From railways to greenways: a complex index for supporting policy making and planning. A case study in Piedmont (Italy)

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Abstract

All over the world, a significant percentage of the railway network has been closed from the 1960s onwards. This represents a heritage that can be used to provide new features to local communities, to support sustainable development and landscape regeneration processes. Disused railways can be converted into greenways dedicated to not motorized users and people with reduced mobility. Greenways can be related both to leisure and tourism and to commuting. The growing interest and social demand for greenways can find obstacles in the scarcity of public funds. Decision-makers and land-use planners need to assess potential benefits and costs for local communities and the attractiveness for users. In this paper, we aim at providing a transferable working tool able to support decision-making and land-use planning processes related to the conversion of disused railway lines into greenways in mixed urban-rural contexts. We tested the developed methodology in Piedmont (Italy) a region with almost 600 km of abandoned railway lines and over 200 disused stations.

We used Geographical Information System (GIS) to carry out spatial data analysis and analytic hierarchy process (AHP) for integrating the preferences of stakeholders.

We defined the Greenway Suitability Index (GSI), a synthetic global index able to take into account and synthetize the characteristics and current conditions of the disused railways network and the territorial and social context (natural element, historical-cultural resources, traditional food and local wine, landscape/scenery, accessibility and population). Decision-makers can use GSI to prioritize and concentrate the investments on the sections with the highest score.

We defined four scenarios (based on the desired prevalent use of the future greenways, i.e. touristic vs recreational/daily travel) and calculated GSI for each of them, in order to verify how the priorities can change in relation to the objectives.

The successful application demonstrated that the methodology can be used to calculate a sort of "priority score" considering stakeholder's preferences and allowing the land-use decision makers to concentrate the investments in a priority way.

Keywords: disused railways, greenways, rail-trails, land-use planning, Multicriteria Analysis

1. Introduction

Starting from the second half of the 19th century, railways played worldwide a central role in transportation triggering regional development through relevant land-use changes. Before the "explosion" of road transport -in some cases predominant since just 1950- railways were key to the development of transport networks. After this period, the importance of the railway declined with a significant percentage of the railway network closing from the 1960s onwards (Martí-Henneberg, 2017). Moreover, in the last decades new railway branches have been built to fast the existing lines and old tracks have been abandoned.

All over the world, the railway heritage represents a potential value reusable to provide the new features that local communities need, to support sustainable development and landscape regeneration processes (Llano-Castresana, Azkarate & Sànchez-Beitia, 2013). Greenways based on old rail infrastructures, often called rail-trails (Moore, Gitelson & Graefe, 1994; Beeton, 2003), are already well known. Disused railways can be converted into greenways dedicated to pedestrians, cyclists, skaters, horse riders and people with reduced mobility (Eizaguirre-Iribar, Etxepare Igiñiz, & Hernández-Minguillón, 2016; Guerrieri & Ticali, 2012; Mundet & Coenders, 2010; Reis & Jellum, 2012; Rovelli et al., 2004).

Greenways are non-motorized transport infrastructures, mainly related to leisure and tourism. According to the Lille Declaration, greenways are “communication routes reserved exclusively for non-motorized journeys, developed in an integrated manner which enhances both the environment and quality of life of the surrounding area. These routes should meet satisfactory standards of width, gradient, and surface condition to ensure that they are both user-friendly and low-risk for users of all abilities. In this respect, canal towpaths and disused railway lines are a highly suitable resource for the development of greenways” (EGWA, 2000).

The rise in urbanization, changes to work and leisure patterns and the protection of lands for conservation, particularly in more developed countries, have resulted in an increasing popularity of greenways used for recreation purposes (Eizaguirre-Iribar, Etxepare Igiñiz, & Hernández-Minguillón, 2015). In addition to leisure or tourism use, many greenways may have a utilitarian purpose and serve as transport thoroughfares for those travelling to attend daily activities such as work, shopping or school. Also, greenways can be integrated in the design of ecological networks and green infrastructures for counteracting landscape fragmentation (De Montis et al., 2017 and 2018). For all these uses, greenways are “settings for activities and experiences” (Taylor, 2015) rather than simply a route to get from one location to another.

The growing interest and social demand for greenways often collides with the scarcity of public funds, as it can lead to controversial choices. In these circumstances, each project should be evaluated through an assessment considering potential benefits and costs for local communities and the attractiveness for users (Senes et al, 2017, Ferretti & Degioanni, 2017, Taylor, 2015, Reis & Jellum, 2012). Often, the solution to these complex projects can be orchestrated by following the indication of regional and provincial land-use planning tools.

The objective of the study is to provide a transferable working tool able to support decision-making and land-use planning processes related to the conversion of disused railway lines into greenways in mixed urban-rural contexts. The proposed methodology is designed and applied to the system of abandoned railway lines of the region of Piedmont, Italy. This test is aimed at providing decision makers with an effective support tool in the perspective of the design of a greenway-based landscape plan for the re-use of the ancient rail sections. Piedmont shows an important system of abandoned railway lines (595 km) and disused service buildings (over 200 stations), most of them are in good conditions because more than a half have been closed between 2010 and 2013.

This paper unfolds as follows. In the next section, we review the scientific literature on rail-trail planning and design. In Section 3, we describe the method used to prioritize the abandoned railways in order to help land-use planners to define a regional rail-trail plan, and illustrate the case study. In Sections 4, we show and discuss the findings. In Section 5, we summarize the concluding remarks.

2. State of the art

This section includes two subsections. In the first one, we report on the state of the art of rail-trail planning and design studies. In the second subsection, we develop on studies concerning the use of Geographical Information System (GIS), Multi Criteria Decision Making (MCDM) with Analytic Hierarchical Process (AHP) for land-use planning.

2.1 Rail-trail planning and design criteria

Greenways based on former railway lines have unique characteristics compared to other infrastructures for pedestrians and cyclists (Betz, Bergstrom & Bowker, 2003; Reis and Jellum, 2012). Rail-trails have been defined by Reis and Jellum (2012) as “multi-use trails used for transportation and recreation, either sited on former railway lines or that run continuously beside an active railway for most of its length”.

Rail-trails can have multiple purposes. In many cases, they have a utilitarian aim and are used by local population as transportation corridors for daily activities, such as work, school or shopping, for moving among urban areas, rural areas and parks or for making physical and fitness activities (Abildso et al., 2012; Bichis-Lupas and Moisey, 2001; Merom et al., 2003; Mundet & Coenders, 2010; Senes et al., 2017). In other cases, especially longer trails, they have become an important recreational resource not only for locals but also for national and international tourists (Reis & Jellum, 2012, Willard &

Beeton, 2012). These rail-trails have unique characteristics, related to length, position, landscape, cultural heritage and railway past, which attract a considerable number of non-local users (Reis and Jellum, 2012). In both cases, rail-trails connect members of local communities offering a shared recreational space, bringing communities together and strengthening their ties and offering tourists the chance to meet the local culture (Baker, 2001).

Disused railway lines, due to their physical characteristics, are privileged infrastructure for the realization of greenways (EGWA, 2000). The abandoned railways are almost completely separated from the ordinary road network with a reduced number of intersections, have gentle longitudinal gradients, with no sharp rises, wide curves and relatively wide and long corridors. Thus, they are ideal for building pleasant, safe and accessible trails, even for the most vulnerable users, such as children, the elderly and the people with reduced mobility (Beeton, 2003; Guerreri & Ticali, 2012; Moore et al., 1994; Mundet & Coenders, 2010; Reis & Jellum, 2012; Rovelli et al., 2004). Moreover, their conversion into greenways makes it possible to preserve old railway items, such as bridges, viaducts, tunnels, signals, distance markers, stations and auxiliary buildings. They are architectural and civil engineering elements of great value that can provide cultural experience for visitors and help to preserve the historical memory of the railway between the younger generation (Llano-Castresana et al., 2013; McKercher, 2001; Mundet & Coenders, 2010; Perrin, 1993; Reis & Jellum, 2012; Taylor, 2015). The stations and the auxiliary buildings can be converted into bars, restaurants, museums, farmhouses for the users of the rail trails, according to their original purpose, i.e. the provision of a break during the journey (Perrin, 1993). In some cases, the disused railway lines cross areas of great naturalistic beauty that cannot be reached by other means of transport, offering unique scenarios to the users of the greenways built on the old tracks. With the conversion into greenways, it is possible to preserve the integrity of the unused railway routes for future restoration of the rail service, preventing them from being deleted by the expansion of urban centers, the creation of new roads, the illegal occupation by privates or the spread of nature (Reis & Jellum, 2012; Rovelli et al., 2004). As Llano-Castresana et al. (2013) assert, “these items can become an icon of a new way of reusing spaces with a value added, giving life back to the heritage, turning it into a useful and socially functional space.” The conversion of disused railway lines into greenways is relatively easy and costs are low compared to the implementation of a similar infrastructure from scratch (Betz et al., 2003). As Neilson asserts (in Turco et al., 1998), “the trail has been blazed, the land cleared, the creeks bridged, hills cut through, swamps filled, and embankments built. An abandoned railroad right of way possesses other unique features. It is level, open, clear, well drained, and self-contained or screened”. This is another important advantage of the reuse of the disused railways for the development of greenways compared to the construction of new routes.

