Reevaluating Historical Road Connections through Historical Cartography

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The Italian province of Monza and Brianza faces challenges in preserving historical road connections. Rapid industrialisation and urban expansion have led to the neglect of the historical road system, minor widespread built heritage and landscape. Historic cartography was used to recover and reevaluate their qualities. Maps serve as valuable tools for synchronic and diachronic analysis, allowing the exploration of spatial transformations over time. They reveal the evolution of roads and their role in economic and religious development. Synchronic analysis, conducted through georeferencing and vectorising of historical maps within GIS, unveils the characteristics of roads in the past, while diachronic analysis demonstrates the current state and position of the remaining road network. The loss of contextual integrity due to landscape and urban changes led to the fragmentation of roads, their devaluation and disuse. While historical roads within centres maintained some original features and context, those outside the centre undergo substantial changes, being substituted by a modern street network, and interrupted by major infrastructure projects or buildings. Nonetheless, the historical road network is traceable in the peripheral areas, in the green 'buffer zone' where agricultural land persisted. The study underscores the significance of historical roads in territorial development and proposes the creation of green corridors for sustainable slow mobility. The approach reveals the condition of historical connections and their interrelation with cultural heritage and landscape. The preservation of natural and built settings remains crucial for enhancing the dual character of roads.

Historical Cartography
Road Connections
Cultural Heritage
Slow Mobility
GIS

Introduction

The majority of the Italian territory is characterised by the 'humanised landscape' (*paesaggio umanizzato*). The natural environment that may appear entirely self-formed is rather a result of past transformations and land uses (Bonfantini, 2012). The built urban environment is also a product of numerous historical changes. Therefore, the understanding and analysis of both natural and built environments can be complex due to various factors. This is particularly evident in territories occupied by smaller municipalities with minor historical centres, located in the proximity of major economic hubs. These areas experienced expansion and growth primarily due to industrialisation, rapidly reshaping the landscape and overall urban tissue. Consequently, the examination of historical road connections is impeded, especially as these elements are commonly disregarded when preserving cultural heritage.

Out of twelve provinces in the Lombardy region, the province of Monza and Brianza has the smallest total surface area (405,41 km^2) but the highest population density (2.150 per km^2). These figures accurately depict the current situation in Monza and Brianza, marked by high-density urbanisation resulting from the migration of industries to the outskirts of Milan, which subsequently led to population displacement. Excluding Monza, all the municipalities are medium-sized (from 15.000 to 40.000 inhabitants), and they hold strategic geographical positions. The territory has held cultural significance for centuries, but urban sprawl has led to the engulfment of historic centres by industrial activity and the constriction of new infrastructure networks. As towns expanded, historical centres remained small and dispersed across the territory. The historical road connections within the province are characterised by the strong presence and influence of farmsteads, diverse land uses, and residential villas constructed for hunting or pleasure. They are situated in an environment that necessitates a rethinking toward sustainable tourism and the development of cultural heritage connected through the road system.

Likewise, historical connections comprised of local and municipal roads that once linked historical centres across the landscape have gradually disappeared. The towns in the central-eastern part of Monza and Brianza are characterised by traces of *decumanus* and some *cardus* axes. This recalls the initial creation of the inhabited areas and agricultural organisation, roads, and canals using

Roman centurions. Although they are not remnants from the Roman period, they still adhere to the original setup. However, due to numerous changes, the historical structure has been disturbed over a long period, and today there are only a few scarce pieces of evidence of ancient division and communications (Dolci, 2005).

Lacking monumental built and natural heritage, iconic tourist destinations, or a defined local identity for the protection of common goods, cultural heritage in these historic centres has often been viewed as an obstacle to modernisation. Consequently, it has been abandoned, demolished or forgotten until today. The 'Cultural Districts' project (Distretti Cult urali) recognised the importance of fostering strong territorial development of the province by enhancing cultural heritage and environmental assets. It includes the province of Monza and Brianza in the programme, proposing the establishment of a stable and permanent network between culture and the local economy (Cariplo, 2006).

Historical centres have the potential to play a significant role in territorial rebalancing. Numerous initiatives are underway to improve the quality of urban and natural environments for their recovery and interconnection (Cerasoli, 2021). Given the complexity of spatial historical stratigraphy, different approaches and techniques are compelled for gathering past and present data. One of the most celebrated methods for recording spatial changes is through maps. Historical maps are valuable repositories of knowledge about spatial environments, transcending their role as mere artistic artefacts. They stand as physical archives of historical data that offer profound insights into the evolution of spatial features in context over time. These two-dimensional historical presentations become increasingly significant in studying territorial transformations of historic centres, landscapes, and infrastructures (Condoleo et al., 2018).

