MAPPING SPATIAL QUALITY OF SLOW ROUTES WITH A GIS-BASED METHOD A COMPARATIVE ASSESSMENT OF ALTERNATIVE ROUTES

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KEY WORDS: slow routes, mapping, spatial quality, assessment, GIS

ABSTRACT:

In the field of cultural tourism, slow routes, especially pedestrian and cycle routes, are considered important resources for sustainable, social and economic development of the territories. The cultural routes, defined by the Council of Europe, have extended the notion of conservation and valorization of cultural heritage to a wider territorial perspective, that allow to join tangible and intangible heritage dimensions, natural and built heritage, in a whole. In this framework, cultural routes, mainly used to rediscover the territory through slow-travel experience, need to be documented and ranked as a system of cultural heritage spread over the territory, by innovative and effective tools. The SQISR method (Spatial Quality Index of Slow Routes), at territorial level, allows to analyze the spatial features of slow routes through GIS-based mapping techniques, but also to compare alternative routes on the base of a set of heterogeneous indicators. The SQIRS method has been applied to evaluate two alternative itineraries of the Monks Route, that cross the agricultural landscape in southern Milan, with aim to document their spatial features and rank them in relation to their spatial quality. The SQISR method, that is based on a quantitative approach, allows to visualize the outcomes by different ways: graded GPS tracks, graphs, diagrams.

1. BACKGROUND

In the last decades, cultural routes have been recognized as an alternative strategy to promote social, cultural and economic regeneration of marginal areas, in a sustainable way. The cultural routes, defined by the Council of Europe, have extended the notion of conservation and valorization of cultural heritage to a wider territorial perspective, as a new approach to cultural tourism and heritage (Majdoub, 2009). The Cultural Route recognizes and emphasizes the value of all of its elements, as substantive parts of a whole (ICOMOS, 2008) (Council of Europe, 2016). Since 1964, the Council of Europe has set up the idea of a network of cultural routes, as mean to create a new appeal for marginal areas that have high potential of cultural heritage and landscape resources (Meyer, 2004). However, in addition to the cultural routes defined by the Council of Europe, there are many other slow routes, used for cultural, touristic, historic and recreational purposes, which are promoted as mean to enhance the rediscovery of minor cultural heritage, historic values, naturalness of places, through slow-travel experiences, that also the European Landscape Convention recognizes as landscapes to be enhanced (e.g. every day and degraded landscapes) (Council of Europe, 2000).
Taking into consideration the slow routes that have a wide territorial dimension, the spatial quality analysis can be identified as tool for the documentation of this kind of heritage, that is spread over the territory, and embed heterogeneous components. In fact, slow routes embed punctual cultural heritage, landscape components (natural and built), intangible values (e.g. historic, spiritual) into a territorial dimension. The spatial quality analysis of slow routes is a very complex issue that involves many dimensions such as urban planning, landscape, cultural heritage, tourism, mobility, geomatics and health. In order to find out a method for measuring spatial quality, that is a key factor for successful experience of slow routes, many research fields have been explored in the scientific literature: evaluation methods for cultural routes and system of built heritage, walkability index methods, landscape indicators.
In the field of evaluation methods for diffuse cultural heritage, the estimation of economic benefits related to slow routes, can be made through the contingent valuation method (Maltese et al. 2017). In terms of spatial analysis, the combination between multi criteria and GIS-based analysis seems to be an effective method to support new strategies for the enhancement of complex system of cultural built heritage (Oppio et al., 2015), but also to analyze strengths and weaknesses of cultural routes, in relation to rural landscape planning (Balestrieri et al., 2015), and for spatial classification of rural land crossed by cultural routes (Diti et al., 2015).
In the research field of walkability index, many studies refer to urban space, and generally explore the relationships between urban environment and users (Cervero et al., 1997), (Cervero et al., 2003) (Frank et al., 2009). This research field is very extensive and include different approaches and methods for measuring walkability index at city level, neighborhood level or street level (e.g. walkscore), (Carr et al., 2010), also referring to walkability index for different distinct pedestrian groups (Moura et al., 2017).
The landscape indicators research field has been explored with aim to find out the most significant indicators for measuring spatial quality and aesthetic landscape values (Cassatella et al., 2011) (Gottero, 2016), but also to analyze those methods that explore the relationships between visual landscape preferences and map-based indicators (Dramstad, 2006), that, nowadays, are also related to social networks data sources (Tieskens, 2018).
In this framework, it seems that the analysis of slow routes is not yet approached from spatial quality point of view and it needs to be explored through a wide approach. Therefore, the current research moves from methods applied to urban scale (e.g. walkability index), and refers to territorial scale, particularly to slow routes that are predominantly located out of the cities.

