

Article

Geotourism Perspectives for Transhumance Routes. Analysis, Requalification and Virtual Tools for the Geoconservation Management of the Drove Roads in Southern Italy

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Abstract: The article illustrates the interest in transhumance routes, the ancient paths connecting high and lowland pastures in Southern Italy and other Mediterranean regions, as elements of particular importance for sustainable geotourism management. As a contribution to the needs of requalification of the drove roads, we propose a method of analysis for their preservation and their reuse for geotourism purposes, showing the steps and instruments necessary to organize, enhance and communicate transhumance routes as integrated cultural landscapes. Results are presented as applied to a specific case study (Molise, IT) of a geoconservation management proposal for the assessment of the state of conservation of the drove roads, of their cultural heritage and of their potential reuse for geotourism. This methodological proposal uses geographical information systems, historical sources, cartography and remote sensing techniques and includes 3D virtual reconstructions of the transhumance landscape. The article is meant to contribute to a non-stereotyped image of transhumance geoheritage, reflecting on communication and learning strategies supported by geo-historical analyses, in order to promote a greater awareness of landscapes genesis and evolution for visitors and local communities. It is argued that future challenges of geotourism relate to the ability to recompose nature and culture to an interpretive unity, both from a theoretical and operative point of view, and that the goal is to reach an integrated tourist offer focused on the relationship between man and environment with the signs of territorialisation processes expressed through economic vocations, traditional production chains, cultural values and territorial identity. To this purpose, the valorisation of the transhumance routes—for their historical-economic, ecological, landscape, patrimonial and identity meanings—seems to respond perfectly.

Keywords: geoconservation; transhumance; landscape; mapping; remote sensing; virtual cultural heritage; geotourism; community tourism; resource-based tourism

1. Introduction

1.1. Geotourism Perspectives for the Promotion of Integrated Cultural Landscapes

In the ongoing global dynamics, local systems can base their territorial competitiveness on the diverse and complex set of internalities that define the originality and identity of the places in a context of innovation of the global value chains. Localized resources and social capital embedded in dynamically open territorial communities are much needed in the current globalized economy as a path towards sustainability, for creating new opportunities for their inhabitants and to face new challenges [1]. In this perspective, the environmental and cultural background of a local context

is to be considered as a stratification of forms, structures and values able to reacquire functionality and enrich themselves with meanings beyond the precise goals that determined their origin. This is the case with any kind of heritage, including geoheritage and landscape [2,3], and the spreading of sustainable tourism—as tourism that takes full account of its current and future economic, social and environmental impacts, addressing the needs of visitors, the industry, the environment and host communities—has made a way for an enrichment of local systems in this sense [4,5].

On the other hand, in the mind of the potential visitors, the tourist space is a cultural construction even before it is a geographical reality [6,7]. A tourist place exists as a product of the imagination of a society, its cultural models and its needs [8]. It follows that every space is potentially a tourist space, as a basin of potential tourist resources, and the activation of development processes derives from the value system of potential visitors as well as from the enhancement of local contexts and the production of territorial innovation [9,10].

In recent times, a different awareness has matured on the management of tourism resources and a greater respect has arisen for the ecosystems they belong to, both in society and in the tourism industry. Geotourism has been developing since the 1990s in many concepts and forms, rapidly growing in popularity as well as in scientific literature, especially in the 2010s [11–13]. In fact, it is still highly contested as a scientific concept, since it has been alternatively considered by different researchers: A kind of tourism aimed at the integrative discovery of an area, with all its natural and human components [14,15]; a form of tourism specifically aimed at the discovery of the geoheritage of a region and focused on geosites, geology and physical landscape [16–18]; a new form of tourist offer and/or a tourist niche segment based on geological and geomorphological features in landscapes involving potentialities and risks [19,20].

Though a common focus seems to exist on geoheritage conservation and geodiversity enhancement through appropriate sustainability measures and management, the role of landscape remains unclear. A landscape forms a whole, whose natural and cultural components are intertwined. With particular reference to Italy, we can say—as asserted by Aldo Sestini, one of the major 20th century Italian geographers much dedicated to the description and scientific interpretation of landscape—that our landscapes are a creation of history [21]. Indeed, they can also be seen as the projection of the values of the human groups that have shaped them; because man, working with nature, moulds the land in certain forms, giving the landscape a character of artistry, combining the idea of contemplation with that of function and giving cultural meaning to this original combination. This is the case for many traditional Mediterranean landscapes [22] that have acquired a meaning of cultural identity over time [23].

As observed by Reynard [24] (p. 225), some authors “analyse geotourism as a system made of three subsystems: forms (landscapes, landforms, sediments, rocks, fossils), processes (tectonic activity, volcanic processes, weathering, erosion, deposition) and tourism (attractions, accommodation, tours, activities, interpretation, planning and management)”, while other authors “show the importance of the relationships between the geological, the biological and the cultural constituents of a landscape” (p. 228). In the first case, landscape is categorized in formal aspects; in the second case, it includes tangible and intangible values. It is this latter conceptualization, which fosters the valorisation of geoheritage as a whole, that we find the most appropriate especially for geotourism promotion [25].

In this paper, a broader approach to geotourism as a form of resource-based tourism focused on the understanding of natural resources and the appreciation of landscape value with its integrated natural and cultural assets is proposed [26], considering landscape as a form of balance between past and present and a meeting ground between inhabitants and tourists [27,28]. In fact, if we assume the tourist’s point of view [29], it is a question of thinking of geotourism as a unitary experience based on a motivational drive more attentive to aspects of diversity and authenticity, that can be perceived through integrated cultural landscapes and based on the awareness of the historical and cultural significance of natural resources. In this perspective, the objective of promoting geotourism

pushes to act towards knowledge-based valorisation of distinctive primary resources in the territory, to implement development processes starting from an integrated vision of the local context.

At the same time our approach intends to provide an answer to the need for a “neo-humanistic” culture in the dialogue between the scientific disciplines addressing earth and landscape issues [25] (p. 12).

1.2. Transhumance Routes as Integrated Cultural Landscape and Potential Geotourism Product

Geotourism destinations need to create and manage a territorial product that must be complete and flexible, reflecting the wishes and appeals of different tourists, at the same time minimizing the negative impacts and conserving the sense of place [30,31]. The article illustrates the steps and instruments necessary to organize, enhance and communicate transhumance routes as an integrated cultural landscape for geotourism development.

In accordance with some classics of geographical literature, in this context transhumance is defined as a complex of seasonal migrations over a wide area between territories with different altimetry and climatic characteristics practiced by a stable population, normally also dedicated to agriculture, in order to ensure the fodder for the herds [32–35]. In detail, in the case of Southern Italy, as in other regions of Mediterranean Europe (Spain and the Balkans in particular), transhumance refers to a highly institutionalized system protected by an autonomous system of regulations and privileges that determine a complex institutional structure [36,37] and in which there is a special relationship of collaboration/conflict with agriculture. As Fernand Braudel argues, every transhumance is launched by a demanding agricultural activity which, unable to bear the full burden of pastoral life and to give up its advantages, is discharged, according to local possibilities and seasons, towards pastures in low or high areas [38].

The paths connecting high and lowland pastures, in this context called either transhumance routes or drove roads in order to highlight both their cultural-historical role and the material nature of roads, are the most tangible signs of such an ancient practice at present [39]. In this study, in view of their historical and cultural value and their role as a reservoir for the geo-environmental heritage of the area, they are interpreted as focal structures for the development of geotourism in an internal area of Mediterranean Europe.

As well as panoramic views [40], the use of transhumance routes for geotourism do not necessarily have an intrinsic value related to geology or geomorphology but offer the chance to have a view of features and areas which do have such values. Opposite to panoramic views, walking the drove roads allows for a dynamic view of the landscapes and a deeper experience in the man-environment relationship of the visited area.

The importance of cultural landscape in the Mediterranean area is greatly highlighted in the scientific literature and includes the relevant presence of historic rural architecture, viability and routes, stone-made terraces and enclosures, traditional buildings [41–43]. Among them, the cultural landscapes of transhumance routes are important examples.

Transhumance routes are seen, in our research design, as a strategic resource for regions provided with a good network of greenways as well as elements of particular importance for implementing models of sustainable geotourism management. By means of a case-study, a geoconservation management proposal is presented which aims at defining a methodology for the assessment of their conservation state, of their cultural heritage and of their potential reuse for geotourism purposes. This method uses geographical information systems, historical sources, cartography, remote sensing techniques and proposes 3D virtual reconstruction in order to promote greater awareness in geotourism practice and to apprehend the nature of transhumance landscapes, their genesis and evolution processes and their cultural value for both visitors and local communities.

The area studied is a small region in Central-Southern Italy that is considering the possibility of becoming a geotourism destination [44]; the region is rich in natural resources and has preserved a good environmental quality, with a valuable appeal for its characteristics of remoteness and authenticity. Interesting experiences of rural tourism, ecotourism and community-based tourism have developed

offering the possibility to also explore the attractiveness of the old transhumance routes as a geotourism product.

The extensive network of transhumance routes created in the past centuries in several Italian regions has become very fragmented over time and has almost completely disappeared in many cases. Nowadays, the territory of Molise holds the best preserved and recognizable tracks compared to those of the neighbouring regions, also because it was the only one to be almost fully crossed by these routes [45]. The major routes are traversed by connecting tracks, so they form a system arranged as a grid articulated in multiple sequences, creating a dense network of greenways. Besides, Molise retains the best conserved traces of transhumance landscape, that can be appreciated at best through any form of slow tourism: walking, hiking, trekking, horse riding, and bike riding seem to be ideal ways to promote their reuse, with the integration of primary and secondary resources and tourism services, because the slow approach allows visitors to experience the meaning of the sights and not just pass by, taking the landscape horizon of the traveller as reference.

Many institutions, organizations and associations are involved in the revitalization of the old transhumance routes and in their use for slow tourism promotion. Tratturo Coast-to-Coast is an interesting initiative carried out by the association "Attraversoilmolise" with different tours offered during the year, thus answering the new request for itinerant ecotourism linked to the rediscovery of the ancient paths and the various forms of heritage accessible along these roads of memory. Known throughout the centuries as sheep tracks but also thought to be used as pilgrimage routes, they are experiencing new potentialities also as cultural itineraries for community-based tourism [46], as proved by *Cammina, Molise!*, an event occurring every year during a week in summer since 1995, characterized by walking in a friendly atmosphere in search of local cultures and landscapes, in a region traditionally associated to the transhumance routes and suited to rural tourism [47]. From all over Italy and abroad, every year in August, hundreds of people come to walk the sheep tracks of Molise, living an existential experience of rare intensity. Therefore, the event caught the interest of Federtrek, an Italian network with more than thirty hiking associations. For organizational reasons, the number of participants cannot exceed 250 people, a limitation meant to maintain the original communitarian spirit and prevent a commercial use of the event, which is contrary to the aims of the cultural association organizing it (named "La Terra" which means "The Land"). The number of requests is increasing and many remain unsatisfied. Accommodation is guaranteed through a combination of hotels, bed and breakfasts and other hospitality facilities offered in the region, including a typical Italian accommodation form called *albergo diffuso*, an innovative concept of hospitality launched in the early 1980s as a means of reviving small, historic villages and town centres located off the beaten tracks.