Significance of Historical Road Connections

Cultural routes are an important part of the complex and multidimensional settings, encompassing both intangible and tangible heritage. The recognition of the significance of cultural routes and their protection was first published the 1987 in Santiago de Compostela Declaration (Council of Europe, 1987). This declaration provided a framework for the revitalisation of cultural routes, considering them as a system or network of cultural heritage along

movement trajectory. Together, these routes shape the identity of a place, uniting natural and built heritage in the vicinity, and tacking various developments and uses over time (Council of Europe, 2015).

In the 2008 ICOMOS Charter, cultural routes were acknowledged as interactive, and dynamic, exhibiting for diversity of human links and needs. The concept of cultural routes considers cultural assets as part of one interconnected system, where these routes emphasise their significance by providing system movement (ICOMOS, 2008). Routes are described as historical phenomena of human mobility and/or exchange which are followed by the construction of other built and natural heritage. Managing and preserving these paths can promote sustainable development and slow mobility on a local level and accelerate regional integration (Suárez-Inclán Ducassi, 2005). Moreover, the European Landscape Convention, also known as the Florence Convention, was the first document entirely devoted to landscape planning, management, and preservation. It stipulates that public access to the landscape is necessary and emphasises the importance of the road network in facilitating it. The document outlines various objectives adopted for any given site, including the continuity of historical documents and the overall agreement on value systems, which encompass minor heritage relevant to the local population (Council of Europe, 2000).

Studies that examine cultural routes, rural paths, waterways, and historical urban road networks, often utilise historical cartography to recover forgotten qualities and historical itineraries. Routes are described as historical phenomena of human mobility and/or exchange, followed by the construction of other built and natural heritage. Managing and preserving these paths can promote sustainable development at the local level and accelerate regional integration (Suárez-Inclán Ducassi, 2005). Road connections can offer insights into the utilisation of past landscapes, the spatial relationship between settlements, and the economic situation at a given time (Lay, 2006). Despite roads and paths being less extensively studied as cultural heritage compared to buildings, they possess a valuable dual character for the whole environment. Being both natural and man-made, their significance and study are recognised as beneficial for territorial planning. The orientation, direction, and connectivity of roads might not be immediately apparent to observers in situ. However, through the use of historical maps, present data, and satellite imagery, one can grasp their importance and understand how they have influenced the development of cities and vice versa.