Although there has been an evident increase in the number and popularity of rail trails around the world, research on this topic is still limited. Literature on rail-trails is mainly focused on users characteristics and experiences (Spencer, 2010; Willard & Beeton, 2012), the economic impact (Beeton, 2009; Bowker et al., 2007; Busbee, 2001; Cope et al., 1998; Cox et al., 2011; Palau et al., 2012; Ryan et al., 2014; Tomes & Knoch, 2009; Taylor, 2015; Zhang et al 2018; Noh, 2019), the ecological value (Carlier & Moran, 2019) the health and physical benefits (Abildso et al., 2012; Merom et al., 2003; VanBlarcom &

Janmaat, 2013), the potential of rail-rails as tourism attraction (Willard & Beeton, 2012; Reis & Jellum, 2012; Beeton, 2009; Mundet & Coenders, 2010; Ryan et al., 2014; Reis et al., 2014), and the impact of greenways on local development (Taylor, 2019). Only a few studies have investigated the development of tools to support decision makers in choosing the best form of requalification of a disused railway (Ferretti & Degioanni, 2017; Senes et al., 2017) and identifying the most suitable disused railway lines in the perspective of a conversion into greenways (Eizaguirre-Iribar et al., 2016; Quattrone et al., 2018).

In the present study the authors develop a support tool for the assessment of the suitability of disused railways to the conversion into greenways.

2.2 Instruments and techniques for spatial data analysis and assessment

According to Collins et al. (2001), a range of methods and procedures for spatial analysis, making use of advanced technologies, are used in land-use planning, with the aim at identifying the most appropriate areas for new land uses, according to specific preferences and requirements (Collins et al., 2001, Malczewski, 2004). GIS is one of the most effective spatial analysis applications in land-use planning (Malczewski, 2004). GIS-based land suitability analysis has been implemented in a variety of situations, including suitability of land for agricultural activities (Akpoti e al., 2019), locating of forest uses (Ferrario et al., 2014), and landscape and greenway assessment and planning (Miller et al., 1998; Tian et al, 2011; Fumagalli et al., 2013). GIS-based land suitability methodologies have become key elements of urban, regional and environmental planning activities (Pedro, 2019; Senes et al., 2016; Fumagalli and Toccolini, 2012).

Several planning issues, such as site selection, can be considered as Multi Criteria Decision Making (MCDM) problems, since they imply the assessment of a set of alternatives with respect to conflicting criteria (Malczewski, 2004; Turk, 2018). MCDM allows an explicit involvement of the stakeholders in the trade-off analysis (Burkhard et al., 2012; de Groot et al., 2010) and is a very useful tool to reduce conflicts in an optimizing framework (Ananda and Herath, 2009). Since greenway planning requires a multi-objective approach and methods that consider multiple physical, economic, environmental and social points of view, the optimization problem underlying most real greenway planning decisions needs to be formulated within the MCDM paradigm (Ciomek et al, 2018).

Analytic Hierarchical Process (AHP) was introduced for the first time by Saaty (1980) and has become one of the most widely used MCDM tools by researchers and decision makers in different fields (Dos Santos, 2019). AHP is a flexible and quantitative method for selecting alternatives based on their relative performance with respect to different criteria (Boroushaki and Malczewski, 2008). Alternatives are structured into a hierarchical tree-like framework, where they are compared pairwise, according to the Saaty nine-point individual judgment scale (Saaty, 1980; Koschke et al., 2012), where "1" indicates that the two criteria compared are equally important, and "9" indicates that one criterion is absolutely more important than the other.

AHP can be easily incorporated into GIS procedures (Seyedmohammadi et al, 2019), in order to derive the weights associated with the attributes of map layers, using both raster and vector databases (Mosadeghi et al., 2015; Ferrario et al., 2014). A GIS-based multi-criteria decision-making approach is relatively easy and flexible (Ananda and Herath, 2008) and can use a great number of criteria and indicators, allowing planners to consider the spatial aspects (Phua and Minowa, 2005). AHP allows trade-offs (Hill et al., 2005) and a fair balance of determinism and flexibility. These are important advantages, when addressing complex problems regarding not trivial human and environmental systems.

3. Methods and application

3.1 Methodology

In order to define a methodology to identify the priority abandoned railway lines to be converted into greenways, we used GIS to carry out spatial data analysis and analytic hierarchy process (AHP) for integrating the preferences of stakeholders in the assessment process (Baskent and Jordan, 1996; Bernetti et al., 1992; Rauscher et al., 2000; Vezeanu et al., 2010). We chose to use AHP in this study because it is: i) based on a structured and quantitative framework, ii) applicable to decision-making situations involving multi-criteria and subjective judgments, iii) easily incorporated into GIS, and iv) adopted in many applications as reported in many essays (Abastante et al., 2018; Ristic et al., 2018; De Castro-Pardo et al., 2019; Balta and Yenil, 2019).

Converting a disused railway line into greenway depends mostly on two issues: i) the characteristics and the state of conservation of the railway line and ii) its territorial and social context (Llano-Castresana et al., 2013; Rovelli et al., 2004). Thus, the design and implementation of an inventory concerning the abandoned railway heritage is preliminary to further actions aimed at protection and valorization. In this respect, knowledge on each stretch of the network should be constructed with reference to relevant factors, such as: state of conservation, current use, and the ownership (Llano-Castresana et al., 2013; Rovelli et al., 2004). As much important is the analysis of the territorial and social context, where the disused railway lines are located. The demand of routes for non-motorized mobility will be higher in more densely populated areas, where higher is the number of potential users, the concentration of aggregation centers (i.e. sports and recreational centers, schools, commercial zones, etc.) and traffic congestion (Rovelli et al., 2004). Usually, such demand has utilitarian or recreational purposes (Toccolini et al., 2006). In less populated areas, the use of greenways will be influenced by the presence of natural, scenic, historical, architectural and tourist-recreational resources. These landmarks attract users, as they represent ideal destinations for people interested in typical greenway activities mostly connected to recreation and tourism (Bichis-Lupas & Moisey, 2001; Toccolini et al., 2006; Reis & Jellum, 2012; Llano-Castresana et al., 2013; Rovelli et al., 2004; Taylor, 2015). In any case, the effective use of greenways will be conditioned by their accessibility, a complex concept that can be assessed by considering the number and spatial pattern of entrances and reachability by public and private transport (Pollock et al., 2007; Reis & Jellum, 2012; Taylor, 2015).

Based on these considerations, in this study we defined a methodology able to support decision makers involved in abandoned-railways-to-greenways project assessment and selection. This methodology includes 3 phases, as sketched in Table 1.

Table 1 – Method adopted: main phases

Phase	Denomination	Scope
1	Data collection	Selection of candidate railway sections
2	Context analysis	Calculation of accessibility and attractiveness
3	Scenario analysis	Calculation of the Greenway Sustainability Index

3.2 Study area

This study focuses on Piedmont, an Italian region located in the north-western part of the country and bordering with France and Switzerland (Figure 1). It has a surface of 25,387 km^2 and a population of 4,375,865 inhabitants (ISTAT, 2018).