2. RESEARCH GOAL

The current research aims at providing a multi-dimensions GIS based method, as tool for the analysis and the documentation of spatial features of slow routes, that can be also applied to the comparative assessment of alternative routes. The application of this method to the existing routes can be used to analyze route features, to support users in route choice, but also for design-strategies of new routes. The research aims at analyzing the most significant physical components of slow routes, by applying GIS-based mapping tools.

3. THE SQISR METHOD

3.1 Introduction

This chapter deals with a brief description of the SQISR method (Spatial quality Index of Slow Routes), as tool for analysis and documentation of the spatial features of slow routes. The method is based on a quantitative approach, that combines a set of macro-scale criteria, that allow to provide a 4-dimensions point of view on this topic. The method is centered on the principle that spatial quality of slow routes can be measured considering the spatial composition of the crossed landscape by the route. The great potential of GIS, in terms of spatial analysis and mapping (Goodchild, 2009), has been exploited for measuring the spatial quality of slow routes, by considering physical components of the landscape.

3.2 Criteria and indicators selection

A set of heterogeneous criteria have been considered in order to describe the landscape crossed by the route, on the base of the scientific literature and through the direct experience (route-survey). The selected macro criteria are: cultural heritage, landscape, infrastructural connectivity and route-specific features (Scandiffio, 2019). For each criterion has been chosen a set of indicators and a way for computing them with appropriate GIS tools. The cultural heritage criterion has been applied through the density of cultural heritage hotspots; the landscape component has been measured through four different indicators: land use diversity, waterways, vegetation and protected areas; the infrastructural connectivity has been measured through: road connectivity, railway and underground stations; the route-specific features have been evaluated through: comfort, user-friendliness and directness (Table 1).

MACRO CRITERIA	INDICATORS	MEASUREMENT	UNITS	SCORE
CULTURAL HERITAGE	Cultural heritage density	Number of cultural heritage	[-]	0-1
LANDSCAPE	Land use diversity	Number of land uses	[-]	0-1
	Waterways	Waterways length	[m]	0-1
	Vegetation	Row of trees length	[m]	0-1
	Protected areas	Parks area percentage	[-]	0-1
INFRASTRUCTURAL CONNECTIVITY	Road connectivity	Number of roads intersections	[-]	0-1
	Railway and metro connectivity	Number of railway and metro stations	[-]	0-1
ROUTE-SPECIFIC FEATURES	Comfort	Paved surface percentage	[-]	0-1
	User-frendliness	Steepness	[m]	0-1
	Directness	Most direct and current route ratio	[-]	0-1

Table 1. Table of selected macro criteria and indicators.

The maps were derived by GIS operations, that allow to measure values in the grid: count points in a polygon, sum line lengths in a polygon, buffering, intersection between lines, join attribute by position, spatial queries (Fig.1).

3.3 Calculation surface: definition of the buffer-grid and computing procedure

In order to evaluate properly the landscape components in the surroundings of the slow route, a buffer zone (500 m for both sides) has been defined. The buffer distance has been chosen with the aim to intercept the landscape components that can be easily reachable from the route, both physically and visibly. The buffer zone has been intersected with a north-south oriented square grid (cell size 500 m x 500 m), that has been used as spatial unit for measurements (Fig.1). The size of the cell has been chosen, according to the travel average speed of cyclists and walkers (15 km/h means 2 minutes for cycle 500 m; 4 km/h means about 8 minutes for walk 500 m), that stop some times to see points of interest along the route. The selected cell size can be considered an acceptable dimension to split out the whole route and recognize route-segments separately. Smaller cell size would be more precise, but the spatial characteristics of the landscape would be less recognizable.