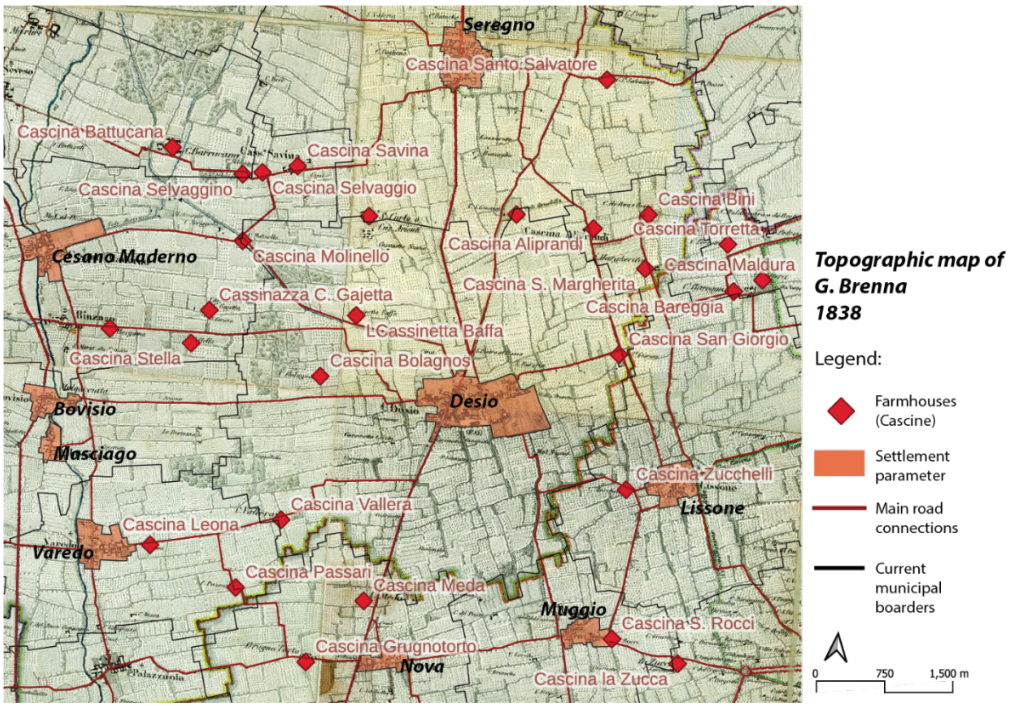


Fig 1. The topographic map presents eight municipalities in the central part of the province of Monza and Brianza and the correlation between historic urban centres, major farmsteads and primary roads in 1838. Source: Map Raccolta 'A. Bertarelli' Grafiche in Comune.

Investigation of topographic maps showed that the landscape on the periphery of towns is delineated by rural architecture. The interdependence between architecture and the road network is detectable on maps. Along major thoroughfares, in proximity to the primary roads, a majority of farmsteads (known as *cascine*) emerged. Simultaneously, local roads were purposefully constructed to facilitate access to these farms. This symbiotic relationship between infrastructure and agricultural production played a pivotal role in shaping the economic dynamics of the region (fig. 1).

Local and Municipal Roads: Past and Present Overview

Historical cadastral and topographic maps depicting the territory of Monza and Brianza reveal several types of roads with distinct jurisdictions, significance, and maintenance regulations. In the past, municipal roads (*strade comunali*) connected urban centres and served religious and economic purposes (Cereseto, 1894). Local rural roads (*strade vicinali*) linked peripheral areas between

	Strada Nazionale	Strada Comunale	Strada Consorziale	Contrada	Vicolo	Unclassified paths
Catasto Lombardo-Veneto (1865-73)	1	55	49	19	15	95
Nuovo Catasto Terreni (1897-1902)	Provinciale 1	61	30 Vicinale 12	Via 37	11	122

Tab. 1. The number of different types of roads within the Municipality of Desio (MB) processed from two historical cadastres, shows changes that occurred over time (length and position were not taken into consideration).

municipalities, usually through rural settings. Along these roads, farmsteads (*cascine*) are located. They played a crucial role in the production and management of neighbourhood land. Additionally, churches and small oratories were typically situated along important connection roads and at their intersections. Other elements, such as drinking fountains, city gates, walls, and services, may also be present along these routes. Due to the dispersal of agricultural activity and abandonment of farmsteads, minor roads such as *strade vicinali* slowly went into disuse, with some being reclaimed by nature, while others were disrupted by buildings, factories or major infrastructural projects (Longo et al., 2009).

With the introduction of the New Street Code in 1992 (updated in 2021), *strade vicinali* were reclassified under the category of local roads or *strade locali* (Ministero delle Infrastrutture e dei Trasporti, 1992). These roads are adjacent to *strade comunali* and *strade consorziali* (tab. 1). The former signifies a public municipal road developed within the municipal territory that owns and manages it, and the latter is a road constructed by private entities with the possibility of public participation, aiming to promote better economic growth and communication by providing supportive roads to enhance connectivity between areas leading to municipal roads. Historical classifications and names are traceable on historical cadastral maps, but streets rarely kept the historical name until today. Additionally, historical roads have immense significance for heritage sites situated alongside them. This connection is evident in the interrelationship between the historical names of roads and buildings in their proximity.

Methodology and collected materials

The methodology relies on historical maps to recover lost and forgotten heritage values in both built and natural environments,