Within the ITINERA (Innovation in Tourism Information Network and Environmental Regional Application) Project, carried out at MoRGaNA Lab (University of Molise), we worked out a methodology for the assessment of the conservation status of the transhumance routes and their potential reuse for tourism, as a first step for an integrated tourism planning and management of the old transhumance routes in Central-Southern Italy, in which not only the tangible assets are to be considered but also the related historical and cultural features are analysed and valorised [48,49]. The methodology has been recently implemented through the discussion of a Ph.D. thesis on the cultural landscape of transhumance, environmental preservation and new applications for sustainable tourism [50] and with the results of a virtual landscape reconstruction applied to a specific stretch in the Unesco Man and Biosphere (MaB) area of Collemeluccio-Montedimezzo, in Alto Molise.

This paper presents therefore a methodological development of previous studies carried out by the research group. The primary aim is to discuss a comprehensive geoconservation management proposal for geotourism enhancement. As a contribution to the needs of requalification of the drove roads, we propose a method of analysis for their preservation and their reuse, showing the steps and instruments necessary to organize, enhance and communicate transhumance routes as integrated cultural landscapes.

The various techniques and the related analysis tools will be discussed, first independently presenting their conceptual and methodical contribution, then illustrating the results of the application to the case-study.

As a secondary aim, the article is meant to contribute to a non-stereotyped image of transhumance geoheritage, thanks to communication strategies supported by geo-historical analyses, in order to promote greater awareness of landscapes genesis and evolution for visitors and local communities. The possibility of creating educational trails to allow knowledge, awareness and fruition of the transhumance geoheritage will be shown. A “neo-humanistic” perspective is proposed, that allows to unite the interest in geophysical features and cultural heritage concerning the transhumance phenomenon.

2. Materials and Methods

2.1. A Geo-Historical Perspective: The Heritage of the Dogana Reinstatement Documents

Transhumance is often associated with the collective seasonal migration of animals and shepherds between two distinct and distant pastures connected by special routes. The geomorphology characterizing much of Mediterranean Europe determines a gradient in the vegetation growth that favours the move between the mountain barrier of the Pyrenees-Alps-Carpathians and the Mediterranean coast [38]. This practice has a complex structure and over the centuries it has played an important role on Mediterranean history with a strong impact on economic activities and influence on the social and cultural spheres of many populations, particularly in Central and Southern Italy [35].

Although the first written indication of this phenomenon by Latin authors dates back to the end of the Republic of Rome, archaeological evidence confirms the argument that pre-Roman populations practiced transhumance in times farther away [51] (p. 212). When Rome conquered the ancient transhumant peoples, this pastoral practice and the related commercial activities were adopted; indeed, Rome made it one of the core activities of the economy of the Empire, as evidenced by several Latin authors, including Cato and Livy, but also by specific laws. In the fiscal and market discipline, Rome subjected transhumant animals to public scrutiny and to taxes which were levied in compulsory passage points, which facilitated the development of towns specially equipped with an imperial tax door. The fall of the Roman Empire led to a rapid decline of transhumance also because its practice needed a reliable and safe spatial organization. In Southern Italy, we must wait for the Norman dominion to find a historic document testifying the continuation of the practice. Normans recreated the political unity in the South and re-established security conditions permitting the resumption of transhumance. Generally, a revival of transhumance occurred only in the fifteenth century, with the emergence of markets and well-structured economic organizations. In Spain, for example, a strong private association as the Mesta ruled the entire livestock sector [52], while in Southern Italy it fell into different domains: the Church of Rome organized the transhumance between Sabina and the Roman countryside, while the Aragons, thanks to Alfonso I who relied on the Spanish experience, set up a network between the Central-Southern companies and a public institution with administrative, tax and legal duties, the so-called *Dogana della Mena delle Pecore di Puglia* [36]. Such a system, created in 1447, managed to resist until 1806, when a law abolished this institution as the economy was moving towards new productive activities. The custom documents, still conserved at the National Archives of Foggia, represent priceless material for the geo-historical analysis of the drove roads and the geocultural heritage of transhumance in Southern Italy.

The transhumance routes have taken specific names in the language of the different European regions: *tratturi* in Italy, *cañadas* in Spain, *carraires* in France and *drumur oilor* in Romania, holding the same features and functions [53]. Despite the recent decline of transhumance, Mediterranean countries still retain significant traces both of the tracks and of the constructions along them (taverns, fountains, churches etc.). In Southern Italy, the major routes (*tratturi*) and the connecting tracks (*tratturelli*) appear as the basic element of transhumance, arranged as a network of meridians and parallels 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 intersections, such as in the case of Altilia in Molise [54] (p. 43). If the length was functional to the distance between the pastures, 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 m, in order to adapt to the economic recovery plan of transhumance, thus representing a safe and solid pathway and at the same time ensuring meadows and pastures during the livestock migration.

In Italy, the definitive end of transhumance came with the three laws passed by the Italian Parliament in 1865, 1868 and 1971 with which the many limitations of the *Tavoliere* (Apulia plains) were dissolved and the lands once used for pasture were sold [55] (p. 8). The nineteenth century marked therefore a time of transition from transhumant breeding to sedentary agriculture [56]. A similar situation was also then recorded in Southern France, Spain and in the Balkans [53] (pp. 23–31). The twentieth century still presents traces of transhumance, even though with very different features from the times of the Aragon Customs [57] (p. 48). The traditional transhumance has been replaced with a more modern and faster one by the use of trains and trucks, or it has been limited to much narrower stretches extending from the mountains to the stables built downstream [58] (p. 28). After the 1930s, the *tratturi* became part of 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 greenways that until then had been placed under protection by numerous regulations issued by state power. In 1977, with the Presidential Decree n. 616 (art. 66), routes and tracks passed under the authority of the regional governments, which operated decisions in perfect autonomy.

The maps of the transhumance routes represented an important basis for the proper functioning of the Customs Office called *Regiae Dohanae Menae pecudum Apuliae* (the Apulia Sheep Custom) and the Administration of the *Tavoliere*, managed by the two magistrates that, from the fifteenth to the nineteenth century, ruled the agro-pastoral activities of the Italian *Mezzogiorno*. The tracks, together with the locations (*locazioni*), the stands (*poste*) and the sheep-pens (*jazzi*) made up the structure of the transhumance system, whose maintenance and defence from possible encroachments were guaranteed by a constant activity of territorial monitoring and cartographic production. In this regard, an important figure was that of the royal *compassatore*, a category of experts in the measurement of the territories which collaborated with the Customs Office and whose job was to distribute the field plots among tenants and farmers in the Apulia plains, to verify the boundaries, to rescue illegally occupied tilled areas, to intervene in order to settle the frequent border disputes between different interests.

The continual encroachments of the drove roads made it necessary to restore their original state through an operation called *reintegra* (standing for “reinstatement of land”). This consisted in the measurement of the tracks on the basis of ancient documents, testimonies of older people and practices of the sites, with the subsequent placement of physical limits made with local stones, on which the letters R. T. (Regio Tratturo) and the reinstatement dating were carved, thus signalling the direction and the width of the sheep track, aimed at the delivery of penalties and fines against the usurpers.

For the first reinstatement surveys, conducted during the 16th century, mapping the various situations examined was not normally required. It was enough to visit the tracks, to recognize the borders and to reinstate the soil tilled or usurped, returning everything in a written report [59] (p. 274). The transition to cartographic representation is an important breakthrough, by which the surveyor also becomes a cartographer, even though these maps were rudimental compared to other coeval cartographic representations, also within the same Kingdom of Naples. In fact, land surveys in this phase were mostly carried out in order to satisfy a merely juridical and administrative purpose. The reason why mapping was so basic in this context is likely to be found in the agro-pastoral system

of the *Dogana* which mastered territories, economies and populations and let the representation of the territories take on a merely institutional significance [60] (p. 592).

During the seventeenth century, the graphic elaboration becomes more detailed, the design covers the entire surface though remaining devoid of colour differentiation—an element that will characterize the maps of the next century—and the use of symbolism starts to be connected to specific situations to be represented [61,62]. For the waterways a corrugated hatch is used, contained between two lines that demarcate the river banks; the same lines but with a thicker pattern, indicate the greens, which in other cases are represented with simple grass tufts; the natural boundaries of the fields are rendered with the clarity and brilliance of the drawing, as well as the conventional ones that connect the limit stones; buildings and infrastructures are made through a technique more defined than that of the surveyors of the sixteenth century. What is lacking is a proper perspective of the images, for example on the roofs of the buildings; sometimes, the tiles are also drawn in the inverse direction. The representation technique however refines: it indicates the orientation of the map through a simple apposition of the cardinal points on its sides or with the representation of a compass rose.

In the second half of the seventeenth century the process of abstraction of the elements advances and will lead to the symbolism of the eighteenth century. A significant evolution in the development of transhumance cartography can be seen in the Capecelatro Atlas (1651), as part of the reinstatement ordered by the Viceroy Count of Ognatte and Villa Medina. Later, new techniques were developed for cartographic rendering, such as the introduction of colour in the Crivelli Atlas in 1712 (Figure 1).

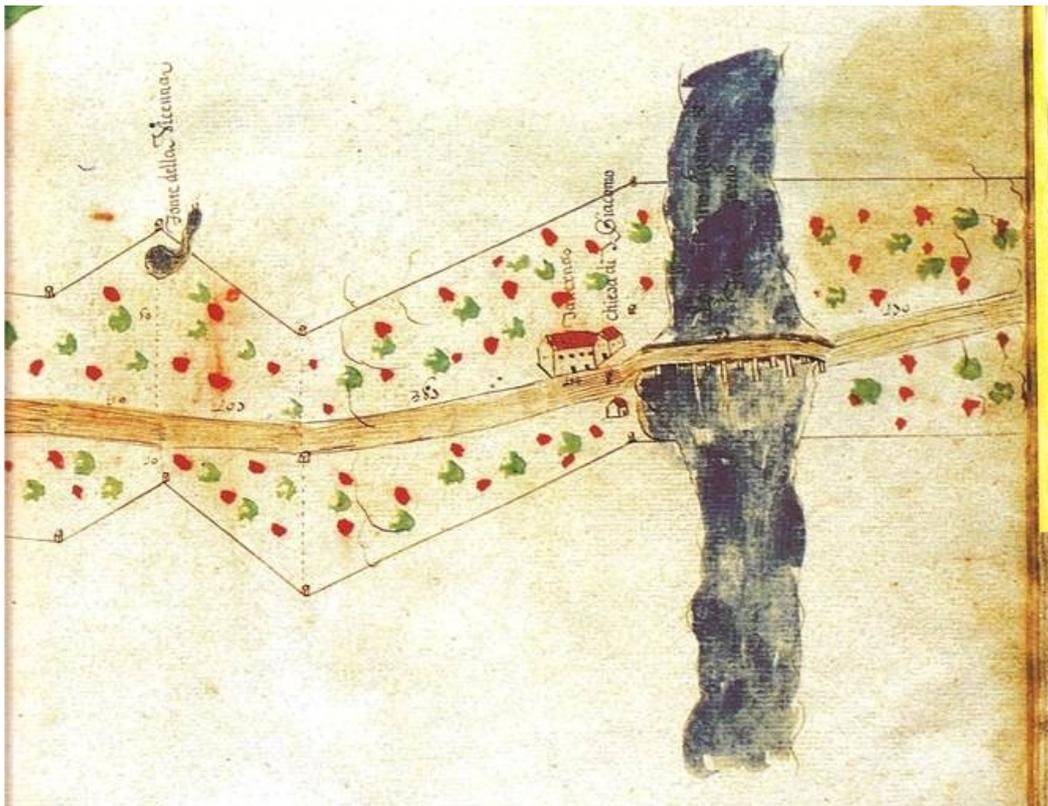


Figure 1. A sheet from the Crivelli Atlas representing the crossing of the Biferno river in the territory of Castropignano (Molise, Italy), 1712.