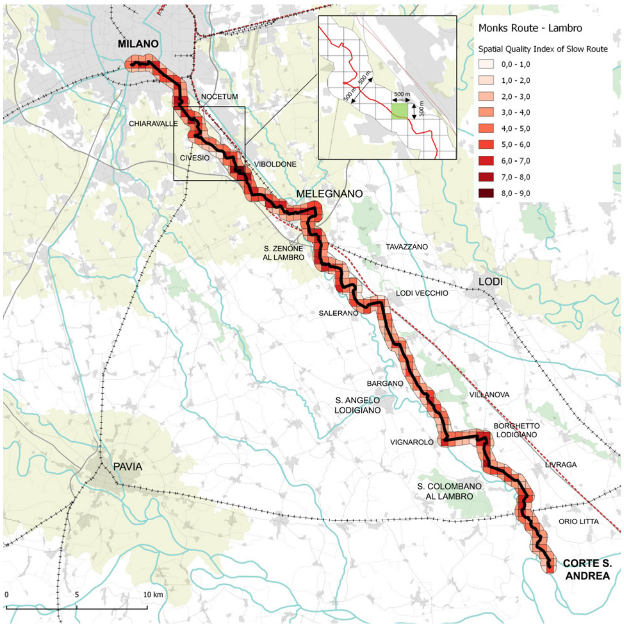

Figure 1. Map of graded grid defined as calculation surface of the route, with evidence of scores (0–10) for each cell. Detail with buffer (500 m) and cell size (500x500 m).

3.4 Scoring procedure: Spatial Quality Index of Slow Routes (SQISR)

The composition of the Spatial Quality Index of Slow Routes (SQISR) is the result of the scoring procedure, through operations on attribute tables in the GIS platform. On the base of the grid, the measured values, calculated for each indicator, have been graded in a scale of values, according to their specific features. To the base values is assigned the standard score of 0 and to the best value the standard score of 1. This means that all measured values are scored in a scale from 0 to 1. In this way all the components have the same weight. All the scores of the ten indicators have been summed to obtain the final score for each cell. The minimum score of the cells is 0 and the maximum is 10. The graded grid contains all the scores along the whole route and shows the variation of spatial quality along the route, as areal entity. The final step of this procedure consists into the intersection between the route (linear entity) and the grid (areal entity), that allow to transfer the scores from the grid to the line of the route, and visualize the final outcome as graded track. The SQISR, in the scale 0 – 10, has been calculated as average score of the cells crossed by the route and is visualized through different outputs: numerical index, graded track, diagrams.

3.4 The SQISR method as heritage documentation tool

The SQISR method can be also considered as a tool in the heritage documentation process, related to the spatial analysis of cultural route, that effectively represent a kind of heritage, that is based on a territorial dimension. In fact, the procedure of analysis and mapping of the slow route, through GIS techniques, allows to integrate, in the geodatabase, all the georeferenced data, recorded by the direct route-survey through GPS tool, with data derived from GIS-based operations. The GPS track is the essential element to link other geo data that are related to the route: photographs coordinates, points of interest (natural and built), service points for users. All the route features are managed in the GIS platform, both in a quantitative and in a visual way.