	SCALE	TYPE	NAME	PERIOD	ACCESS	SOURCE
GEOREFERENCED	1:2000 (1:1000)	cadastal	Catasto Teresiano_Prirmo Rilievo	1720-23	digitised on payment	Archivio di Stato di Milano
			Catasto Teresiano_Attivazione	1721-22		
			Catasto Lombatdo Veneto_Nuovo Censo_Attivazione	1865-73		
			Catasto Lombatdo Veneto_Aggiomamento	1875-98		
			Nuovo Catasto Teneni_Mappe di Impianto	1897-1902		
	1:28.800	topographic	The second Military Survey of the Hapsburg Empire	1818-29	digitised on payment	Arcanum
	1:25.000	topographic	Topographic map of G.Brenna	1833-51	digitised, free access	Raccolta 'A. Bertarelli'
	1:25.000	topographic	Carta d'Italia_Monza and Barlassina	1888 1924 1937	digitised on payment	IGM, GeoData@Polimi
	1:25.000	topographic	Carta Topografica del Milanese e Mantovano	1788-96 (r.1927)	digitised, free access	Astronomi di Brera, IGM,Raccolta 'A. Bertarelli'
RASTER/WMS	1:10.000	orthographic	Ortofoto Volo GAI 1954 proprietà IGM 1:33.000 scale of single photograms	1954	WMS free access	Geoportale della Lombardia
	1:10.000	orthographic	Ortofoto AGEA 1:15.000 scale of single photograms (For 1975)	1975 1998		
	1:10.000	orthographic	Ortofoto AGEA	2021		
VECTOR	-	data map	Architetture storiche (SIRBeC)	l.u.*2021	vector free access	*l.u. - last update
			Rete storica principale e secondaria	l.u.*2019	vector free access	
	-	cadastre	Proprietà comunali e catasto	2021-22	Vector restricted	The Revenue Agency Agenzia delle Entrate

Tab. 2. The list of used historical topographic and cadastre maps, present data, and orthophotos, and their allocations.

examining their unique past and present contents. The developed approach involves analyses that delve into the connections between spatial elements. Historical maps alone are seldom sufficient as the exclusive source of information for establishing a timeline of the town's historical strata. Therefore, diachronic analysis depends on the comparison and integration of data from both the past and the present (Osaci-Costache & Armaş, 2016). Current data are also utilised for georeferencing maps and creating a project within Geographic Information Systems (GIS). The process of georeferencing uses a Coordinate Reference System (CRS), which adheres to the Italian standard recommended by the Geographical Military Institute (IGM), indicating the UTM projected coordinate system referred to as EPSG: 7791, RDN2008/UTM zone 32N (Istituto Geografico Militare, 2022).

Historical maps from the 18th to 20th centuries were collected for this study and categorised into two groups – one comprising historical cadastres on an urban scale, and the other involving the topographic maps. The referencing of historical maps was accomplished using Ground Control Points (GCPs) derived from the vector shapefile data of a present cadastre. In the subsequent phase of the survey dedicated to diachronic analysis, orthophotos were introduced (tab. 2). Following the placement of selected historical maps into an appropriate CRS, synchronic and diachronic

analyses were conducted. The former focuses on the analysis of individual maps, considering only the time of their creation, while the latter involves map regression and the examination of the territory's evolution over time and impact on the present day.

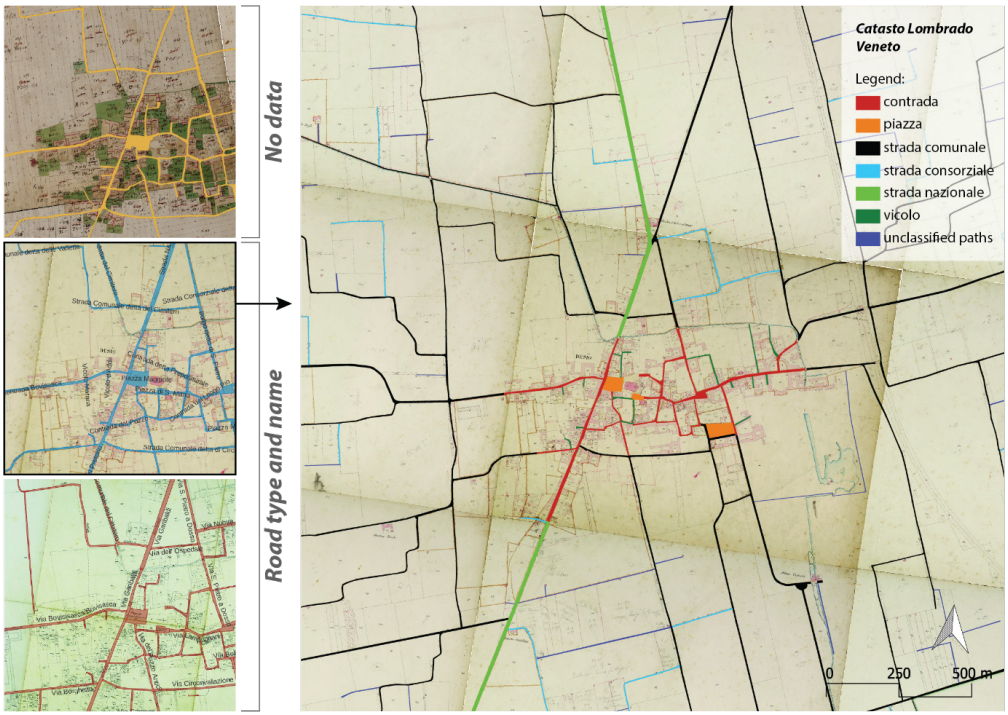
Most of the Lombardian territory possesses three main historical cadastres produced on an urban scale – *Catasto Teresiano* (1718-60), serving as the inaugural geodetic cadastral survey, subsequently leading to the creation of *Catasto Lombardo-Veneto* (1835-87) and *Nuovo Catasto Terreni* (1895-1902), all on the scale of 1:2.000. Topographic maps at a scale of 1:25.000 (or similar) were georeferenced and utilised to illustrate road connections between settlements. Synchronic analyses were applied to each map, facilitating a profound understanding of the positions of roads at specific periods, the relationships between toponyms, and built features. Diachronic analysis concentrated on the comparison of created map layers in GIS, providing a spatial-temporal digital environment for observing transformations over time.