With maps produced by Michele della Croce, the result of a lengthy investigation conducted between 1735 and 1760, the scale (in 1000 Neapolitan feet) was introduced for the first time, providing a reliable technical basis. When the Apulia Sheep Custom was abolished, a new arrangement became necessary which began in 1809 and engaged a large group of surveyors; they introduced

the geometric scale of 100 feet for the length and 60 feet for the width, with rare use of colour in the mapping.

The transhumance cartography of the nineteenth century shows a certain refinement of the land surveying techniques and the progress, taking place within the Foggia customs, of the mathematical-geometrical knowledge [63]. Such advances are accompanied by both a more accurate representation and new forms of encoding giving priority to abstract, conventional signs [64,65].

The nineteenth century reinstatement was mainly managed through a royal decree that prescribed the complete conservation of all the royal sheep tracks including their interconnections (*bracci*) and rest areas (*riposi*). The result of such an enormous enterprise was a huge, detailed cartographic production; from 1809 to 1884 as many as 98 Atlases relating to three reinstatements were made [66] (p. 66). The first reinstatement was carried out by the *Giunta del Tavoliere* between 1809 and 1812. The atlases documenting such experience witness many graphic innovations, such as the insertion of the geometric scale. Moreover, these sheets contain detailed information on the occupied area (land use, extension, etc.) and their occupants.

The second reinstatement, commissioned by the Intendant of Capitanata marks a strong change from a technical and communicative point of view. It was carried out in 1826 by Giovanni and Michele Jannantuono. The quality of the maps is particularly accurate. They contain thematic boxes that accurately report all the measurements made in miles, in Neapolitan steps and in degrees. Each box is dedicated to a portion of the land with information on the state of the track, the crops and the consistency of the grass. The scale used is 15 miles for every 60°. The maps, drawn on single sheets of 63 cm × 44 cm, are preceded by an index map. The reinstatement contains the Atlas 38, representing the Celano-Foggia drove road, and the Atlas 39, representing the Castel di Sangro-Lucera drove road, which will be recalled in the applicative part of this paper.

The third reinstatement took place after the National Unification of Italy: by abolishing the institution of the *Tavoliere di Puglia* in 1865, the management of the sheep tracks was entrusted to the state offices of the provinces where they were located. This reinstatement is documented by maps at a scale of 1:5000. Each atlas contains a brief historical description of the track, with an indication of the state-owned land crossed, the list of terms placed along the tracks with indication of the distances among them. Atlas 118, relating to the Celano-Foggia drove road, shows the verification carried out from 1879 to 1881 in execution of a ministerial circular, as a result of which the section was verified by three groups of provincial delegates, namely for the provinces of Foggia, Campobasso and L'Aquila. Atlas 118 concerns the portion that falls within the province of Campobasso, in the present territory of Molise.

2.2. The Vegetation Index as An Instrument for Assessing Conservation and Fruition

The integration of Remote Sensing and Geographic Information System for geoconservation and valorisation has represented another step in the interpretive process of transhumance routes and landscapes. The Normalized Difference Vegetation Index (NDVI) has been used in our research as an instrument of analysis of the state of conservation and usability of the drove roads.

The NDVI [67,68] is a standardized index which generates an image displaying different degrees of 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 the state of vegetation because photosynthetic pigments, above all chlorophyll, absorb the incidental electromagnetic radiation in a selective manner exploiting energy in the range of wavelength of visibility. The index output values range between −1.0 and 1.0: The negative values represent clouds, water and snow, values near zero represent rocks and bare soils, moderate values represent shrubs and grassland, while high values indicate temperate and tropical rainforests.

As for the research fields of application, its use finds excellent results in the multi-temporal analysis of landscape and land use, allowing to highlight trends of fragmentation of the vegetation cover that create important implications for biodiversity and ecosystems, to model development scenarios with priority areas for further analyses, to identify and protect valuable resources and contribute to

sustainable management. Therefore, the index is frequently used for the analysis of changes in forested and non-forested areas, agricultural and pastoral lands, parks and protected areas [69–76].

Other studies concern archaeological heritage: in this case the use of remote sensing data and the derived vegetation index are connected to the anomalies produced by the buried objects that over time produce anomalies in the chemical-physical properties of the soil and therefore in the vegetation cover. These anomalies are detected either by means of satellite images [77] or by the use of self-built open source UAVs (Unmanned Aerial Vehicles), that is remote-controlled drones aimed at remote sensing and, more generally, at aerial archaeology [78,79].

A further field of application, experimented in our research, is based on a methodological approach that combines remote sensing techniques with geo-historical analysis. This new field of application has been successfully tested for the Castel di Sangro-Lucera drove road [49]. With the help of historic maps, the transhumance route is georeferenced and selected, then satellite imagery is acquired covering the study area and processed in the GIS (Geographic Information System) environment [80], eventually the NDVI index is calculated producing a map aimed at evaluating the accessibility and usability of the transhumance route for geotourism enhancement.

The integrated use of satellite images and NDVI allows to detect the information necessary for subsequent inspections on the field, discarding in advance the areas with weak geotourism potential. In fact, the abandonment of the transhumance practice has led to a progressive reduction in the width of the drove roads, as a consequence of spontaneous vegetation growth and of soil occupations, as demonstrated by the presence of asphalt roads, factories or soccer fields right on the path of the pre-existing sheep tracks [49].

The index has proved to be effective, together with other sources, for the identification and the assessment of still existing tracks, also of those which were interested by a change in the vegetation cover. The research method allows to identify barriers on the transhumance routes, as a consequence of natural reforestation or soil occupations, and to verify the continuity of the track in specific areas that deserve requalification and promotion. In this paper, a further use of the vegetation index is shown, for the assessment of the role of transhumance routes as present pasture areas in respect to side meadows.

2.3. GIS and Cultural Virtual Environment for Geotourism Enhancement

Information and multimedia technologies have been used during the research as an instrument for the interpretation and representation of the natural and cultural heritage of the transhumance practice, according to the documents produced by the *Dogana* reinstatements during the 19th century.

The method used can be summarized as follows. In a first phase, the techniques of digitization of historic maps associated with those of remote sensing are combined in a geographic information system allowing the recognition of the still existing paths and the analysis of their state of conservation in terms of accessibility and usability. On the one hand, the original route is defined through image interpretation, carried out with the overlaying of the topographic maps and satellite images. On the other hand, to assess the relevance of the elements still present as signs of landscape conservation, recourse is made to the historic sources, maps and other documents, with a precise identification of the elements that today can be considered as geoheritage. The analysis regards not only the strip of the trail but also what can be observed along the route, with reference to the material elements of the landscape traversed by it and due to the past economy of transhumance: taverns, churches, limit stones and so on. Then the elements mentioned are georeferenced, taking as a basis the Italian Military Geographic Institute (IMGI) topographic maps; subsequently, the historic maps are implemented in the GIS as iconographic material. All the landscape features implemented in the information system are meant to undergo a process of spatial analyses aimed at geoconservation management and the organization of the visits; besides, they can be used for promotion and communication needs.

A second phase concerns the 3D virtual rendering of the landscape according to Cultural Virtual Environment techniques [81]. The application of a virtual environment to places and cultural resources is known with the acronym CuVE (Cultural Virtual Environment). It allows interactive and real time navigation of environments, places and monuments of historical, artistic or archaeological interest, designing an immersive simulation that aims to highlight the historical-cultural dimension of the site. The strength of CuVE lies in the multiple possibilities offered by virtual reconstruction through three-dimensionality, interactivity and spatial exploration. A philological scientific approach is pursued which aims to integrate traditional research systems with the potential of digital technologies: validation can be seen as a guarantee of the correctness and punctuality of the virtual reconstruction and of the research path that produced it.

From a technical point of view, this cultural environment is based on the acquisition of territorial data and on the retrieval of historical sources. All collected data are analyzed, catalogued and implemented in GIS or relational databases; then, the most suitable instruments to communicate the obtained data and display them are identified; the processing and optimization of data follows, this is done with computerized processing (post processing) in order to build the virtual environment. The use of Virtual Cultural Heritage software—relying on the concept of cultural heritage in the meaning recognized and shared by Unesco (United Nations Educational, Scientific and Cultural Organization) and Icomos (International Council on Monuments and Sites)—consists in the application of virtual reality technologies to different fields of cultural heritage study and dissemination, particularly linked to historical [82–84] and archaeological research [85,86]. It aims at educating and engaging the public in the cultural value of original sites, which become the object of new forms of interpretation, comprehension and communication, developed through information technologies [87,88]. The advantage lies in the possibility of representing—on the same platform, with an edutainment approach—a plurality of information coming from different sources: iconographic representations, photographs, ancient texts, historical cartography, GIS data [89].

In our research, drawing on some theoretical thought regarding the use of iconography for symbolic landscape representation [90] and the example of some previous experiences on the virtual reconstruction of cultural landscapes in Italy [91–93], Cultural Virtual Environment techniques have been implemented allowing to return the primary and secondary sources used in new visual forms, mainly a video with an edutainment objective, to be included in broader enhancement projects in order to augment the general visitors' experience and awareness of geoheritage as well as to promote a deeper interpretation for geotourists.

3. Geo-Historical Evidence and Geotourism Potential of the Drove Roads in a Man and Biosphere Area

3.1. The Application to the Study Area

The method described above was applied to the territories of the Unesco Man and Biosphere area at Collemeluccio-Montedimezzo Alto Molise (Figure 2) and, particularly for geotourism enhancement, to a pilot area in the municipalities of Vastogirardi and Carovilli located between the two reserves in the buffer zone of the MaB area.

The choice of the area, at a regional scale, is primarily due to its location, which defines it as a territory of obligatory passage for the practice of transhumance. Secondly, the choice is supported by a series of studies on the role of drove roads in the organization of the regional territory in the past and their potential for new paths of regional development, to which our research is connected [94–99]. Finally, the choice of the area was also conditioned by the opportunities of a follow-up of the research in the identification of strategic axes of enhancement already partly present in the regulatory tools for protected areas and regional planning [54,100].