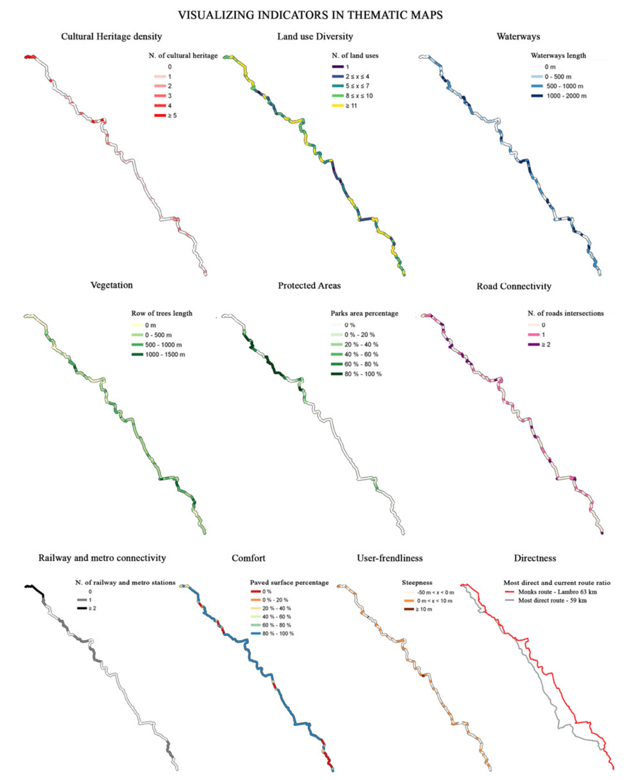

Figure 2. Visualizing indicators in thematic maps. The variation of spatial features along the route has been represented through color ramps. Case study: Monks route – Lambro.

The graded GPS track, that is one of the most significant output of SQISR method; it contains all the georeferenced data about indicators measurements (n. of cultural heritage along the routes, n. land uses, waterways length, row of trees length etc.), that effectively allows to document and query the spatial features of the route. A thematic map for each indicator has been drawn with the aim to visualize the results in the geographical configuration (Fig.2).

4. THE COMPARATIVE ASSESSMENT OF ALTERNATIVE ROUTES

4.1 Introduction

In general, the SQISR method can be used to analyze and compare existing alternative routes through a ranking, but also to support design-strategies of new routes. In the current research the SQISR method has been applied to evaluate two alternative itineraries of the Monks Route, between the city center of Milan and Corte Sant’Andrea on the river Po, by analyzing similarities and differences of the routes.

4.2 Case study description

The Monks Route, as part of Via Francigena Renana (Rotterdam – Corte Sant’Andrea – Roma), that crosses the agricultural landscape in the southern Milan, has been identified as case study for the application of this methodology. The selected itineraries pass through a very complex landscape, that intersect the south-east urbanized area of Milan, the rural area of Parco Agricolo Sud, characterized by farm houses, historical abbeys (Chiaravalle and Viboldone), small villages, that are strongly connected to the waterways network (Lambro river, Vettabbia canal, Muzza canal), that support the agricultural production; on this landscape is overlapped the infrastructural system of the regional and high-speed railway, and the motorway A1, that has been inserted in the direction of historical via Emilia (AA.VV, 1998). Two different alternative itineraries of the Monks Route have been analyzed to test the SQISR method and to make the comparative assessment between them. The itineraries are called: “Lambro” (63 km) and “Sillari” (64 km), because of waterways names (Fig.3). The first part of the selected routes (Milano – Melegnano) is almost coincident; in this part the differences are negligible and they are due to the spatial composition of the grid. From Melegnano to Corte Sant’Andrea, the routes are effectively alternatives.