GIS technologies and interdisciplinary methodologies for visualising landscapes and architectural heritage enable spatial-temporal analysis within a digital setting. This approach facilitates comprehensive examination and analysis of all components shaping a landscape, enabling us to discern its evolving forms over time and the intricate dynamics inherent in the territory (Salerno, 2023).

Synchronic Analysis: Map as a source of information

The roads were vectorised using polygon features on the urban scale and line features on the territorial scale. The Catasto Teresiano exhibits a rich iconographic representation of land use using colours and patterns to depict various qualities. However, it lacks information on road names and classifications, which can be found in the subsequent two cadastres. The typologies and names visible on the maps were stored in the attribute tables of vectorised roads, enabling the creation of thematic maps (fig. 2). The contrade or vie are situated in the urban centre, while strade comunali, strade consorziali, and strade vicinali traverse agricultural fields, connecting to other urban centres in the vicinity.

The creation of historical roads was also influenced by religious goals. For instance, Desio, as a former parish head town, served as a religious focal point for the adjacent territory. The



diocesan historical archives hold numerous documents and maps made for pastoral visits commencing since the 16th century (Buratti, 2002). These documents illustrate and describe road connections between parishes, including the networks of churches and the movement between them. Historical maps reveal a denser radial network of connections emanating from other municipalities towards Desio. The agrarian and religious systems shaped the territory in the past, but today these relationships are not evident, since both systems lost their initial power, importance and organisation.

The arrival of the railway in 1849 introduced stations in Desio and Seregno, intensifying the influx of residents to these two towns – a trend that persists to this day. The advent of the railway system resulted in a transformation of historical road connections, effectively bisecting agricultural fields. Subsequently, it attracted additional industrial and commercial activities, leading to a divergence from the initial usage and context of the roads. As manufacturing activities shifted, the landscape underwent alterations marked by a reduction in arable agricultural land and livestock, contributing to the abandonment of farmsteads. While remnants of historical roads

Fig. 2. An example of vectorised roads in the Municipality of Desio. The *Catasto Lombardo Veneto* and *Nuovo Catasto Terreni* provide information about the typology and name of the road. By incorporating this data into the attribute table, it is possible to create thematic maps. Source: *Cadastres ASMi.*

Figure 3. An example of the historical street *Strada Consorziale della Bareggia* on the eastern side of Desio. In situ survey and map regression of both historical and contemporary data are necessary to analyse road connections in the landscape context. The presented area of landscape degradation is surrounded by the zones of great interest. Source: *Cadastres ASMi; Google Maps.*

persist today, many have lost their original characteristics, perceived as fragmented traces of a bygone era.

The use of historical cadastral maps is closely intertwined with the examination of their second undividable part called land registers (*sommarioni*). They contain information about past land usage, which contextualises historical roads within the landscape and allows for the assessment of changes over time (Jovanović & Oreni, 2021). The land, roads, and buildings depicted on historical cadastres were vectorised, and a database was established to visualise information found in land registers. This facilitates classification, the creation of thematic maps, and comparison between different datasets. Furthermore, contemporary data provided by public administrative entities offers insights into the current state of the territory, including regulations and zones of various interests. Provincial-Territorial Coordination Plans (PTCP) serve as overarching planning instruments at the provincial level, outlining objectives

and fundamental elements of the provincial-territorial structure in alignment with socioeconomic development guidelines. They categorise municipal territories into areas for regeneration, protection, and development, while also providing indicators for further revitalisation of historical roads and landscapes.