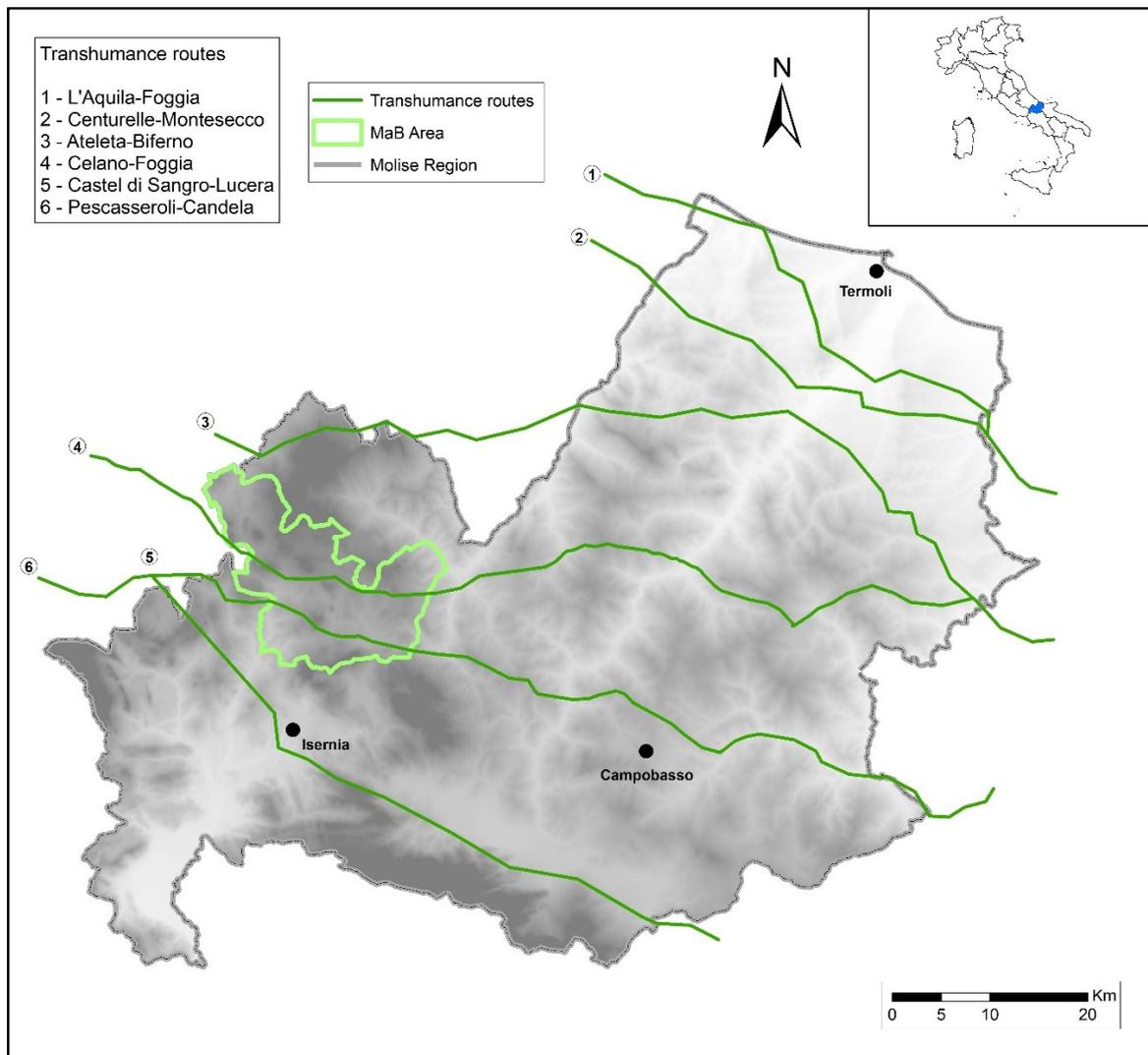


Figure 2. The localization of the study area.

The MaB area preserves an important and internationally recognized natural and cultural heritage. It is characterized by the closeness of two of the most important transhumance routes, that is the Tratturo Celano-Foggia and the Tratturo Castel di Sangro-Lucera; this makes the case study particularly interesting for a rethinking of development programs aimed at enhancing sustainable forms of tourism and their integrated use. The value of the natural capital (Figure 3) is confirmed by the presence, apart from the two forests of Collemeluccio and Montedimezzo designated as Natural Reserves in 1977 by the Italian Ministry of Agriculture and Forestry, of seven Sites of Community Importance (SCI) belonging to the Natura 2000 network, characterized by Community interest habitats regarding not only forests but also shrubs and meadows [101] and many geosites catalogued by the Molise Region [102]. Of the latter, there are 17 in Alto Molise, 6 of them located along the Tratturo Celano-Foggia.

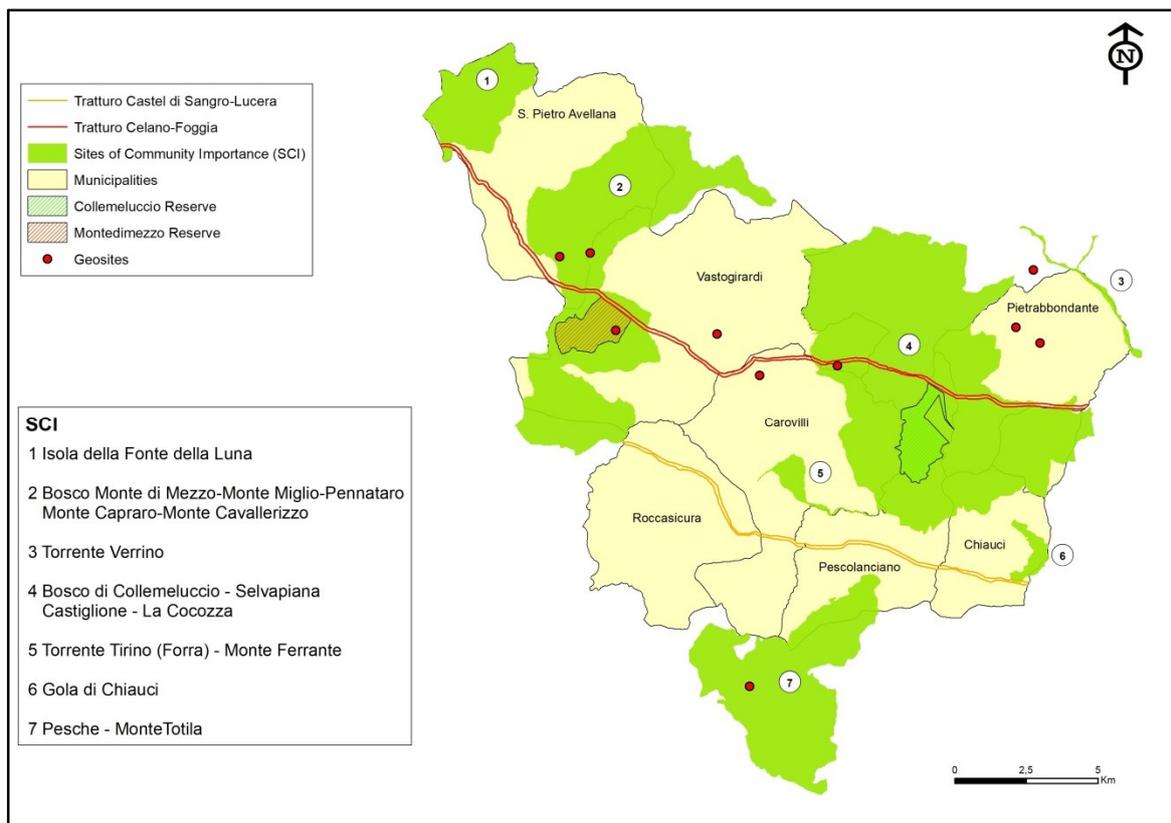


Figure 3. The natural capital of the MaB area.

The study area presents a series of isolated peaks often aligned in a NNW-SSE direction, the same followed by the transhumance routes, mainly constituted by a succession of marl, limestone and marly limestone of the middle-upper Miocene and by marly clay-Oligocene and lower Miocene soils [103]. An important alignment is represented by the one formed by the structures of Monte Miglio (1350 m)—Montagnola—Monte Pizzi (1373 m)—Monte Ingotta (1189 m). This alignment has been interpreted as a retrovergent compressive structure, represented as a whole by an anticlinal fold, which led to the tectonic overlap of the soils constituting the backbone of Monte Pizzi on the silicoclastic deposits of the Agnone Flysch, which can be found in the south-west of the relief. The predominant morphological processes are linked to the karst dissolution to which, at altitudes above 1200 m, phenomena of frost weathering are associated. Furthermore, there are processes related to concentrated water erosion and to creep phenomena, to which collapse landslides are associated in the most inclined sections; processes of fluvial denudation origin also have an important role, causing a series of slow and rapid landslide phenomena. Particularly representative of these landforms and geological processes is the area of Monte Pizzi, where considerable deep-seated gravitational slope deformations were singled out [104].

Besides the presence of large green spaces and woodlands, the conservation of ancient agricultural roots and the still strong bond between man and his environment characterize this area. Tourism does not appear among the major sectors, despite important tourism attractors are nearby: Agnone, known for the manufacturing of bells by the Marinelli Pontifical Foundry operating for nearly a millennium and Capracotta, that is an important cross-country skiing destination in the Apennines. For its natural resources, we can say that the area is considered as an ecotourism destination, where the visitors can immerse themselves in nature hiking or mountain-biking along forest trails and discover the secrets of plants and animals, extensively documented in the MaB Reserves. But it does not lack historical and archaeological wealth: outstanding evidence of pre-Roman Samnite civilization can be found in Pietrabbondante, with the Temple-Theatre complex in the whole archaeological site,

as well as in Carovilli and Vastogirardi, while Pescolanciano stands for medieval times historical and cultural heritage [105].

3.2. The Promiscuity of the Transhumance Landscape: Geo-Historical Signs

As previously pointed out, the study area has been strongly characterized by the phenomenon of transhumance in the last centuries [106–109]. The analyses of the *Dogana* sources show that between 1600 and 1800 there was a more or less constant traffic of around than 850,000 sheep per year and shepherds were present in almost all the municipalities of the area [66]. The nineteenth century atlases well document the transhumance culture in its material aspects, particularly highlighting a series of tangible elements of the landscape such as limit stones, taverns (*taverne*) and farms (*masserie*). The limit stones are elements of high symbolic and functional value for the reinstatement and reorganization of the drove roads and, although rare today, still represent a geo-symbol of the sheep track. These elements are represented by consecutive numbers and placed in pairs on both sides of the track (Figure 4); this precise representation allowed for a faithful reconstruction of a landscape evidence now partly disappeared.

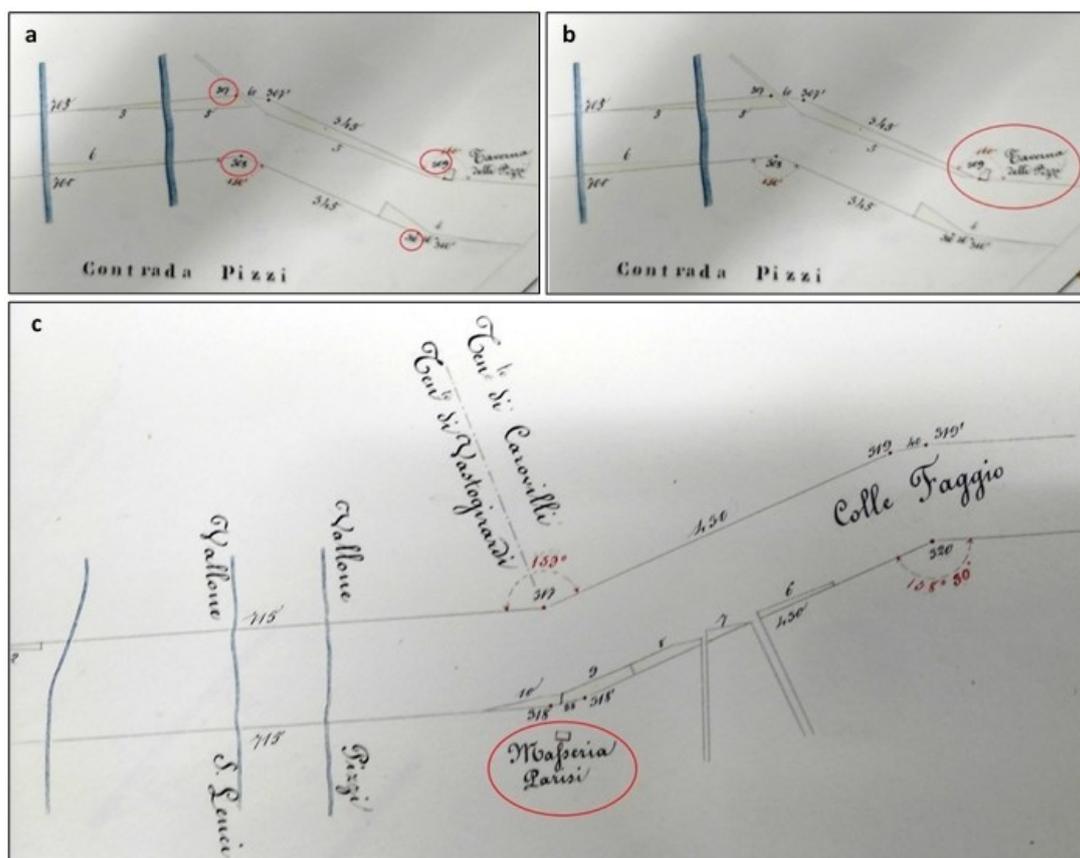


Figure 4. Heritage signs of the Celano-Foggia drove road in the territory of Vastogirardi (red circles): (a) Limit stones. Source: National Archives of Foggia, Atlante 118, p. 23; (b) Taverna delli Pizzi. Source: National Archives of Foggia, Atlante 118, p. 23; (c) Masseria Parisi. Source: National Archives Foggia, Atlas 118, p. 24.