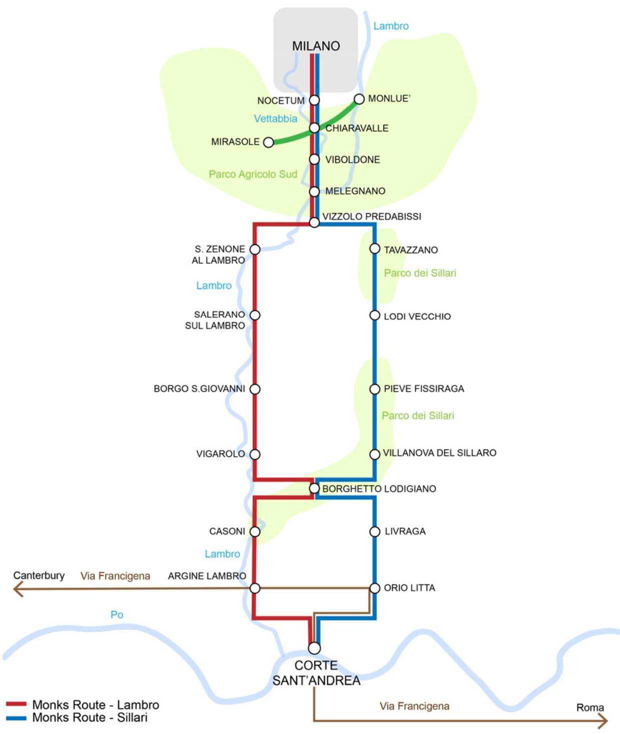

Figure 3. Territorial scheme of the alternative routes: Monks Route - “Lambro”, Monks Route - “Sillari”.

4.3 The slow routes assessment: main outcomes

The SQISR method allows to generate different outputs that can be used to compare the selected routes in different ways: the numerical index, the graded tracks, the indicators analysis (histogram), the spatial quality trend (graph).

The synthetic evaluation of the two routes, by computing the numerical index, is: "Lambro" route SQISR 5,1; "Sillari" route SQISR 5,4. The numerical index, as average score of the cells crossed by the routes, gives the global score about the spatial quality of the routes. This result can be visualized on the georeferenced graded tracks (Fig.4), that shows, on the map, the variation of the spatial quality, segment by segment, in relation to the geographical position of the places. The color ramp links the numerical scores to the GPS tracks (higher scores corresponds to darker colors, lower scorers to lighter colors), and makes evident the spatial quality differences on the map.

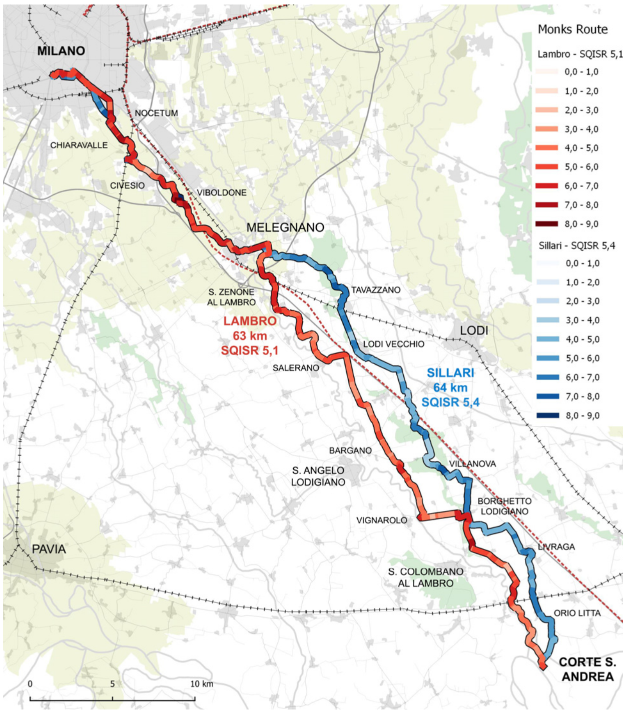

Figure 4. The map shows the comparison between the two routes on the base of graded GPS tracks.

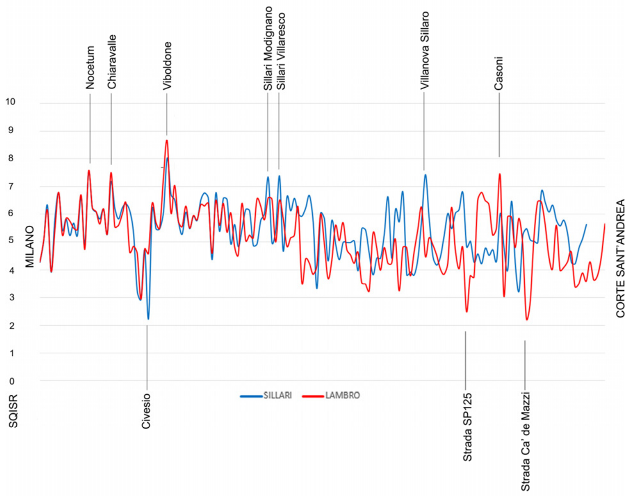

Figure 5. Graph with the comparison of the spatial quality trends of the selected routes. Best and the worst points along the routes have been highlighted.