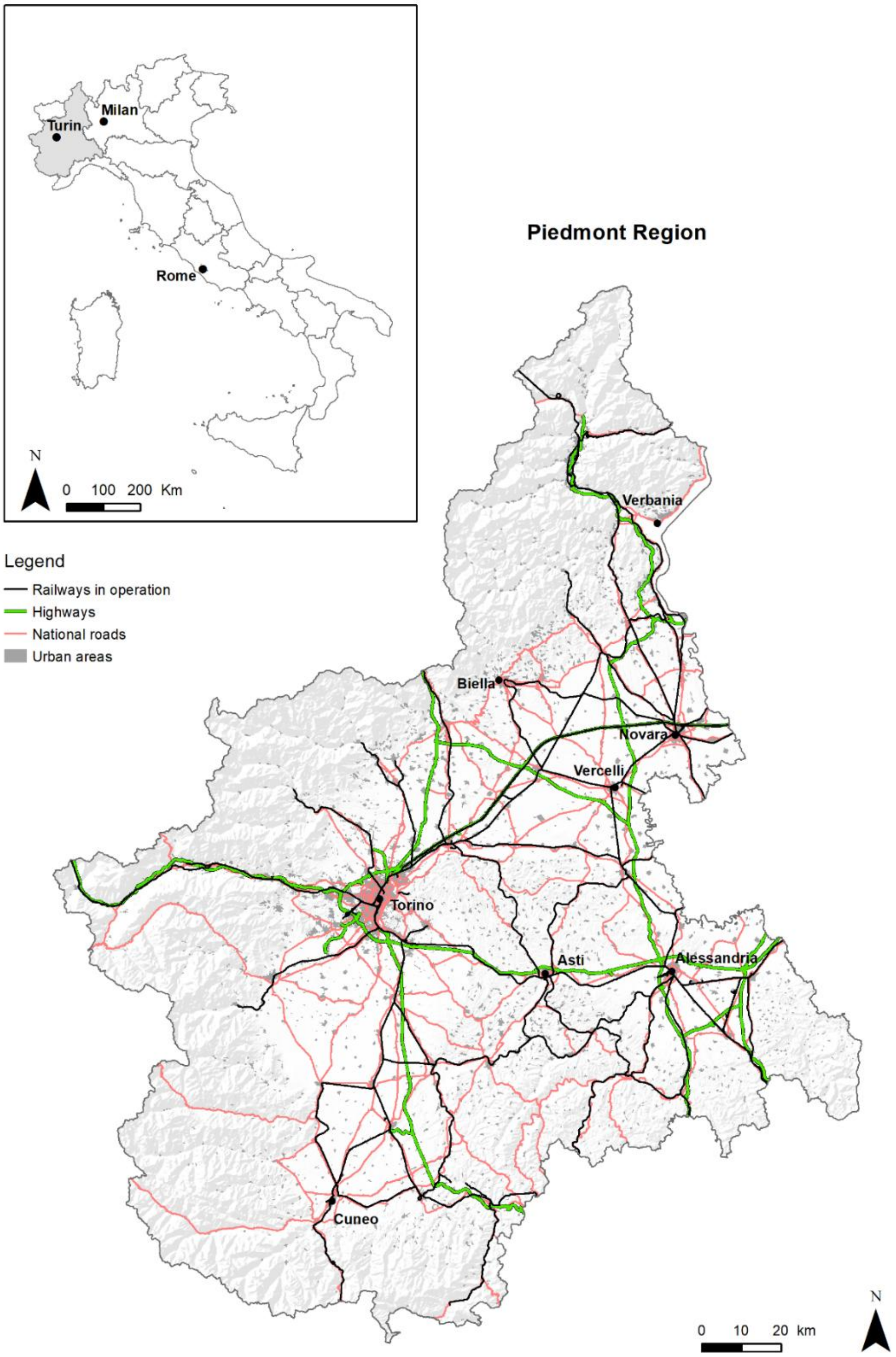

Figure 1 – The Study area

In this region, railway development began in the 1840s and continued very rapidly, leading to the creation of a dense network of lines, which at the beginning of the 20th century covered the entire surface of Piedmont. The closure of the railway lines occurred mainly in two periods: in the two decades between 1950 and 1970, due to the massive diffusion of the automobile, and during this last decade, because of the public spending review policies. Nowadays, in Piedmont abandoned railway lines extension sums up to 595 km (Table 2).

Table 2 – Disused railway lines and stretches of the Piedmont Region.

Year of closing	**Railway line/stretches**	**Length (km)**
1871	Susa - Bar Cenisio - St. Michel de Maurienne (F)	*17,9
1916	Serravalle Scrivia – Rigoroso	3,4
1924	Gozzano - Alzo	7,4
1934	Grignasco - Coggiola Portula	14,5
1948	Frugarolo (FVO) - Basaluzzo	8,9
1958	Biella (FEB) - Ponte Cervo - Balma	12,2
1958	Biella (FEB) - Ponte Cervo - Castellazzo - Valle Mosso	20,5
1958	Castellazzo - Masserano	5,5
1958	Candelo – Biella (vecchia)	5,0
1959	Cavallermaggiore - Moretta	15,3
1959	Verbania Intra - Premeno	13,3
1960	Cuneo Gesso - Borgo S. Dalmazzo	12,1
1963	Stresa Ferrovia - Mottarone	9,9
1966	Bricherasio - Barge	11,5
1966	Busca - Dronero	12,5

1985	Rivarolo - Castellamonte	7,2
1986	Airasca - Moretta - Saluzzo	33,4
1986	Bastia Mondovì - Mondovì	11,8
1994	Bra - Bastia Mondovì - Ceva	50,0
2005	Galliate - Novara Nord (vecchia)	2,8
2010	Mortara - Casale Monferrato - Asti	*55,5
2011	Bolzano Novarese - Gozzano (vecchia) - Borgomanero	3,1
2011	Chivasso - Asti	51,3
2012	Asti - Castagnole delle Lanze	20,1
2012	Mondovì - Cuneo	30,2
2012	Cantalupo - Nizza Monferrato - Castagnole delle Lanze - Alba	59,6
2012	Pinerolo - Bricherasio - Torre Pellice	16,4
2012	Santhià - Rovasenda Alta - Romagnano Sesia - Borgomanero - Arona	65,0
2013	Vercelli - Casale Popolo	19,2
**Length of the stretch in the Piedmont Region*	**Total**	**595,5**

All the data reported in the paragraph concerning the state of the railways come from a specific analysis made by authors (see also par. 3.3).

This figure is remarkable, as it corresponds to 22% of the maximum extension of the railway network ever.

The system of abandoned stretches includes: i) 25 disused railway lines (581 km), ii) 4 stretches of active railways lines that were abandoned due to path variations. Along these abandoned railway lines, there are 214 stations, of which only 30 still operate belonging to active railways.

As Table 3 demonstrates, the 76% of the abandoned railways is still present and re-usable, and the 3.2% has been already converted in greenways (Figure 2).

Table 3 – Summary of the disused railway lines situation in Piedmont.

Typology	**Classes**	**Percentage**
Sections still present and re-usable as greenways	Armed railway corridors	61.7
	Railway corridors no longer armed but present and viable	6.6
	Railway corridors no longer armed but not viable because invaded by vegetation	7.7
Sections not more existent	Railway corridors no longer present, disappeared because transformed into an ordinary street or canceled by urbanization or agriculture	20.8
Sections already converted in greenways		3.2