The atlases also represent elements localized outside the trails as part of the transhumance ecosystem. These are shepherd's huts, water sources for both the sheep and the shepherds, taverns for their repose and farms often built as a result of the occupations for agricultural use to facilitate the control of the land [110]. These signs remain evident in the place names of the area, as in the case of Taverna delli Pizzi and Masseria Parisi (Figure 4).

Not only is the shape and distribution of these elements conditioned by natural elements—geomorphology, soil nature, hydrography and climate—but a strong relationship between the building materials and the physical aspect of the territory influenced the localization and the architecture of permanent and temporary buildings and infrastructures. The role of the Colle Faggio mount as a natural element conditioning the direction of the route is quite interesting: the linear continuity of the drove road is in fact interrupted in order to pass it by.

The analysis of the nineteenth century atlases allows us also to discover and analyse signs of the transhumance landscape that in the present are no longer recognizable, due to the abandonment of the pastoral economy, the strong depopulation and the economic decline recorded in the area during the century. In fact, this landscape can be at present identified in its systemic coherence only through the historic atlases. Moreover these tools, through their detailed data on land use and occupations during the nineteenth century, help us to rebuild a landscape that over the centuries had never been exclusively devoted to sheep-farming.

Nineteenth-century atlases, indeed, permit to recognize landscape peculiarities at a time of great change. The crisis of the wool trade, particularly dramatic during the nineteenth century [35,36] and the consequent decrease of the sheep trade led, in fact, also in the mountain territories, to a progressive lack of interest in the sheep track as a transhumance route and to a growing interest in it as an agricultural land. There was a tendency, always existing but particularly accentuated during the course of the century, towards an occupation of the *tratturi* for agricultural use. This trend, whose abuses were fought throughout the various reinstatements of the nineteenth century, contributed to the emergence of a new promiscuous landscape, where sheep-farming and agriculture seemed to coexist for many decades, imposing strong, sometimes unusual connotations on the area. The atlases witness such transformation and a comparative analysis between the maps of 1826 and 1879 points out the evolution of the phenomenon, particularly significant during the second half of the century.

On the Celano-Foggia drove road, the increase in occupations was overall considerable. A comparison between the data of the two reinstatements shows how the occupations, almost inexistent in 1826, reached more than 12 hectares in 1879. The occupation rate was not uniform and seems to be higher in territories with a strong decline of pastoral economy from the second half of the eighteenth century (i.e., Pietrabbondante) and in contexts where agricultural activity is promoted by the presence of local agricultural entrepreneurship (i.e., Pescolaniano). This tendency was accompanied by a trend towards less parcelling out of occupied land and a greater extension of farms: this is probably a consequence of a conversion of the activities by the ancient sheep owners. A specific analysis of the types of cultivation, also reported in the atlases, reveals a series of territorial specificities. In San Pietro Avellana, for example, in contrast to what happens in other municipalities, the nature of the occupations in 1826 was diversified with a slight prevalence of grassland for grazing purposes witnessing the original function of pasture.

An analysis of the reinstatements related to the Castel di Sangro-Lucera section also shows even more marked transformations, with the extension of occupations dramatically augmenting between 1810 and 1882 (Figure 5).

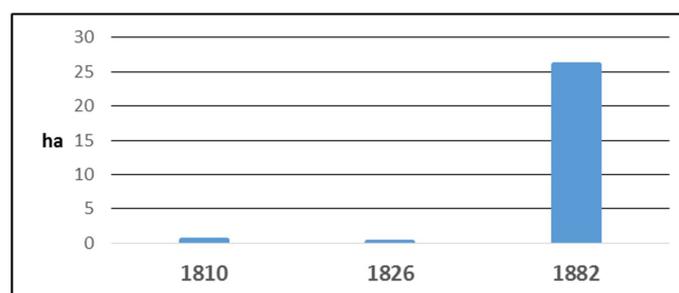


Figure 5. Evolution of the occupations of Castel di Sangro-Lucera. Years 1810, 1826, 1882. Source: National Archives of Foggia Source: National Archives of Foggia, Atlases 2, 39, 121.

The case of Pescolanciano is symbolic of the overall trend in the occupations land use. That municipality registered an already strong and diversified agriculture in 1810. In 1826 there was a mixed use of the occupations, with a prevalence of agriculture but also of civil use (streets and buildings); the atlas, in detail, witness the presence of a strongly anthropized territory (with mills and vegetables gardens); in 1882 the use for arable crops was predominant, followed by the use for the construction of buildings and vegetables gardens: these signs confirm a constant, strong exploitation of the land (Figure 6).

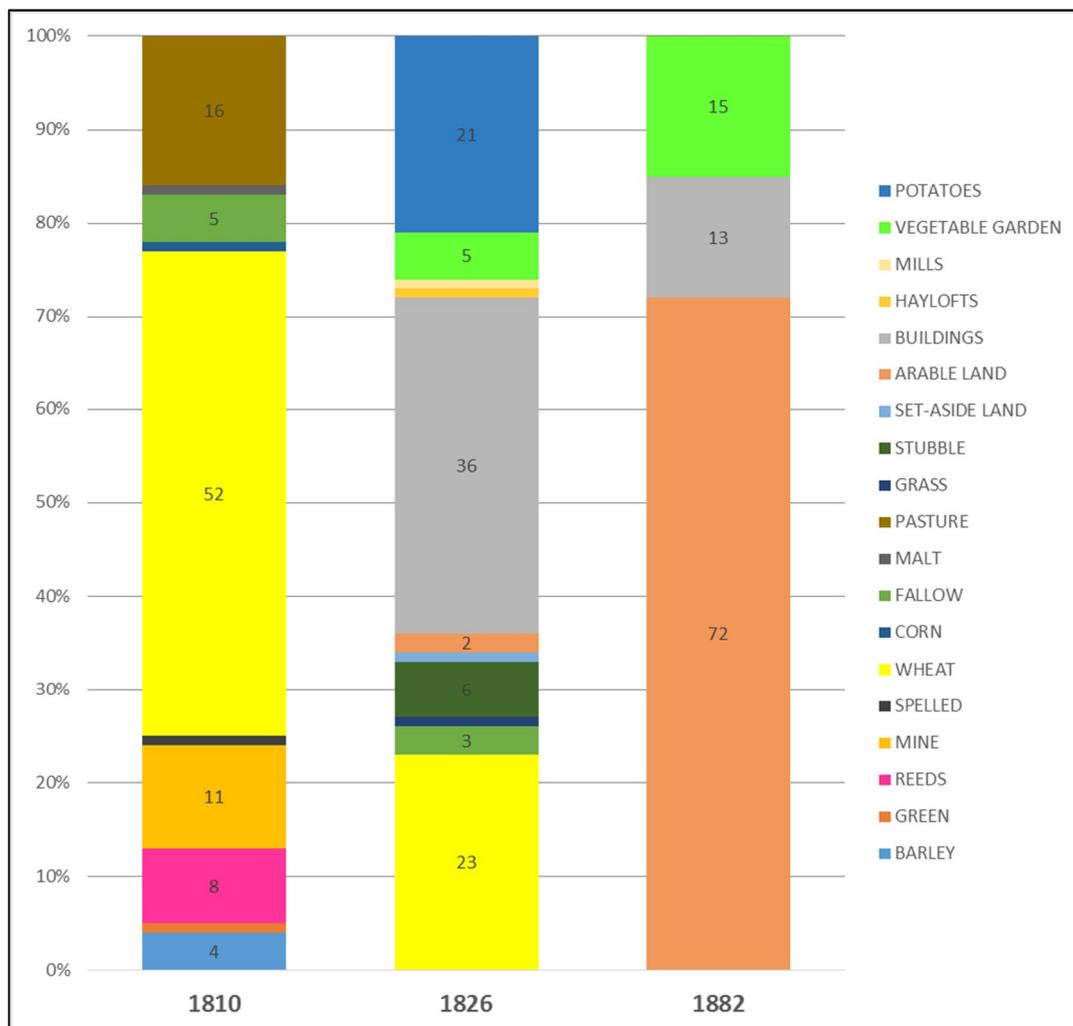


Figure 6. Castel di Sangro-Lucera occupations land use in the territory of Pescolanciano. Source: National Archives of Foggia Source: National Archives of Foggia, Atlases 2, 39, 121.

The geo-historical analysis clearly shows the crisis of transhumance in the nineteenth century, with almost all land occupations owing to agricultural uses, increasingly uniformly oriented to arable land, and the presence in many cases and in the various individual plots of private buildings, most likely farms. This confirms the trend towards a sedentarization of the basic economy and the gradual abandonment of the practice of transhumance, which had characterized the territory of Molise until at least the end of the eighteenth century. This replacement of the transhumant practice with an agricultural practice from the 19th century onwards had a strong influence, determining new mixed landscape configurations that can be still found, for some different reasons, in all the territories of the Man and Biosphere area.

3.3. A Virtual Model for the Representation of the Transhumance Landscape

A 3D model for the reconstruction of the transhumance landscape was developed, working on a stretch of the Celano-Foggia drove road located in the territories of Vastogirardi and Carovilli within the Collemeluccio-Montedimezzo MaB area. Within a designated 34 km² extension (Figure 7a), crossed by the Celano-Foggia transhumance route, a 5 km stretch of drove road was selected and represented through documentation contained in Atlas 118 of the 1865 reinstatement (Figure 7b). The selection responded to geo-historical representativeness criteria, based on the presence, considered particularly significant, of transhumance geoheritage [50], plus general landscape attractivity and accessibility issues.