The spatial quality index can be also visualized in the form of graph, that show the spatial quality trends of slow routes, cell by cell. In the graph it is possible to distinguish clearly the best and the worst points along the routes, but also compare the global trends of the routes (Fig.5).

The SQIRS method allows to make the detailed comparison between the selected routes, through the indicators analysis. In this way it is possible to distinguish the main similarities and differences between the two routes, indicator by indicator, through the histogram (Fig.6).

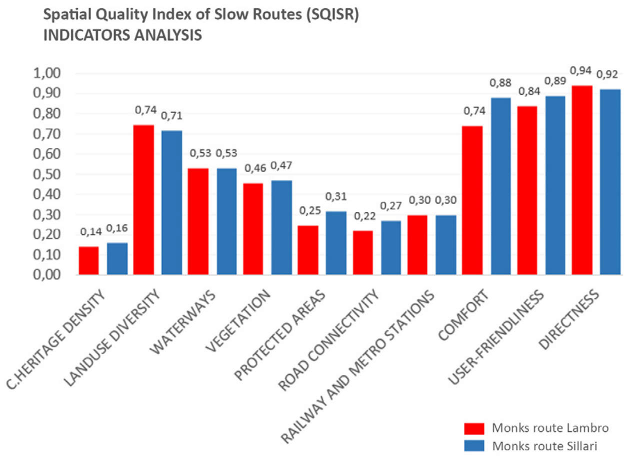

Figure 6. Histogram with the indicators analysis.

N. Cultural Heritage	0	1	2	3	4	≥ 5
Score	0	0,2	0,4	0,6	0,8	1

N. Land use	1	2 ≤ x ≤ 4	5 ≤ x ≤ 7	8 ≤ x ≤ 10	≥ 11
Score	0	0,3	0,6	0,9	1

Waterways length	0	0 ≤ x ≤ 500	500 ≤ x ≤ 1.000	≥ 1.000
Score	0	0,5	0,75	1

Row of trees length	0	0 ≤ x ≤ 500	500 ≤ x ≤ 1.000	≥ 1.000
Score	0	0,5	0,75	1

Parks areas percentage	0	0 < x ≤ 20	20 < x ≤ 40	40 < x ≤ 60	60 < x ≤ 80	80 < x ≤ 100
Score	0	0,2	0,4	0,6	0,8	1

N. Roads intersections	0	1	≥ 2
Score	0	0,5	1

N. Railway and metro stations	0	1	≥ 2
Score	0	0,75	1

Paved surface percentage	0	0 < x ≤ 20	20 < x ≤ 40	40 < x ≤ 60	60 < x ≤ 80	80 < x ≤ 100
Score	0	0,2	0,4	0,6	0,8	1

Steepness	+40< x ≤ +50	+30< x ≤+40	+20< x ≤+30	+10< x ≤ +20	+1< x ≤+10	-50 < x ≤ 0
Score	0	0,2	0,4	0,6	0,8	1

Most direct and current route ratio	x > Direct route	Equal distance
Score	0 < x < 1	1

Table 2. Indicators: intervals of measured values and scores.

4.4 The slow routes assessment: outcomes interpretation

In this section, a detailed interpretation of the outcomes is presented, with aim to show how each indicator has been taken into account in the SQISR method, in terms of measured values and assigned scores (Table 2). Datasets and georeferenced information, used for this research, are public accessible on Lombardy geoportal.