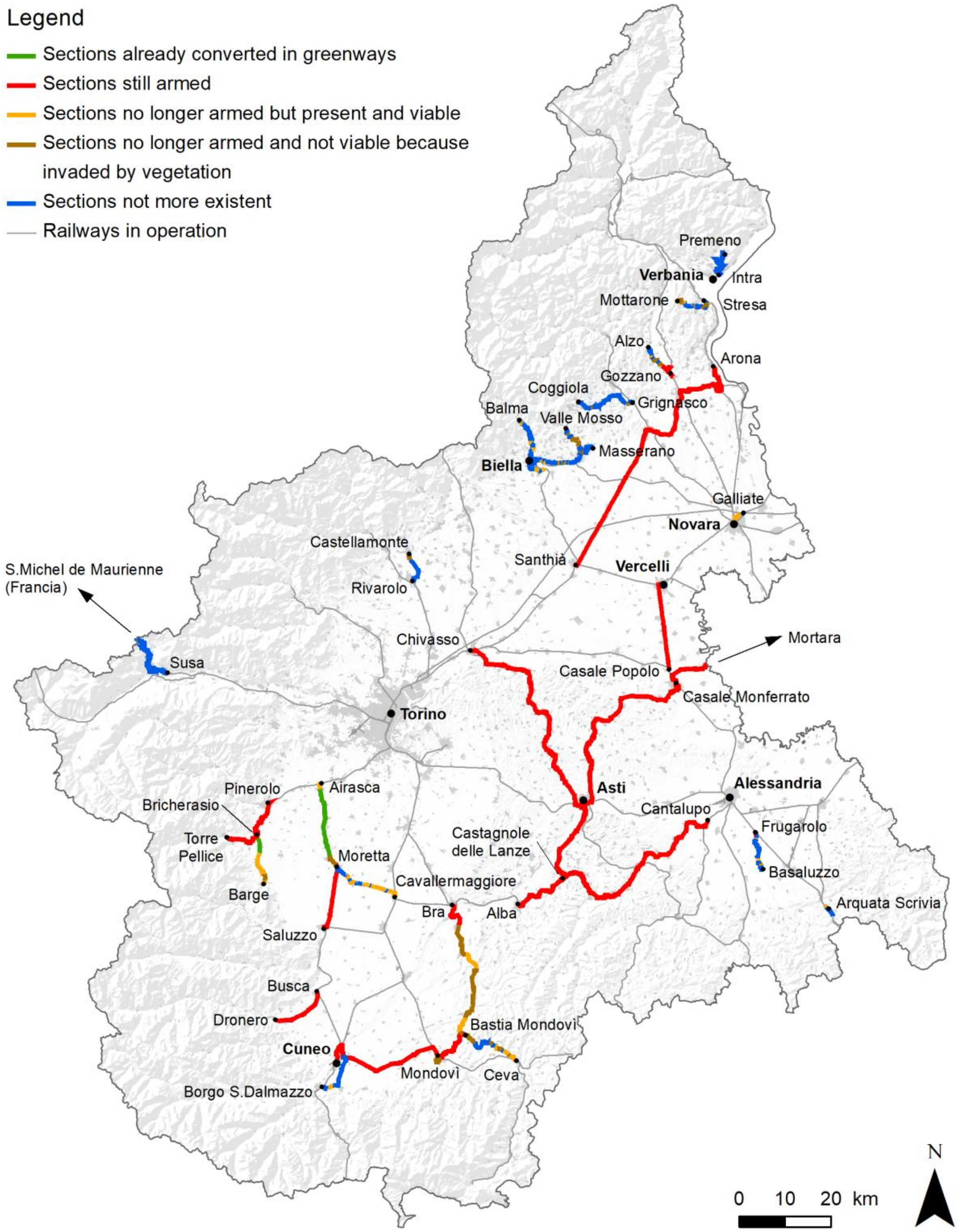

Figure 2 – Disused railway lines and stretches of the Piedmont Region.

Given the state of the lines, the length of the sections available, the frequency and extension of the interruptions, the possible connection with disused railways already transformed into greenways, and the connection with the network of active railways, this study considers a compound extending for a remarkable part (78%) of the abandoned railways total length (see details in Table 4 and Figure 3).

Table 4 – Lines/stretches suitable for the conversion into greenways and included in the study.

Year of closing	**Railway lines/stretches**	**Length of present railway corridor included in the study (km)**
1924	Gozzano-Alzo	5.9
1958	Biella-Ponte Cervo-Castellazzo-Valle Mosso	6.4
1959	Cavallermaggiore-Moretta	15.3
1966	Bricherasio-Barge	11.5
1966	Busca-Dronero	12.5
1986	Airasca-Moretta-Saluzzo	33.4
1986	Bastia Mondovì-Mondovì	11.8
1994	Bra-Bastia Mondovì-Ceva	50.0
2010	Mortara-Casale Monferrato-Asti	55.5
2011	Chivasso-Asti	51.3
2012	Asti-Castagnole delle Lanze	20.1
2012	Mondovì-Cuneo	30.2
2012	Cantalupo-Nizza Monferrato-Castagnole delle Lanze-Alba	59.6
2012	Pinerolo-Bricherasio-Torre Pellice	16.4
2012	Santhià-Rovasenda Alta-Romagnano Sesia-Borgomanero-Arona	65.0
2013	Vercelli-Casale Popolo	19.2
	Total	**464.1**

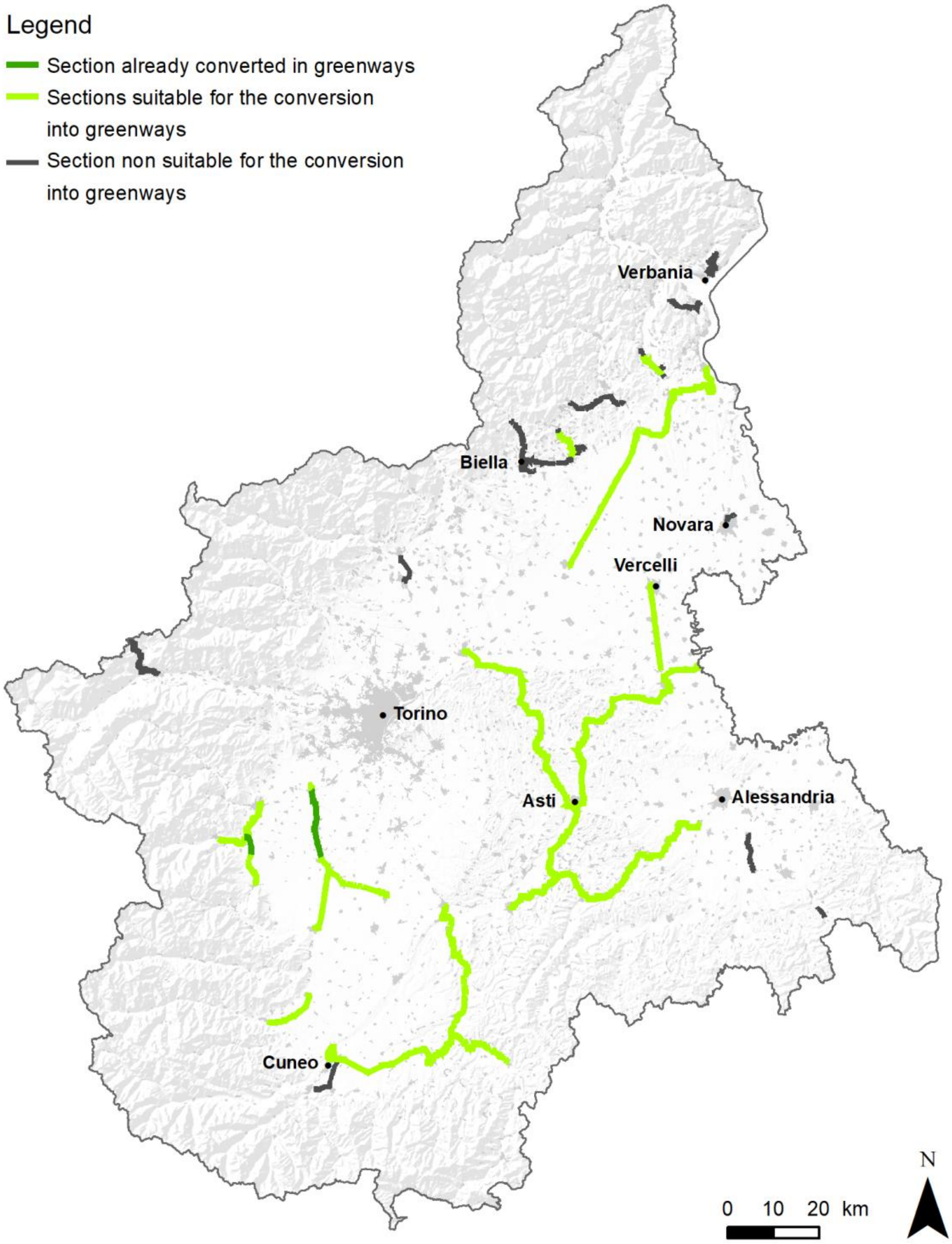

Figure 3 – Disused railway lines and stretches included in the study.

3.3 Application of the methodology to the study area

The methodology defined has been applied to the study area, in order to test it capability and efficacy.

In the first phase, data have been collected, systematized, and spatially referred. The abandoned railway tracks have been digitized using a GIS software, using as main spatial reference historical cartography of the Italian Geographical Military Institute (IGMI) at scale 1:25000 (in this way it was possible to digitize also the abandoned lines, not more present in the updated cartography). Information regarding the current state of the railway tracks and the main bridges and tunnels have been collected. Starting from this data, we selected the railway lines (or stretches of them), which can be converted into greenways, considering aspects, such as length, frequency and extension of interruptions, and connection with other greenways.

In the second phase ("context analysis"), we assessed the territorial and social context where the railway lines selected in phase 1 are located. We focused on the attractiveness for the future greenways users of the surrounding environment, by evaluating i) the presence of elements of interest, ii) accessibility through public transport, and iii) the proximity to residential areas. The level of interest has been assessed applying the concept of "area of influence", which mirrors the relations between the disused railway paths and its surrounding environment (Eizaguirre-Iribar et al., 2016). In the present study, we were interested in potential destinations that can be reached by walking and cycling from a candidate disused railway segment. The attractive elements considered are shown in Table 5. According to Reis & Jellum (2012) and Taylor (2015), greenway paths evolve on gentle gradients: thus, we considered only the elements showing an elevation difference of maximum 200 m, with respect to the closest stretch of the selected railway line.

Table 5 – Elements of interest considered for the analysis of the territorial context.