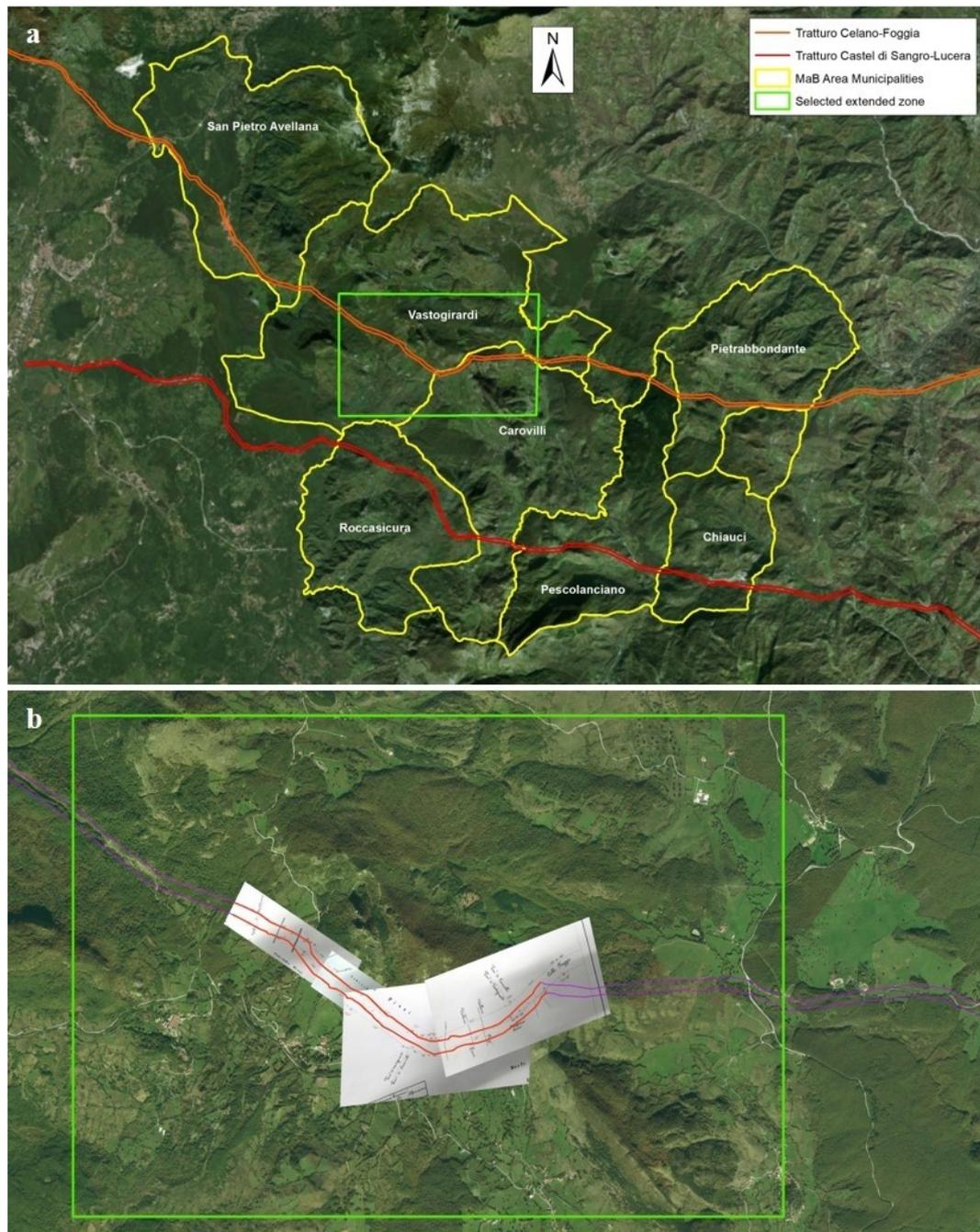


Figure 7. The pilot area in the territories of Vastogirardi and Carovilli: (a) Selection of the extended zone (green) in the MaB area; (b) The historic maps georeferenced related to the selected stretch of the Celano-Foggia drove road.

The choice of the period to be used for the virtual landscape reconstruction, a critical aspect of the research, fell on the 19th century. Even though this was a period of decline in the economic activity of transhumance, it can be seen as the latest most realistic period of a still alive transhumance practice. Besides, this century represents an important reference for the archive of territorial information contained in the *Dogana* reinstatement documents, which include detailed descriptions of the drove roads and designs showing a promiscuous transhumance landscape scenery, with many elements that could be faithfully rebuilt in the 3D reconstruction project. From a cartographical point of view, the nineteenth-century mapping offered a more accurate information of the transhumance network, also thanks to the introduction of the metric scale and a symbolism similar to the current cartographic system, which allowed for a more precise implementation of the historic maps in the GIS environment and consequently a more realistic 3D representation.

The 3D model was meant to serve as a cognitive tool by which to increase geoheritage awareness and it was built on the following documentary items: cartographies, photographic historical documents, oral evidences of transhumance practices and rural traditions. The virtual reconstruction is the result of a series of steps:

- Organization of information layers from different periods testifying to the territorial evolutions and stratifications, identifying the most characteristic elements of transhumance landscape that need to be conserved and valorised;
- Space-time contextualization of the cultural assets of the transhumance landscape, localizing tangible signs and intangible values sources and setting both of them in a unique system of relations that gives significance to geoheritage;
- Production of knowledge-based communication tools, useful for promotion strategies, for educational applications, tourism enhancement.

Three project phases led to the construction of the 3D model:

1. Digitization and georeferencing;
2. 3D modeling of the selected area and the elements of the landscape;
3. Importing models and 3D rendering of the area with Lumion 6.0 (Varmond, The Netherlands).

A first phase concerned the digitization with a 300 dpi resolution of the sheets of the nineteenth-century atlases representing the Celano-Foggia and Castel di Sangro-Lucera transhumance routes in the study area and subsequently their georeferencing. The maps were managed in the GIS environment: through the ArcGis 10.1 software (Redlands, CA, USA) they were georeferenced with the support of the topographic maps and the satellite images integrated in ArcGis, which revealed to be good supports for the georeferencing in raster format. In fact, it could be just an approximate georeferencing, since the reference scales of the various maps used were different: the scale of the 19th century Atlas is 1: 5000, while the largest cartographic scale of the IMGI topographic maps is 1:25,000, hence the adjustment of the georeferencing also through the interpretation by image comparison. As some points of the drove roads represented in the nineteenth-century maps showed scarce information for their georeferencing, in these cases the interpretation of the IMGI cartography and of the satellite images in the GIS environment contributed to the validation and standardization of the geodata contained in maps for different periods and characteristics (Figure 8).

A restitution of the transhumance landscape as it was in 1865 was taken into account, with a series of technical limits. The 3D modelling and rendering software used was Lumion 6.0 which allows the management of a 4 km² maximum extension, so the choice of the area to be reconstructed had to adapt to instrumental limits.

Therefore, a model adapted and reduced to the software scale was created (Figure 9a), which however makes it possible to obtain a realistic representation of a stretch, which can be used to promote the area and enhance the geotourism of transhumance landscape, also by means of augmented reality instruments during the visit.

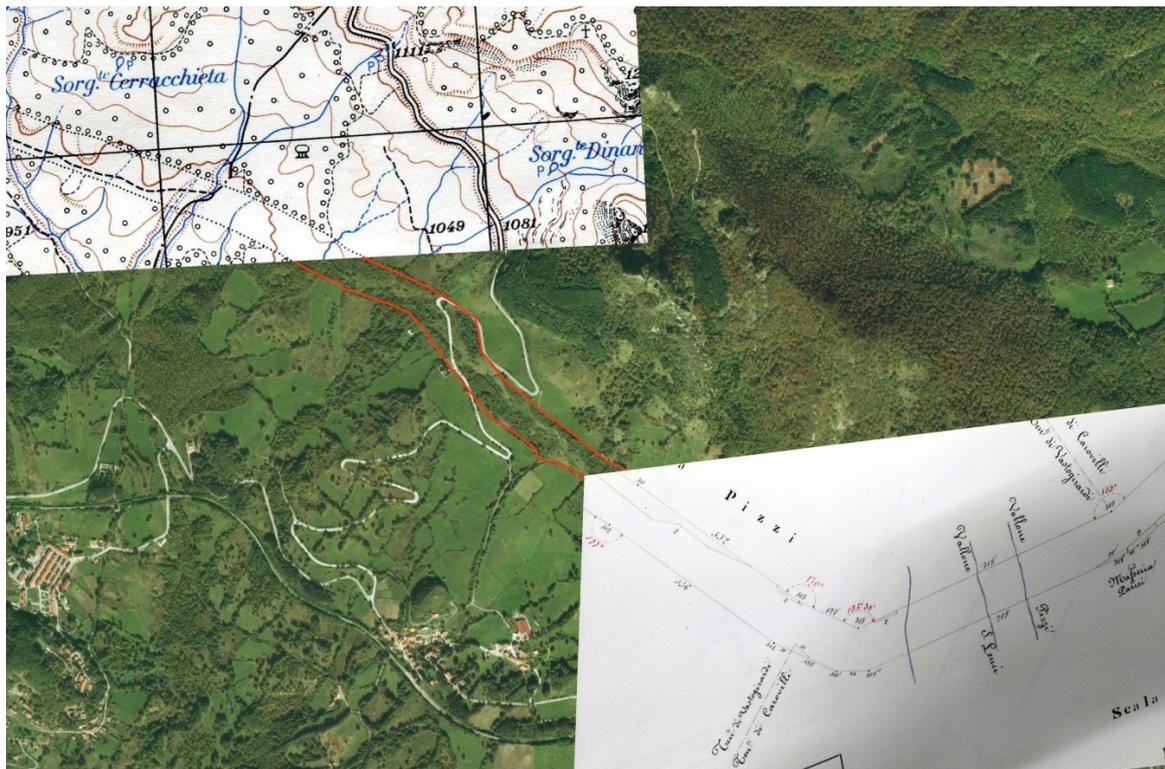


Figure 8. Example of georeferencing through interpretation of three different sources in the territory of Vastogirardi.

In the following phase, the selected area was modelled using Sketchup 2018 (Sunnyvale, CA, USA), a 3D software that allows access to a large library of natural and anthropological forms, very useful for the modelling both of physical features and of cultural elements.

The elevation was implemented through Google Earth images; their advantage is to contain metadata with a digital terrain model (DTM) that is recognized by the Sketchup software by activating a specific tool. In this way it was possible to shape the terrain model of the selected part of the Celano-Foggia drove road and of the surrounding territory and save it in skp format, compatible with Lumion 6.0 software (Figure 9b).

The Sketchup 2018 software was also used for the creation of the 3D models related to the natural and cultural elements identified in the previous phase. The virtual reconstruction was made on the images of an almost completely disappeared cultural landscape, thus making the rendering of the true characters of the past quite important. As far as possible, the regional specific characteristics and functions were analysed, searching for the various forms taken on in the Alto Molise area. All the models created were the result of a work based mainly on iconographic sources, also by the interpretation of the constructive forms, so as to make the model quite realistic [111,112]. Specifically, the cultural landscape 3D models which were created are of two types (Figure 9c,d):

- Living and moving elements—shepherd, dog, *taverna* owners, *masseria* owners;
- Stationary elements—limit stones, occupied land, *taverna*, *masseria*.