Diachronic Analysis: Maps as an instrument

Upon georeferencing historical maps and vectorising their pertinent features in the GIS project, the map regression process ensues. The vectorised road networks from three cadastres are juxtaposed and scrutinised against orthophotos dating from 1954 (aerial frames on a scale of 1:33.000), 1975 (aerial frames on a scale of 1:15.000), 1998 and 2021 (equivalent scale of 1:10.000). The alterations in road connections, distribution, and utilisation transpired over time, influenced by significant infrastructure projects, industrial developments, and urbanisation. Presently, vestiges of historical connections are primarily manifested in the demarcation of property parcels, three rows, and the contemporary street network.

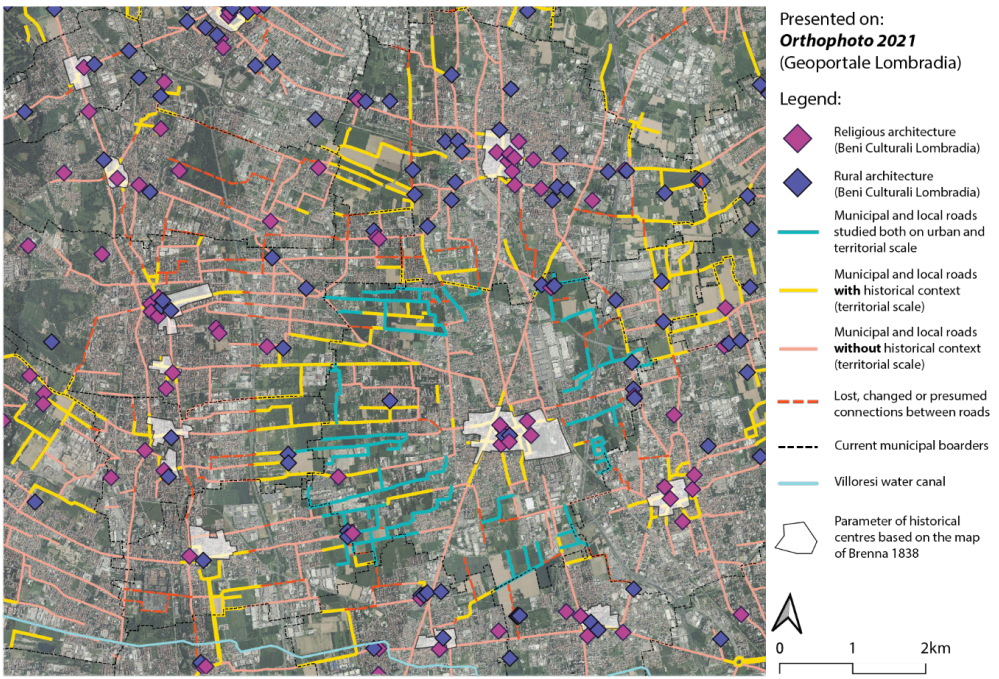
Conducting diachronic analysis has facilitated the acquisition of new insights into the current state of the historical infrastructure network. The vectorised roads from all three cadastres were overlaid on orthophotos from various periods to minimise the error regarding their position. The findings have been elucidated through vectorised features, incorporating metadata collected from both historical and contemporary document sources. A novel map has been created to illustrate the present condition of historical connections within the segment of the provincial territory. Additionally, their interrelation with the cultural heritage embedded in the landscape was assessed. The metadata encompasses details concerning the historical and present nomenclature of the roads, their historical typology, accessibility in present, and the quality of the surrounding landscape (both past and present). A distinctive layer has been generated to explicate the remnants of historical municipal and local roads, which have to some extent, retained their natural and built context (fig. 4).

The historical position of the road network is crucial, but it becomes inconsequential when nearly all contextual elements undergo severe transformations. Factors such as street structure, surroundings, and both natural and built characteristics play

Figure 4. The positions of historical roads, vectorised from three historical cadastres, were compared through orthophotos from 1954, 1975, and 2021. Their historical position and importance disappeared due to new infrastructure and urbanisation. The previously mentioned centuriation, completely missing today, is visible on the orthophoto from 1954.

pivotal roles in shaping the context. The historical connections lose their contextual integrity when these interdependent elements are altered. The loss of natural features and built settings diminishes the inherent qualities of the street.