Attractive elements			**Source of information**	**References**
Natural elements	PA	Protected Areas	Piedmont Region	Coutts, 2008.
	R	Rivers		
	L	Lakes		
Historical-Cultural resources	HC	Villages, churches, historic buildings, monuments, museums.	Touring Club Italiano	Reis & Jellum, 2012; Taylor, 2015.
Traditional Gastronomy	TG	Restaurant with traditional food and local wine	Specialized sector guides *	Taylor, 2015.
Landscape or Scenery	LS	Vineyards, rice fields, water bodies, wooded areas.	Piedmont Region	Reis & Jellum, 2012; Wearing et al., 2009.
** Only the elements in proximity of the disused railways have been mapped*				

For each attraction, we calculated the Influence Radius (IR), which obeys to the following expression (Coutts, 2008; Eizaguirre-Iribar et al.; 2016; Wolter & Lindsey, 2001):

$$\boldsymbol{IR_i = t_i * \bar{v}} \tag{1}$$

where IR_i is the Influence Radius related to attraction i, t_i is the estimated time that a cyclist is willing to spend to achieve that attraction, and $\boldsymbol{\bar{v}}$ is the mean speed at which a standard person cycles in plain, determined in 12 km/h (Eizaguirre-Iribar et al., 2016; Millward et al., 2013). For pedestrians, moving at a lower speed, the influence radius is always included in that calculated for cyclists. IR_i values calculated for the study are shown in Table 6.

Table 6 – Influence Radius (IR_i) values calculated for the different elements.

Category of elements of interest		**Classes**		**t_i values (minutes)**	**IR_i values (km)**
Natural elements	PA	Protected Areas		-	0.0
	R	Rivers	Po River	15.0	3.0
			Main rivers	7.5	1.5
			Other important rivers	2.5	0.5
	L	Lakes		20.0	4.0
Historical-Cultural resources	HC		Resources of great interest	25.0	5.0
			Very interesting resources	20.0	4.0
			Interesting resources	15.0	3.0
			Bandiere Arancioni*	25.0	5.0
Traditional Gastronomy	TG	Restaurant with traditional food and local wine		10.0	2.0
Landscape or Scenery	LS		Vineyards	-	0.2
			Rice fields	-	0.2
			Water bodies	-	0.2
			Wooded areas	-	0.4

** "Bandiere Arancioni": founded by Touring Club Italiano, the "Orange Flag" is a seal of excellence awarded to towns and villages that not only have an historical, cultural and environmental heritage of merit, but are also renowned for offering tourists a quality welcome.*

We set IR_i for the Protected Areas (PA) to zero, in order to not overestimate their influence. In fact, protected areas have already a significant size due to the presence of a "respect area", a buffer zone bounding the areas of highest interest (integral reserve areas, areas of greater naturalistic value, etc.). As for Landscape and Scenery (LS), we estimated IR_i according to their visual perception, assuming a value of 200 m for the predominantly horizontal elements (rice fields, vineyards, water bodies) and 400 m for those with vertical growth (forests) (Bacon, 1979). Then, we applied GIS analysis tools to calculate the influence area of each element of attraction and analyze the spatial relation with the disused railway lines (Figure 4). We overlaid the influence areas with the abandoned railways network obtaining its "fragmentation" in several "sections". Then, we reclassified the sections based on the category (PA, R, L, HC, TG, LS) of the elements of attraction (Table 6). Finally, we calculated, for each *i-th* section, a specific *index of presence* for each category, equal to the number of "areas of influence" of the category crossing the stretch (Table 7).

Table 7 – Indexes of presence for each category of the elements of attraction.

Index	**Description**
PAI_i	Protected Area Index of the *i-th* section
RI_i	River Index of the *i-th* section
LI_i	Lake Index of the *i-th* section
HCI_i	Historical-Cultural Index of the *i-th* section
TGI_i	Traditional Gastronomy Index of the *i-th* section
LSI_i	Landscape/Scenery Index of the *i-th* section

The access by private means to the selected railway lines can be taken for granted, because of the considerable extension and the capillarity of the road network. Instead, we assessed the accessibility through public transport services. We considered only the active railways, because they represent the principal public transport reaching the greenways. We mapped the active railway stations located along or within 3 kilometers from the disused railway lines.

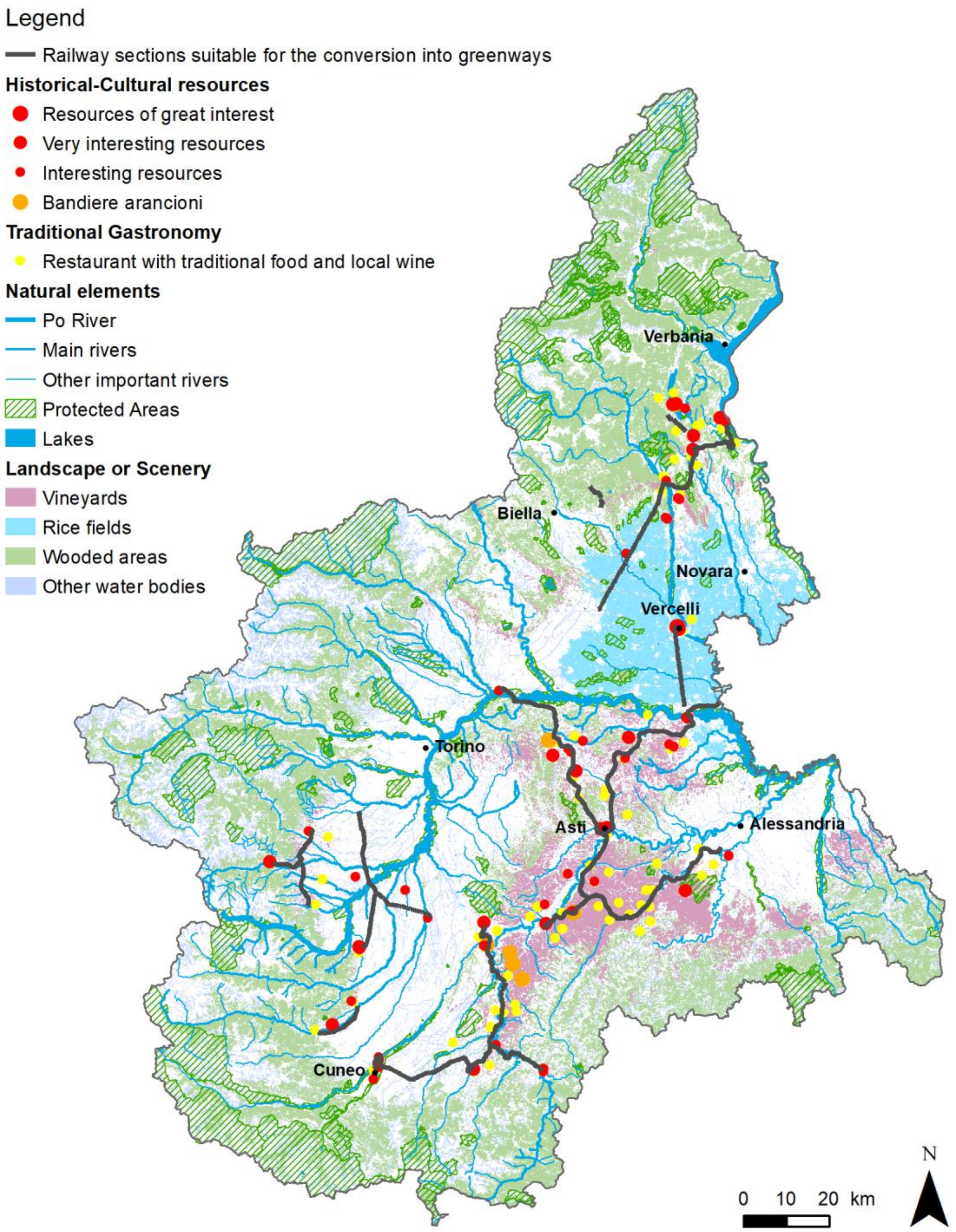

Figure 4 – Elements of interest and selected abandoned railway lines.

We related the active stations with the abandoned railways through a "network service area analysis". We "cut" the disused railways network every 1 km, starting from each active railway station, up to a maximum of 20 km, which has been considered the distance limit for a daily return trip in relation to the average speed (Eizaguirre-Iribar et al., 2016; Millward et al., 2013). For each resulting “section”, we considered the accessibility index (AI_i), which is able to measure the “cumulative proximity” to an active station, and obeys to the following equation:

$$AI_i = \sum p_i \tag{2}$$

Where p_i stands as the proximity of each *i-th* section to each active station. P_i is calculated as follow:

$$p_i = 20 - d_j \tag{3}$$

where d_j is the distance in km of the *i-th* section from the *j-th* station. In this way, the p_i value increases with the proximity to the station: for example, a section of the network 15 km far from an active station, has a proximity value of 5 (= 20 – 15), while a closer section (for example, 4 km far from an active station) has a proximity value of 16 (= 20 – 4).