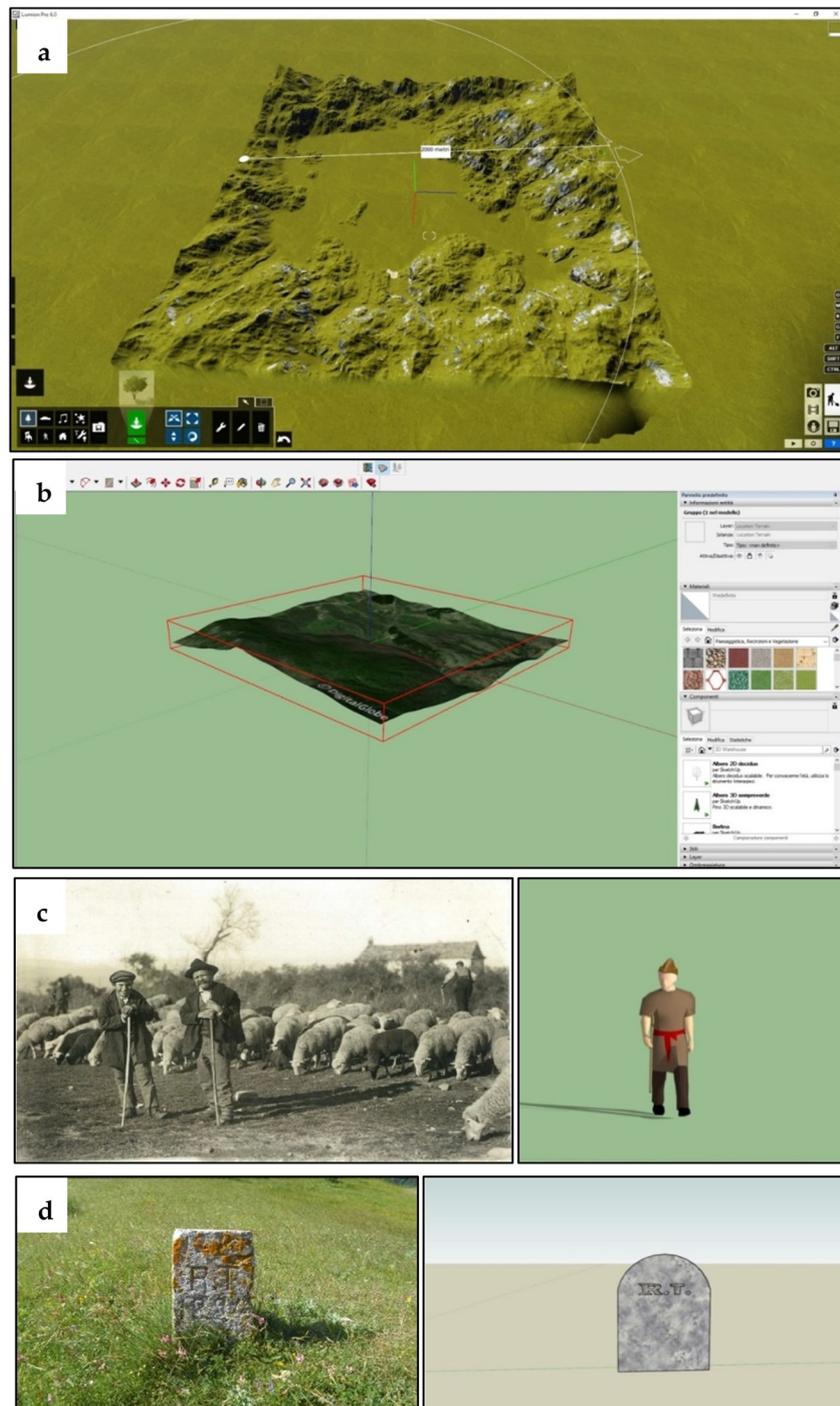


Figure 9. Details of the virtual reconstruction model: (a) the area chosen (maximum extension manageable by the Lumion 6.0 software); (b) Modelling the terrain through Sketchup 2018; (c) Shepherd model construction from historical photo; Source: photo by Giuseppe and Emilo Pilone, Larino, 1887. [111] (p. 41); (d) Reconstruction of the limit stones with the capital initial letters of *Regio Tratturo*; Source: photo by Daniela Adducchio, 2012 [49] (p. 227).

Once the models were built, the next phase was managed in the Lumion 6.0 environment. The first step was to import in Lumion the selected terrain model and adapt it to the extension dimensions tolerated by the program. The dressing of the model respected the landscape characteristics of the selected area trying to reproduce the geographic reality as faithfully as possible in order to make it recognizable to tourists when visiting the area; for this purpose satellite images were used, which hold

the altimetry data. The model was also enriched with the current flora (Figure 10), taken from today's satellite images, which constitute an immediate reference for the in situ fruition of the model for tourism purposes.



Figure 10. The inclusion of the current flora in the model.

After building the natural landscape, the drove road was created through the simultaneous interpretation of the nineteenth-century maps, IMGI cartography and satellite imagery. The same procedure was carried out for the agricultural occupations with their effective geometry, the limit stones, the tavern, the sheep fold and the farm, recovering the various forms and the distances existing between the various elements from the historical documentation. The last elements inserted, very important for the definition of the transhumance landscape, were the main actors of the practice: the sheep, the shepherd and the dog. There is no wonder that the flock in the simulation is only made of a few sheep, whereas in past centuries there were up to more than 20,000 for a single property; this reduced number is meant to reflect on and remind of the continuous and inexorable abandonment of the practice, in favour of other land uses.

The final product of the reconstruction of the transhumance landscape in Alto Molise in the nineteenth century was presented with the creation of an HD (High Definition) video that reproduces the transhumance route and its landscape, as well as a series of significant scenes of the practice [50]. In accordance with the Virtual Cultural Heritage approach, this final product, even in its prototype form, aims to engage the public in a playful and emotional way on the patrimonial value of transhumance and enhance it as a potential attraction for geotourism. This phase of the research has showed an alternative way to the understanding of a practice that came to a crisis in the nineteenth century but which has left deep evidence in the territory and it is precisely this last aspect that virtual reconstruction wanted to exalt.

The model of reconstruction of the transhumance landscape has also been thought of as an instrument for promoting tourism in the MaB area, which could enrich the offer of this territory increasing the knowledge of the transhumance cultural landscape, starting from current walkable trails. The use of 3D virtual reconstruction, based on accurate geo-historical research, could improve the recognition of these ancient routes and promote the enhancement of the integrated cultural landscape of transhumance.

One of the future implementations of the results obtained could be that of augmented reality products, in which the aspects related to geoheritage and its historical evolution should be appropriately considered, together with the integration of a specific multimedia equipment.

3.4. A First Step in the Fruition Analysis

This kind of analysis was carried out in a pilot area in the municipalities of Vastogirardi and Carovilli. In order to assess the present character of the transhumance landscape and to estimate its effective fruition, in the same territory analysed for the creation of the transhumance landscape virtual model, the vegetation index was finally calculated, as explained above, whose results have given interesting insights for the definition of geoconservation measures and geotourism scenarios.

The first calculation was related to the stretch of the Celano-Foggia drove road in the municipality of Vastogirardi, near Mount Pizzi. This stretch was extracted from the Landsat 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 drove road. The result was a new raster layer of the stretch, from which the NDVI was measured returning the path with the spectral responses of the surface coverage (Figure 11a).

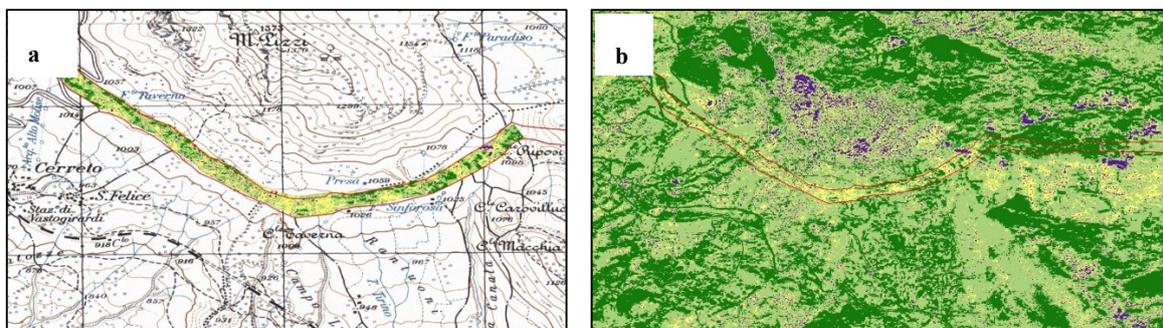


Figure 11. The result of the NDVI analysis in the pilot area (Tratturo Celano-Foggia): (a) selected stretch; (b) extended zone.

At first, the analysis showed that the selected stretch of the drove road still preserves a high degree of vegetation heritage which recalls the turf used in the past by grazing transhumant sheep. Indeed, we can find a prevalence of the grassy areas (42%) over the bushy ones (33%), at times with denser vegetation characterized by the presence of trees (19%) and a minimal occurrence of areas with scarce vegetation (6%).

However, the same analysis performed on a wider territorial extension of 1700 ha. containing the selected stretch (Figure 11b) permitted a meaningful valuation of the current presence of pastures in the drove road and outside of it. The result of the analysis on the extended zone shows that the whole context is characterized by a rich presence of grassy areas—evidently destined to pasture—mixed with forested areas—which represents the most important natural capital in the MaB reserves –, while the bushy areas are less important and the areas with a low vegetation index represent either the settlement system or, more diffused, the stone heritage of this zone.

The comparison between the two indices related to the selected stretch and the extended zone (Figure 12) demonstrates that the grassy areas are mostly located at the margins of the drove road, so outside the transhumance routes, with a share of 48% against 42%; on the contrary, the share of the bushy areas is much less (9% against 33%), replaced by the areas with dense vegetation (37% against 19%).

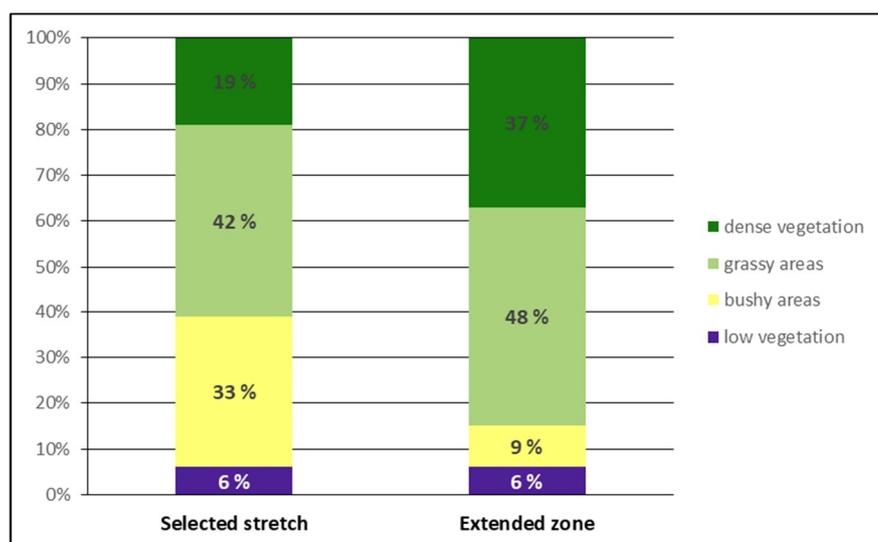


Figure 12. Distribution of vegetation types (% of pixels): comparison between the selected stretch of the drove road and in the extended zone.

Considering the gradual abandonment of the practice of transhumance and the increasing trend in sedentary livestock raising which have characterized also the territory of Molise in the last century, these results confirm that—while the surrounding private properties underwent a process of enclosure for pasture use—the ancient drove roads, destituted of any real function and control, began to suffer more and more disuse and sometimes misuse, which resulted in a progressive change not only of the land use but also of the landscape. In fact, nowadays the greenest areas are not inside but outside the transhumance route and the drove roads can be used for other purposes, such as recreation and tourism, compatible with their still rich natural and cultural heritage.