The topographic map called *Carta d'Italia* (IGM, 1888) was primarily used to recover the position and landscape qualities of the historical road network, whose remains were later presented on the 2021 orthophoto. Within the confines of historical centres, most of the roads maintained their original positions, intricately weaving through built cultural heritage and open spaces, following the ancient town formation. Beyond the core, where industrial and residential developments proliferate, the vast number of historical roads retains their spatial positioning yet experience a complete transformation of their context. Modern and expanded infrastructure replaced older roads, and finally, housing and industrial developments fragmented them (fig. 5). Furthermore, the project of the Villoresi artificial irrigation canal that was finished in 1890 significantly changed the territory's initial



composition, horizontally cutting the province to the south and expanding for 86km.

The study reveals that within historical centres, certain roads have managed to preserve their original setting, dimensions, and inherent qualities to some extent. Another subset of roads that has maintained its position within a partially retained historical context comprises those located on the peripheries of municipalities, within the green buffer zones that have sustained agricultural activities and the majority of the area is also part of the PLIS (Local parks of supra-municipal interest) (Figure 6). Safeguarding these zones and rejuvenating neglected pathways, tree rows, and farmsteads constitutes a crucial aspect of the territorial urban planning agenda for sustainable development and mobility (Provincia Monza e Brianza, 2013). The overarching objective is to ensure the protection of these areas, contributing to the establishment of a green corridor that relies on historical connections. This corridor, rooted in historical linkages, aims to foster connectivity among municipalities and enhance the collective well-being of the region through slow mobility actions.

Fig 5. An example of the Municipalities of Seregno, Lissone, Bovisio Masciago, Desio. The results of the diachronic analysis reveal the remnants of the historical road network today, including their position, size, setting, and function, as well as their relationship with the remaining rural and religious built heritage.

Fig. 6. An example of the Municipalities of Seregno, Lissone, Varedo, Bovisio Masciago, and Desio, which illustrates the positions of historical roads referred to a context – those that kept their natural and built setting are located in the historical centres or the green buffer zone of the remaining historic landscape.

Conclusions

The use of the GIS approach for synchronic and diachronic analyses of historical road connections necessitated georeferencing of historical topographic and cadastral maps. The vectorisation process occurred in two distinct phases, addressing both urban and territorial scales. At the urban scale, the polygon feature was employed for local and municipal roads characterised by a high level of retained qualities. Conversely, for roads with less discernible historical values, the line feature was utilised to represent them on the territorial scale. The map regression analysis revealed the historical road network in the present context, illustrating a preserved buffer green zone between municipalities. This zone encompasses areas of enduring agricultural activity, landscape qualities, natural elements, farmsteads, villas, and remaining forests. The preservation and revitalisation of these areas hold significant value for residents, dispersed cultural heritage, and the overall well-being of flora and fauna.

In pursuit of this objective, the creation of green corridors, aimed at fostering slow mobility and rejuvenating historical roads, is acknowledged in provincial territorial management and planning documents as a collective asset. Additionally, they provide an alternative infrastructure for movement, supporting sustainable and responsible use of natural resources, particularly

through pedestrian and bicycle routes. In agricultural areas, the slow mobility network may encompass *strade vicinali*, often running alongside natural areas like forests, meadows, and tree rows. These pathways connect to municipal roads, serving to link discontinued areas, facilitating local movement and slow tourism (Maltese et al., 2017).

The planning of an ecological network can serve as a foundation for natural aspects in both rural and urban areas, connecting heritage-rich landscapes and minor historical centres (Rolando & Scandiffio, 2022). To comprehend the entire human environment, the application of UNESCO's Recommendation on Historic Urban Landscape (HUL) framework becomes necessary. This framework is oriented towards sustainable methods in planning and designing spaces considering various factors for successful development and implementation (UNESCO, 2011). These recommendations and initiatives represent necessary steps towards the recovery of historical roads, respecting their dual character.

Notes

[1] Data and WMS of orthophotos were obtained from the Geoportal of Lombardy (*Geoportale della Lombradia*) URL: https://www.geoportale.regione.lombardia.it (Accessed on 2/9/2023).

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