The last parameter we took in consideration is local population, which can represent an important part of the users of the future greenway (Taylor, 2015). We considered the residential zones placed within a distance (buffer) of 2 kilometers from the disused railway lines, according to Wolter & Lindsey (2001), who report that between 67% and 84% of the users live no more than 10 minutes from the greenway. For each residential zone in the buffer, we calculated the “approximate resident population”, according to the formula:

$$RP_{\boldsymbol{j}} = AR_j * PD_m \tag{4}$$

where: RP_j is the approximate resident population of the *j-th* residential zone, AR_j is the area of each *j-th* residential zone, and PD_m is the so called “urban density” (resident population / residential area), calculated on the residential area of the municipality *m* in which the *j-th* residential zone falls. In order to "assign" to each abandoned railway section a "reference population", we calculated the population index *PI*, i.e. the whole population living in a 2 km distance from that section, according to the following formula:

$$PI_i = \sum RP_j \tag{5}$$

where: PI_i is the population index of the *i-th* section and RP_j is the approximate resident population of the *j-th* residential zone.

In the third phase, we investigated on the priority of conversion from abandoned railway lines to greenways by building and comparing four scenarios, verifying how the priorities can change in relation to the objectives, and helping decision-makers to select and promote the most urgent actions (Mundet & Coenders, 2010). The first scenario envisages that the greenways will be used mainly for tourism purposes, and the second one mainly for recreational purposes and daily trips. We made a comparison of these two scenarios with a "Scenario 0", where all the characteristics have the same importance, and with an "Average Scenario", calculated as the weighted average of Scenario 1 and 2.

Once scenarios have been defined, we assessed the relative importance (weights) of each elements of interest described in Tables 5 and 6, asking to 9 people (3 experts, 3 stakeholders and 3 land-use decision makers) to make a pairwise comparison giving their score for the application of AHP, following the conceptual scheme reported in Figure 5 (natural elements have three sub-criteria). Each expert compiled an individual matrix (for Scenario 1 and 2) and then the weights were calculated as the weighted geometric means of the all participants' judgments.

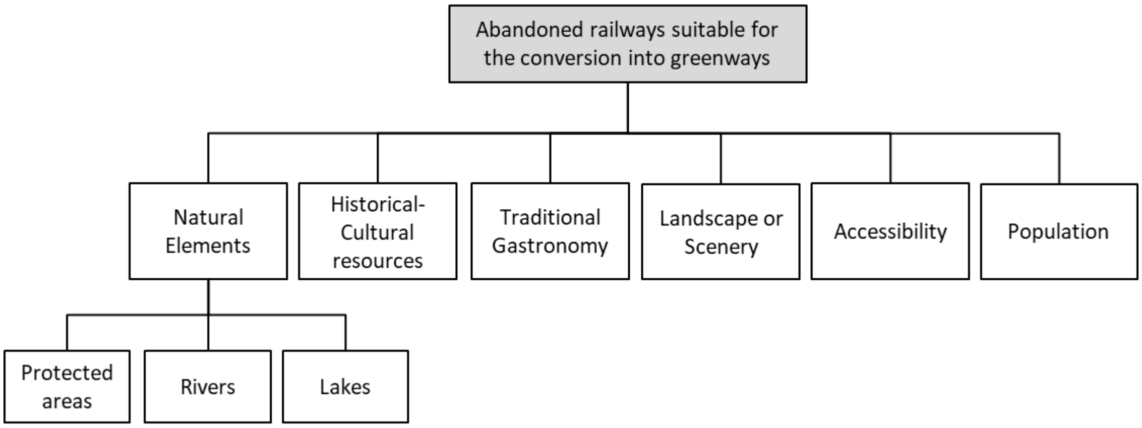

Figure 5 – Conceptual scheme of the criteria used to evaluate the suitability to the conversion into greenways of the disused railway lines.

For each priority matrix, we also checked the reliability of the expressed preferences by calculating the Consistency Ratio (C.R.), as follows:

$$C.R. = \frac{C.I.}{R.I.} \tag{6}$$

where

$$C.I. = \frac{\lambda_{max} - n}{\mathrm{n-1}} \tag{7}$$

represents the Consistency Index (measuring the consistency of the judgments across all pairwise comparisons) with $\lambda_{\max}$ corresponding to the main eigenvalue of the matrix and n to the number of matrix components; and R.I. corresponds to the Random Index, an arithmetic mean of random matrix consistency indexes (the arithmetic mean of the C.I. values of several reciprocal matrices of the same order whose coefficients are randomly generated). The Consistency Ratio always remained below 10%, thereby proving the congruity of the preferences. The final weights obtained for each characteristic are shown in Table 8.

Table 8 – Weights for the two scenarios derived from the AHP application.

Characteristic	**Index**	**Weights**		
		Scenario 1	**Scenario 2**	**Scenario 0**
Protected Areas	PAI_i	0.023	0.022	0.056
Rivers	RI_i	0.043	0.047	0.056
Lakes	LI_i	0.077	0.054	0.056
Historical-Cultural resources	HCI_i	**0.359**	0.078	0.167
Traditional food and local wine	TGI_i	**0.208**	**0.102**	0.167
Landscape/Scenery	LSI_i	0.090	**0.129**	0.167
Accessibility	AI_i	***0.153***	***0.169***	0.167
Population	PI_i	0.047	**0.399**	0.167
		1.000	***1.000***	***1.000***

As shown in Table 8, the overall sum of all the weights, for each scenario, is always equal to 1.

In “Scenario 0”, we modeled a situation where all the characteristics have the same importance, i.e. weight. Given the nesting of the scheme in Figure 5, the weights attached to the second level items - Protected Areas, Rivers and Lakes - sum up to the value (0.167) of the importance associated to the first level item - Natural elements - and the other peer characteristics. In Scenario 1, the presence of historical-cultural elements and restaurant with traditional food and local wine resulted the most important criteria, while in the scenario 2 the resident population resulted as the most important one (as well as landscape/scenery and traditional food/wine). In both scenarios, the accessibility emerged as an important criterion.

The weights resulted from the priority matrices were used to calculate the single weighted indexes and obtain the Greenway Suitability Index (GSI), the global suitability index for each section of the whole disused railway network.

Before the weighting calculation, the single indexes of presence (PAI_i, RI_i, LI_i, HCI_i, TGI_i, LSI_i, AI_i, PI_i) were winsorized, in order to limit the extreme values and to reduce the effect of possibly outliers. Threshold values have been set to *Q3* + 1.5**1QR* (the highest threshold) and *Q1* - 1.5**1QR* (the lowest threshold), where: Q1 and Q3 are the first and third quartile and IQR is the interquartile range. The values higher and lower than the thresholds have been replaced with the threshold values (Reifman & Keyton, 2010; Clark, 1995; Kwak & Kim, 2017), and then were normalized to a 0-1 scale.

The global Greenway Suitability Index (GSI) obeys to the following formula:

$$GSI_i = PAI_i \cdot W_{PA} + RI_i \cdot W_R + LI_i \cdot W_L + HCI_i \cdot W_{HC} + TGI_i \cdot W_{TGI} + LSI_i \cdot W_{LS} + AI_i \cdot W_A + PI_i \cdot W_P \quad (8)$$

where $G.S.I._i$ is the global Greenway Suitability Index of the *i-th* section, and the indexes of presence and weights are illustrated in Tables 6 and 7. Since (8) is a weighted summation, the following typical condition holds:

$$W_{PA} + W_R + W_L + W_{HC} + W_{TGI} + W_{LS} + W_A + W_P = 1 \quad (9)$$

The calculation of GSI allows to consider the effect of cumulative attractions, as suggested by Taylor (2015), who observes that “a collection of attractions within a tourist destination is generally more likely to succeed than one that is alone”.

We have calculated GSI for each disused railway line and for the two defined scenarios (1- prevalent use for tourist purposes, 2- prevalent use for recreational purposes and daily travel). These values have been compared to the GSI figure obtained for

“Scenario 0” (all weights are equal) and for an “Average Scenario”, calculated as the weighted average of Scenario 1 and 2 (weighted sum divided for the length of the lines).

We calculated GSI so that it provides policy makers and planners with an indication of priority of the disused railway-greenway conversion for the different sections of the network and in each scenario.