With this end in mind, the vegetation index was also used to identify any barriers to the practicability of the track and its potential reuse in terms of slow mobility. In fact, the abandonment of the transhumance practice has led to a reduction in the width of the drove road, mainly as a consequence of spontaneous vegetation growth. An interesting evidence of the method efficacy is that the NDVI analysis of the selected stretch highlighted the part near Colle Taverna for a greater continuity of the bushy area (yellow colour in the Figures 11 and 12), thus drawing attention on it for further analyses. The comparison with satellite imagery suggested the hypothesis of a landslide at this point of the route, which was later confirmed with an in situ inspection; obviously the presence of a landslide strongly influence the practicability of the route, even if it properly reflects the geomorphology of the area and should be correctly addressed as an important issue in the definition of a geotourism scenario. The use of NDVI in these terms has been seen as a support tool to encourage the requalification of transhumance routes in a perspective of integrated land management, with a view to geotourism enhancement.

The method has proved to be effective in identifying the best preserved areas, on which to concentrate subsequent inspections (Figure 13), aimed at identifying the degree of geoconservation and usability of the route as well as of environmental and cultural heritage and of tourist services with a greater precision.



Figure 13. Landscapes and services in the pilot area: (a) The selected stretch of Tratturo Celano-Foggia, with the shrubs conquering the grass terrain in the foreground and the mountain ranges all around; (b) A few sheep grazing in the side pastures and the typical shepherd dog controlling them; (c,d) The chromatic contrast, due to the different index and quality of vegetation, between the drove road (the T on the wooden signal stands for *Tratturo*) and the side pastures; (e) A small family-run dairy at the edge of the drove road and a cheese shop in a renovated building maintaining the typical stone architecture; (f) The small station of Vastogirardi on the Isernia-Sulmona panoramic railway line, now only used for tourism with historical trains, in the village of Cerreto, a few meters from one of the access points to the selected stretch of the drove road; (g) Indicators near the railway station to reach the drove road (15 min) and a bed and breakfast.

4. Discussion and Conclusions

The research here presented is of broad and general interest, surely not limited to the study area, as it deals with the phenomenon of transhumance, which is widespread throughout the world. This antique traditional practice has recently aroused the interest of the international scientific community as it presents problems of requalification and compatibility of uses [113–115]. This article addresses these issues and proposes a method of analysis for the preservation of the drove roads and their reuse for geotourism purposes, showing the steps and instruments necessary to organize, enhance and communicate transhumance routes as integrated cultural landscapes.

Such a composite method allowed us to highlight, through the analysis of the case-study, both the geophysical features and cultural heritage of the transhumance territories, characterized by a landscape that still retains the signs of the pastoral economy, as well as the vocation of such contexts towards geotourism activities. The main results can be summarized as follows:

1. The geo-historical approach highlighted the strong relationship between the anthropic and the natural aspects of the territory, with evidence in the localization and the architecture of

- permanent and temporary buildings and infrastructures. Moreover, it led to the comprehension of the complexity of transhumance landscape. In particular, it pointed out the structure of a landscape characterized by an overlap of pastoral and agricultural signs whose traces are well documented by the analysed historic atlases. Particularly for the case-study, the phenomenon was more evident in those territories with a long tradition of an agro-pastoral entrepreneurship linked to noble families (i.e., the D'Alessandro, dukes of Pescolanciano), who were *locati* during the *ancien regime* and landowners during the nineteenth century. Geo-historical analysis allowed to explain—as other studies have recently done [116]—the promiscuous nature of a mountain area where agricultural and pastoral economies coexist, confirming that promiscuity is one of the fundamental traits of the Mediterranean region landscape and identity [38]. The landscape of transhumance, as a part and a significant type of this complex landscape system, is no exception, even in the core of internal areas, where indeed a great heritage has been protected which turns out to be very useful today for a geo-historical reconstruction aimed at geotourism enhancement.
2. The integrated use of satellite images and vegetation index proved to be a good instrument to identify the best preserved areas on which subsequent inspections should be concentrated aimed at comprehending the degree of geoconservation and usability of the transhumance routes. Moreover, the application to the selected stretch of the Tratturo Celano-Foggia enabled us to comprehend that, due to the abandonment of the transhumance practice in the last decades, nowadays the greenest areas are not inside but outside the drove roads and these can be used for other purposes, such as recreation and geotourism. Finally, the vegetation index proved to be a valid tool for assessing potential geotourism fruition of the drove roads, allowing to verify the continuity of the track in specific areas that deserve requalification and promotion.
 3. Contextualized historic maps and Cultural Virtual Environment approach, together with 3D virtual rendering tools, allowed to better understand the potential of rescuing a landscape that in some cases has completely disappeared and only a scientific reconstruction like the one here proposed can bring it in use again. The application of this method on a regional scale opens the possibility to create dedicated web-GIS aimed at the accurate visualization of information in a layered virtual environment where data are collected, processed, distributed, developed, analysed and accessed [117]. Geographic Information Systems can also provide the basis for new geomedia products that can be retrieved remotely or in situ, in order to enhance the attractiveness of drove roads and create narrative tools for transhumance landscapes [118]. The results of our research offer a remarkable quantity of reflections useful for discussing future perspectives.

In regard to the replicability of the methodology, we can state that it certainly applies to many regions. Although there are many ways of practicing transhumance in different regions of the world, our proposal makes specific reference to pastoralism in the classical transhumance version known in the Mediterranean basin—the so-called “normal transhumance” [119]—and in particular to the spaces historically involved in the institutionalized management of the practice, as the case in Italy and Spain was, where the complexity of the theme and the abundance of excellent archival and bibliographic sources have stimulated a rich historiographical production [120] that can be used nowadays to sustain edutainment activities properly.

In Italy, especially in the central and southern regions, transhumance routes can be seen as a strategic element of environmental requalification and geotourism enhancement for less visited areas, where cultural heritage can be interpreted both as an essential part of the natural and socioeconomic context and as an expression of community identity [121].

To make this possibility concrete, innovations in the governance is needed at various levels but mainly at the regional and local ones. While the management and control of the drove roads is a regional matter in the present regulation, tourism legislation is quite ambiguous in Italy about competences and management issues. In fact the regional legislative competence in tourism is counterbalanced and sometimes hindered by the powers of the State, which influence the choices of

the Regions. The latter are formally competent to regulate the tourism-administrative sector but in reality depend, both financially and for the general interest, on the State.

However, network governance is one of the most important factors in sustainable tourism implementation that cannot be considered separately from the environmental, socio-cultural and economic factors [122]. Regional tourism organizations, which represent a weak form of governance and whose effectiveness in implementing sustainable tourism is limited, need to strengthen public-private networking to make the most of the best practices carried out individually by different stakeholders, as in the case of the cultural associations promoting walking tours along the drove roads.

Another geotourism enhancement perspective for transhumance routes is that of natural protected areas crossed by them. There is a need to integrate the economic, social and environmental dimensions of human activity and good opportunities can be offered by protected areas as reference models for promoting integrated sustainable development in the wider surrounding territory [123]. Indeed, on the one hand protected areas can be seen as a model of sustainable development in which the cultural value can be better explored and exploited in the approach to natural resource management, as suggested by the Unesco MaB programme [124,125]; on the other hand, protected areas can have wider appeal by implementing transhumance landscape in their recreational programmes.

The geotourism approach is holistic and all-inclusive. As stated in the Arouca Declaration signed in 2011, “geotourism should be defined as tourism which sustains and enhances the identity of a territory, taking into consideration its geology, environment, culture, aesthetics, heritage and the well-being of its residents”. Territories are stimulated to develop geotourism focused not only on the environment and geological heritage but also on cultural, historical and scenic value; at the same time an effective involvement of local citizens and visitors is encouraged, so they are not restricted to the role of tourist spectators, thus helping to build a local identity and promote what is authentic and unique in the territory. In this way we can ensure that inhabitants obtain environmental integrity, social justice and sustainable economic development through innovative pathways.

Greater attention should be paid to the present role of transhumance landscape in building a common cultural identity at local-regional and interregional levels, to strengthen geoheritage consciousness without cultivating closed localistic mentalities and nostalgic revivals. In this case, the objective is a productive version of cultural identity [126] (p. 9), with proactive goals, also aimed at strengthening ecological consciousness [127]; in fact cultural identity formations are often problematic and risk to generate false myths or even a frightening collusion of culture and identity based on fundamentalism bias.

To investigate the meanings and the value creation related to transhumance landscape is very important, also because it helps to address it as a sensitive issue in the governance game [128]; it allows to explain the spatial reflections of social projections and power frameworks, that is to better understand the human dynamics involved in territories and to see the landscapes as the result of a cultural mediation (between insiders and outsiders but also between different subjects of the same community). The attribution of social value to the landscape is permanently under construction, as is the attempt to reconcile the natural and the man-made characters in landscape interpretation. The path advocated by Unesco and other international agencies is towards empowerment and embeddedness, so that visitors and local communities rediscover the value of the landscape, not so much in the sense of postcard scenery to be sold to tourists but as a responsible recovery for the construction and management of what must be primarily considered as common good [129,130].

It is with the aim of contributing to a non-stereotyped promotion of transhumance geoheritage that our research has been designed, thinking of communication and learning strategies based on a relevant contribution of geo-historical analyses. Our methodological proposal gains a concrete sense in the context of the recent candidacy of Transhumance as intangible cultural heritage of outstanding universal value in Unesco’s World Heritage List. The candidacy, proposed by a transnational network led by Italy together with Greece and Austria on 27 March 2018, affirms the role of transhumance as a cultural element with a strong identity content, which has been able to create strong social and cultural

links between practitioners and villages crossed by them, as well as representing a sustainable economic activity characterized by a peculiar relationship between man and nature. We think this heritage can be comprehended at best by qualifying some stretches of the ancient routes for geotourism, through adequate edutainment tools and methods aimed at perceiving the transhumance signs as a whole, that is an integrated cultural landscape, while at the same time supporting the maintenance of traditional activities.

In regard to geotourism management, planners and managers need to provide visitors with recreation opportunities, which maximize visitors' ability to attain recreation benefits with an experiential appeal (i.e., nature exploration, physical fitness) resulting in increasing visitors' emotional attachments and intentions to revisit [131]. The landscape of transhumance, as perceived and experienced today [132], has been assumed in our research as the result of the transformation of the territory, becoming a means in the definition of new imaginaries and new territorialization paths, including those driven by tourism, for a resignification of the drove roads' tangible and intangible heritage.

The documents used for the virtual reconstruction highlighted some specificities of the study area and some common characteristics of this traditional practice that help frame individual phenomena and manifestations in a unitary interpretation of natural and anthropic processes. This method can be useful for the local management of sustainable development policies [133,134]. In the policy options to support the conservation of transhumance landscapes, the importance of new alliances has long been recognized, for instance between livestock and agriculture [135]. However, the role tourism can have in geoconservation and in making the value of these landscapes recognizable is rarely emphasized. Our proposal tries to cover this gap. Eventually, the long-term objective is to link traditional production chains, cultural values and territorial identity with new development opportunities through landscape interpretation [136,137].

With regards to the language to use in geotourism education and communication to promote a new attractiveness of transhumance landscapes, we cannot forget that emotions play an important role in making memorable visitors' experiences; particularly a resignification process like the one needed to make transhumance landscape a geotourism product must pass through an emotional way leading to an effectively immersive interpretation of geoheritage [138].

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