The cultural heritage indicator gives the average score of the cultural heritage points along the routes. This indicator has been measured through the density of cultural heritage points for each cell. In this research major and minor cultural heritage are considered at the same level, because the itinerary itself should be intended as a system of built heritage spread over territory. Along the routes many typologies of built heritage have been taken into account: abbeys, farmhouses, churches, chapels, bridges, walls, mills, archeological sites, but they have been considered with the same level of importance. In fact, each of them can be recognized as a component of the cultural route. Each cultural heritage artifact has been considered as point of interest along the route, as well as the presence of natural components (e.g. waterways, row of trees etc.), or infrastructural connections. In the Chiaravalle Abbey cell, crossed by "Lambro" and "Sillari" route, the most relevant spatial features connected to heritage and landscape dimensions are: 4 built heritage (abbey, church, mill, cemetery); 22 patches of land use; row of trees length 900 m; waterways length 1.600 m, 100% in the area of the Parco Agricolo Sud Milano (fig.7).

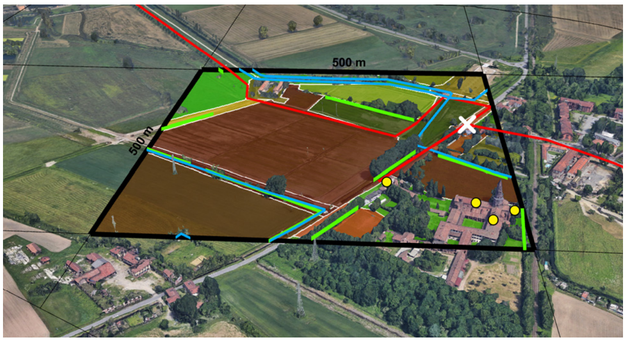

Figure 7. 3D interpretation of the Chiaravalle cell – score 7,5/10

Considering the whole routes, the "Sillari" route obtains the score 0,16, that means an average of almost 1 cultural heritage point per cell, that totally correspond to n.140 heritage points along the whole route. The "Lambro" route obtains the score 0,14, as cultural heritage density, that effectively correspond to a lower number of cultural heritage points along the route n.123. From the spatial distribution point of view, most of the cultural heritage points are concentrated in the urban settlements (Milano, Melegnano, Lodi Vecchio, Borghetto Lodigiano, Orio Litta), but some of them are spread over the countryside (Fig. 8).

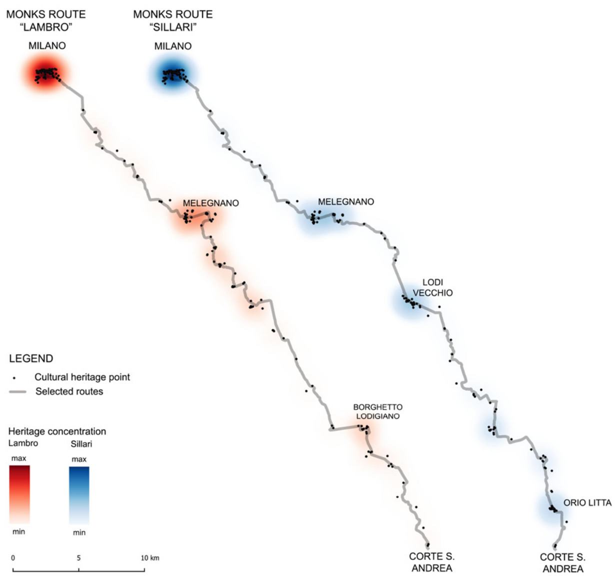

Figure 8. Spatial distribution of cultural heritage points along the itineraries (buffer 500 m).

The land use diversity indicator reveals the landscape simplicity/complexity (high number of different land use means high number of heterogeneous components). In the current case study, the "Sillari" route obtains the score 0,71, that means the average of 8,69 land uses per cell. The "Lambro" route obtains the score 0,74, that means the average of 9,15 land uses per cell. In synthesis this indicator shows that "Lambro" route crosses a more various landscape than "Sillari" route.

The waterway indicator shows the presence of water along the route, that is a key factor to enhance people's landscape experience (Natural England, 2009). The calculation is based on the sum of lengths related to natural and artificial waterways (rivers, navigli, canals) per cell. Both "Sillari" and "Lambro" routes obtain the same average score 0,53, that means substantially 500 m as average length of waterways per cell.