4. Results and discussion

4.1 Phase two: assessing the influence of the elements of interest

In Table 9, we report on the results of the second phase concerning the assessment of the interplay between the selected disused railway lines and the elements of interest included in the environmental and landscape context. As the last two columns demonstrate, only 6% (30 km) of the Piedmont selected disused railway lines is not interested by any of the considered elements of interest (mostly concentrated in just 4 lines). The presence of rivers and streams is widespread: 56% of the selected disused railway lines (around 260 km) presents RI>0. Only one line does not show any presence of water courses. Lakes are much less widespread: only 5% (22.4 km) has LI>0, with only 3 lines interested. Also, the presence of protected areas is very limited: only 3% (about 12 km) of the lines has PAI>0, with only 3 lines absorbing nearly the entire set of elements of interest. Figure 6 includes a spatial analysis of PAI, RI and LI. In addition, this figure presents the spatial representation the overall Natural Elements Index (NEI), a measure considering the combination of PAI, RI and LI.

Table 9 – Elements of interest by length of the selected disused railway lines (absolute and relative values), with a positive value of the relative index.

Railway line	**Length**	**PAI>0**		**RI>0**		**LI>0**		**HCI>0**		**TGI>0**		**LSI>0**		**No element of attraction**	
	km	**km**	**%**	**km**	**%**	**km**	**%**	**km**	**%**	**km**	**%**	**km**	**%**	**km**	**%**
Airasca-Moretta-Saluzzo	33.4	0.8	2%	10.0	30%	*0.0*	*0%*	6.4	19%	0.7	2%	12.5	37%	12.7	38%
Gozzano-Alzo	5.9	*0.0*	*0%*	*0.0*	*0%*	5.9	100%	5.6	94%	2.7	47%	5.9	100%	*0.0*	*0%*
Asti-Castagnole delle Lanze	20.1	*0.0*	*0%*	18.4	92%	*0.0*	*0%*	8.9	44%	8.3	41%	18.0	89%	*0.0*	*0%*
Bastia Mondovì-Mondovì	11.8	*0.0*	*0%*	10.4	88%	*0.0*	*0%*	10.8	91%	4.3	36%	9.8	83%	*0.0*	*0%*
Biella-Ponte Cervo-Castellazzo-Valle Mosso	6.4	*0.0*	*0%*	6.4	100%	6.0	94%	*0.0*	*0%*	*0.0*	*0%*	6.4	100%	*0.0*	*0%*
Bra-Bastia Mondovì-Ceva	50.0	*0.0*	*0%*	47.1	94%	*0.0*	*0%*	27.5	55%	16.7	33%	47.7	95%	*0.0*	*0%*
Bricherasio-Barge	11.5	*0.0*	*0%*	1.3	11%	*0.0*	*0%*	*0.0*	*0%*	0.5	4%	8.8	77%	2.7	23%
Busca-Dronero	12.5	*0.0*	*0%*	12.5	100%	*0.0*	*0%*	9.9	79%	2.3	19%	4.9	39%	*0.0*	*0%*
Cantalupo-Nizza Monferrato-Castagnole delle Lanze-Alba	59.6	*0.0*	*0%*	52.3	88%	*0.0*	*0%*	20.6	34%	31.8	53%	49.1	82%	2.3	4%
Vercelli-Casale Popolo	19.2	*0.0*	*0%*	2.2	12%	*0.0*	*0%*	5.9	31%	2.7	14%	16.9	88%	*0.0*	*0%*
Cavallermaggiore-Moretta	15.3	*0.0*	*0%*	7.4	48%	*0.0*	*0%*	3.3	22%	*0.0*	*0%*	5.3	34%	5.2	34%
Chivasso-Asti	51.3	3.1	6%	30.2	59%	*0.0*	*0%*	30.3	59%	16.9	33%	45.8	89%	*0.0*	*0%*
Mondovì-Cuneo	30.2	3.1	10%	12.8	42%	*0.0*	*0%*	12.4	41%	6.4	21%	19.3	64%	5.2	17%
Mortara-Casale Monferrato-Asti*	55.5	0.3	1%	29.4	53%	*0.0*	*0%*	25.9	47%	18.1	33%	44.7	81%	1.0	2%
Pinerolo-Bricherasio-Torre Pellice	16.4	*0.0*	*0%*	5.1	31%	*0.0*	*0%*	7.6	46%	4.8	29%	13.0	79%	1.0	6%
Santhià-Rovasenda Alta-	65.0	4.6	7%	14.2	22%	10.5	16%	24.8	38%	23.0	35%	64.2	99%	*0.0*	*0%*

Romagnano Sesia-Borgomanero-Arona															
Total	**464.1**	**11.9**	**3%**	**259.6**	**56%**	**22.4**	**5%**	**199.9**	**43%**	**139.2**	**30%**	**372.3**	**80%**	**30.1**	**6%**
**Length of the stretch in the Piedmont Region*															

3

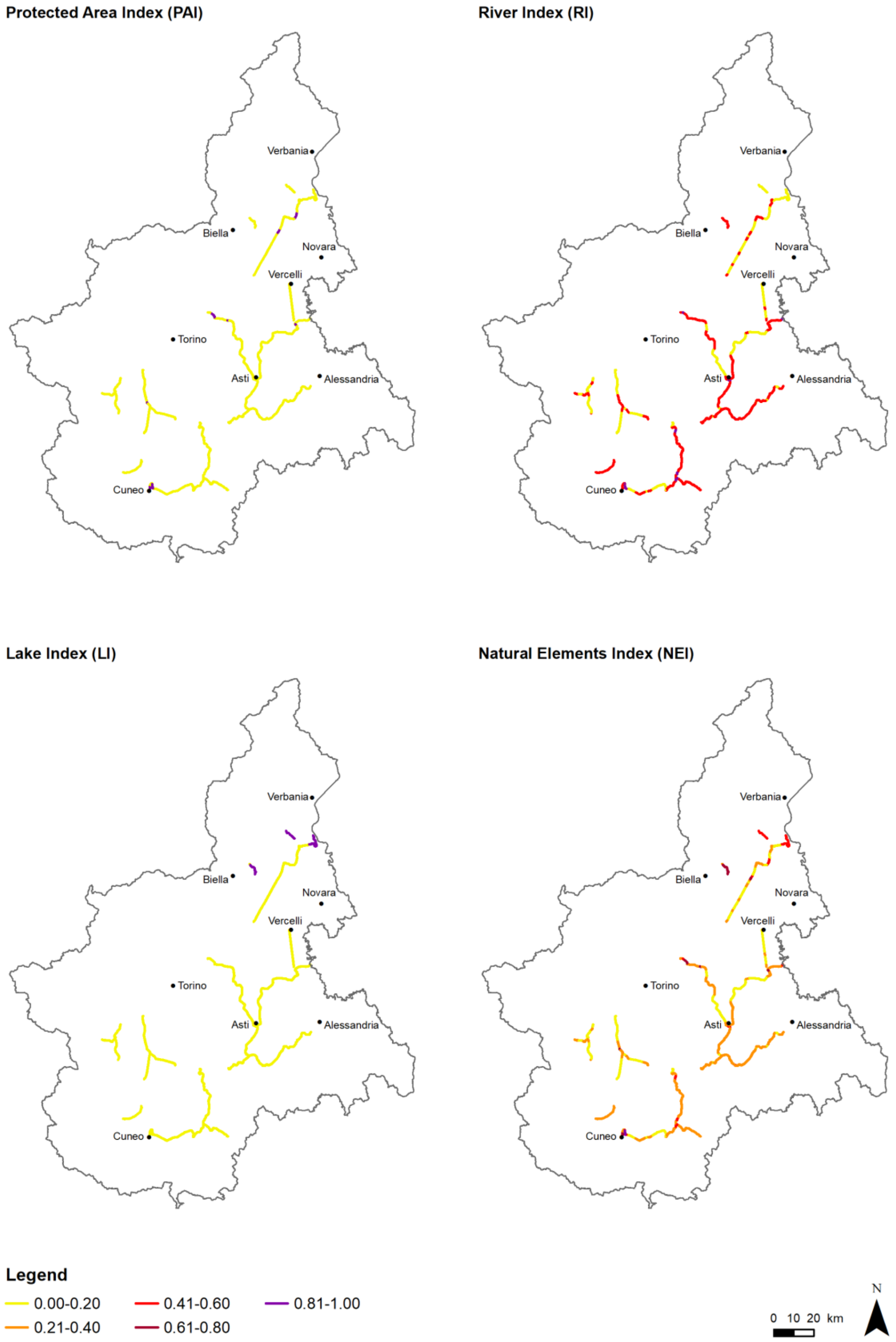

Figure 6 – Spatial analysis of Protected Area Index (PAI), River Index (RI), Lake Index (LI), and Natural Elements Index (NEI) in Piedmont. Values are normalized between 0 and 1.

