, by which it was possible to map the transhumance legacy along one of the most important sheep tracks in Italy, thus identifying the parts of greatest interest in terms of heritage. Today, despite having a quite restricted configuration due to continual usurpations, the Castel di Sangro-Lucera transhumance route has mostly preserved continuity of the trail and passes through an interesting cultural landscape, thus becoming a symbol of the transhumance civilization.
The use of satellite images allows to detect the information necessary for inspections, discarding in advance those parts of the path which are not relevant and incapable of enhancement. Field surveys will be carried out limited to the traits and elements of the

landscape that emerge as potential attractions.
The basic research carried out using remote sensing and GIS techniques could be useful to encourage the requalification of the route in a perspective of integrated land management. An implementation with data related to the pastoral system, the dairy supply chain, the manufacturing and marketing of DOP cheese, and the safeguard and enhancement of ancient handicrafts is argued with the main aim to improve the quality of information for a better management of these important element of Italian culture and history.

Footnotes

[1] In Altilia, remains of a Samnite settlement going back to the 4th century B.C. were found; these made up a closed space with wooden stakes used for the rest and shelter of flocks, that is, a service station which was created at the crossroads of important sheep tracks.

[2] Other important Atlases are: the Crivelli Atlas (1712) which introduced the use of color; the della Croce Atlas (1735-1760) that introduced the scale (in 1,000 Neapolitan feet) for the first time; the Atlases realized by Michele Jannantuono in 1843, with more accurate measurements and modern techniques of representation.

[3] The official topographic map of Italy, called Carta topografica d'Italia Serie 25V (last edition of old series, 1957) consists of 1:25,000 out of production maps, named «Tavolette».

[4] NASA Blue Marble: Next Generation 500m resolution imagery at small scales (above 1:1,000,000), i-cubed 15m eSAT imagery at medium-to-large scales (down to 1:70,000). http://www.esri.com/home/item.html.

[5] The conversion was made according to the formula: (Neapolitan feet x 2) - (10% of Neapolitan feet). This formula was also used by Liebetanz (1999) in his recognition.

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