In this case study, the vegetation indicator has been calculated on the base of the row of trees, that are specific components of the agricultural landscape between Milano and the river Po. The calculation shows that "Sillari" route obtains the score 0,47 that means 350 m, as length average of the row of trees per cell. The "Lambro" route obtains the score 0,46 that means 335 m as average length of the row of trees per cell.

One of the most significant difference between the two itineraries is related to the protected areas indicator. This indicator shows the percentage of protected areas per cell, that is crossed by the route. The "Sillari" route obtains the score 0,31, while "Lambro" route obtains the score 0,25. This means that "Sillari" route passes through the protected areas for a longer length than "Lambro" route. In fact, in the territories in between Milano and Melegnano, the two itineraries cross the Parco Agricolo sud Milano, approximately for the same length, while the main difference is due to the intersection with the Protected area of Parco locale di Interesse Sovraccomunale dei Sillari. By analyzing the data, the "Sillari" route passes through the protected area of Parco dei Sillari for 11 km, while the "Lambro" route passes through the park area for 4,3 km. This aspect is very important in terms of spatial quality, because of more naturalness that is perceivable through the protected area.

From the road connectivity point of view, the "Sillari" route obtains the score 0,27, compared to "Lambro" route that reaches the score 0,22. This means that the "Sillari" route has a stronger connection with road network, than "Lambro" route, that can be also interpreted like a stronger connection with the surrounding territory (presences of urban settlements, services).

The railway and metro stations indicator gives a measurement of intermodal connectivity of the slow route. The presence of railways and metro stations in the surroundings makes the slow route well connected to farther places. In this case study the two itineraries obtain the same score 0,3.

The comfort indicator shows a significant difference between the two routes: "Sillari" route obtains 0,88 score, while "Lambro" route 0,74. In fact, on the "Sillari" route, the paved length is 57 km long; on the "Lambro" route, the paved length is 49 km long. This difference is very important in terms of comfort and wider route accessibility to all categories of users (not expert users: children, elders, disabled).

The user-friendliness indicator, based on the morphology, shows the difference in level between the routes. This indicator reveals the score 0,89 for "Sillari" route and the score 0,84 for "Lambro" route. This means that "Sillari" route has a flatter morphology than "Lambro" route, that is more difficult to be ridden. This is indicator has been processed through the DTM.

In the end, the directness indicator shows how much the slow route is direct to the final destination, compared to the shortest route (highways are not considered in the shortest route). Directness shows the slow route capability to reach the final

destination without wandering. In this case study the "Lambro" route seems to be more direct (0,94), than "Sillari" (0,92).
The indicators analysis shows a more detailed comparison of the route features, that support the values of the numerical index. In order to make a synthesis from indicators analysis point of view, it seems that the "Sillari" route has a higher spatial quality because it crosses more protected areas, it has stronger connectivity with roads network, and higher accessibility for users (higher user-friendliness and comfort).

5. CONCLUSIONS AND FUTURE DEVELOPMENT

The research shows the effectiveness of the GIS-based method as tool for spatial analysis of slow route alternatives at macro scale level; however other indicators, both at macro scale and at street level, can be added to improve the SQISR method. The GIS tools are able to manage the complexity of the cultural routes issue, as multi-dimensional heritage, but also to generate effective outputs both in visual and numerical form. The outputs (numerical index, graded GPS track, diagrams) allow to analyze the results from different points of view. The numerical index, the graded tracks, the diagrams are complementary outputs of the same issue. Each of them shows something different; visually: segment by segment on the georeferenced map (graded GPS track); numerically: on the whole route (index) and on the base of single/aggregate indicators (histogram and graph). Future development of the research could be addressed to improve the method. Questionnaires for expert users would allow to receive a feedback about user preferences for indicators, and consequently data could be used to optimize the indicators weights in the scoring procedure. Slow routes, with other spatial configuration (mountain, hill, waterfront etc.), can be taken into consideration in order to test the effectiveness of the method in different spatial environments.

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