As for historical-cultural elements, about 200 km (43%) of abandoned railway lines show HCI>0, with only two lines with HCI=0. Only the 22% (102 km) of the lines has HCI>0.4. With respect to restaurants with traditional food and local wine, about 140 km (30%) of disused lines have TGI>0, with four lines with less than 1 km interested by the presence of restaurant with traditional food and local wine. Only 30% (138 km) of the lines has TGI>0.5. Finally, almost all the abandoned railway lines cross a valuable landscape: the 80% (372 km) is characterized by the presence of Landscape and Scenery (LSI>0), with only 2 lines with less than 50%. Figure 7 presents spatial analyses of NEI, HCI, TGI and LSI. Evidence shows that about 76% of the selected disused railway lines (353 out of 464 km) is somehow affected by naturalistic, historical-cultural and eno-gastronomic elements. This percentage rises to more than 93%, when considering landscape and scenery elements (Table 10). We start from the assumption that the greater the aspects of interest along a line, the greater the suitability to its transformation into a greenway. In Figure 8, the “cumulative level of interest” is shown. Overall, 72% of the lines (333 km) presents at least a “double interest”, with almost the 11% (about 50 km) with a “quadruple interest”. It is possible to observe that the two sections (Bricherasio-Barge and Airasca-Moretta) already recovered as greenways do not represent the best sections from the point of view of the presence of elements of interest (Figures 2 and 8).

Table 10 – Cumulative level of interest of the disused railways in Piedmont.

Railway line	Length	No interest		Single interest		Double interest		Triple interest		Quadruple interest	
	km	km	%	km	%	km	%	km	%	km	%
Airasca-Moretta-Saluzzo	33.4	13.17	39.4%	12.71	38.0%	6.30	18.8%	1.26	3.8%	0.00	0.0%
Gozzano-Alzo	5.9	0.00	0.0%	0.00	0.0%	0.00	0.0%	3.50	59.0%	2.43	41.0%
Asti-Castagnole delle Lanze	20.1	0.00	0.0%	0.00	0.0%	10.23	50.8%	6.72	33.4%	3.17	15.8%
Bastia Mondovì-Mondovì	11.8	0.00	0.0%	0.00	0.0%	2.28	19.4%	7.44	63.3%	2.04	17.4%
Biella-Ponte Cervo-Castellazzo-Valle Mosso	6.4	0.00	0.0%	0.00	0.0%	6.38	100.0%	0.00	0.0%	0.00	0.0%
Bra-Bastia Mondovì-Ceva	50.0	0.00	0.0%	0.65	1.3%	17.30	34.6%	24.53	49.0%	7.56	15.1%
Bricherasio-Barge	11.5	2.61	22.6%	7.14	61.9%	1.80	15.6%	0.00	0.0%	0.00	0.0%
Busca-Dronero	12.5	0.00	0.0%	1.86	14.9%	5.42	43.2%	3.94	31.5%	1.31	10.5%
Cantalupo-Nizza Monferrato-Castagnole delle Lanze-Alba	59.6	2.29	3.8%	2.58	4.3%	21.56	36.2%	24.58	41.2%	8.57	14.4%
Vercelli-Casale Popolo	19.2	0.00	0.0%	11.47	59.8%	6.80	35.5%	0.90	4.7%	0.00	0.0%
Cavallermaggiore-Moretta	15.3	5.72	37.4%	5.56	36.3%	2.09	13.6%	1.95	12.7%	0.00	0.0%
Chivasso-Asti	51.3	0.01	0.0%	7.25	14.1%	22.41	43.7%	15.85	30.9%	5.82	11.3%
Mondovì-Cuneo	30.2	5.23	17.3%	9.60	31.8%	9.20	30.5%	1.66	5.5%	4.48	14.8%
Mortara-Casale Monferrato-Asti*	55.5	0.99	1.8%	15.00	27.0%	19.61	35.4%	15.63	28.2%	4.23	7.6%
Pinerolo-Bricherasio-Torre Pellice	16.4	1.03	6.3%	6.20	37.9%	4.81	29.4%	2.59	15.8%	1.73	10.6%
Santhià-Rovasenda Alta-Romagnano	65.0	0.00	0.0%	20.38	31.4%	22.71	35.0%	12.66	19.5%	9.19	14.2%

Sesia-Borgomanero-Arona											
Total (km)	**464.1**	**31.26**	**6.7%**	**100.69**	**21.7%**	**159.58**	**34.4%**	**123.31**	**26.6%**	**50.55**	**10.9%**

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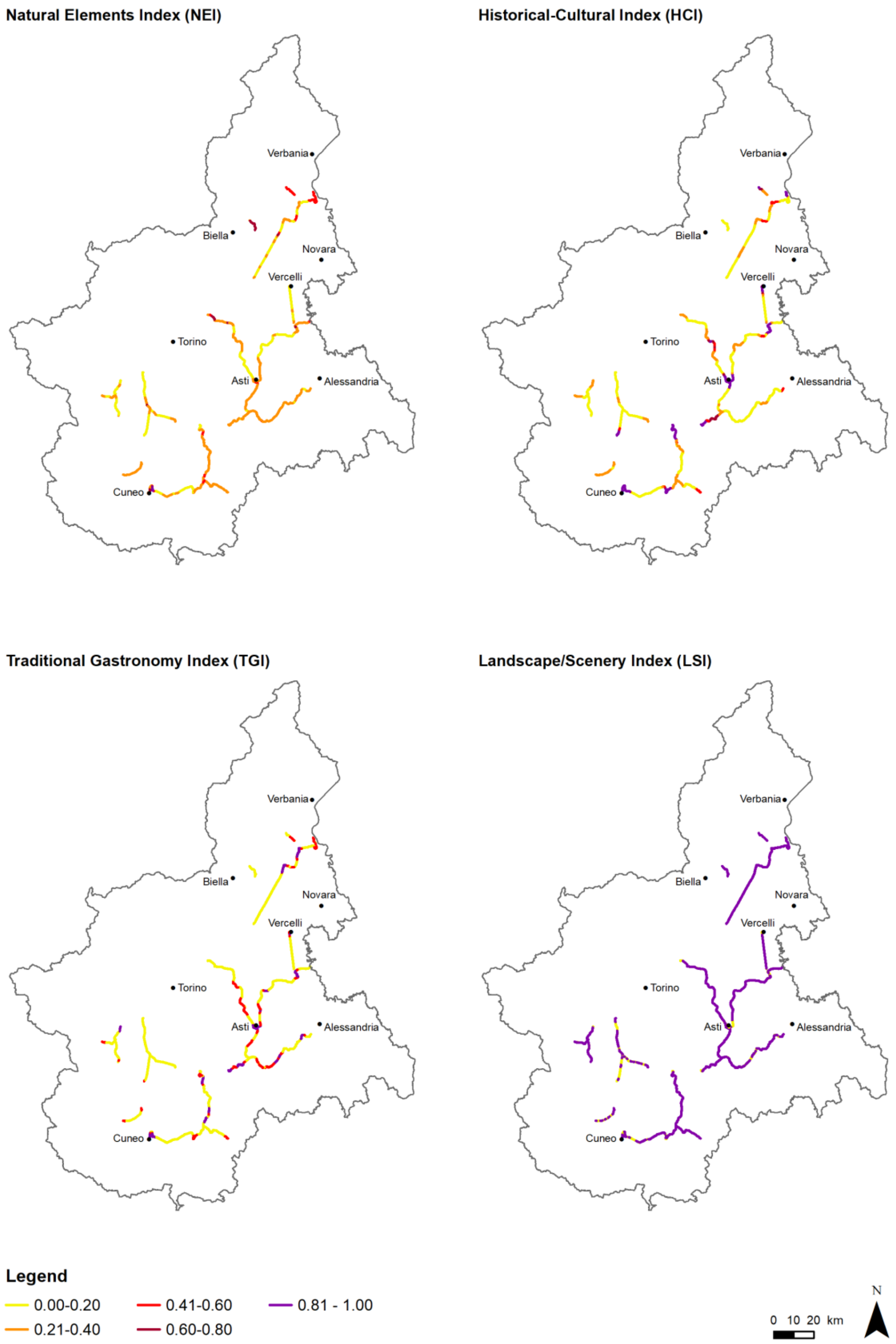
Natural Elements Index (NEI)

Historical-Cultural Index (HCI)

Traditional Gastronomy Index (TGI)

Landscape/Scenery Index (LSI)

Figure 7 – Maps for the Natural Elements Index (NEI), Historical-Cultural Index (HCI), Traditional Gastronomy Index (TGI), and Landscape/Scenery Index (LSI), in Piedmont.

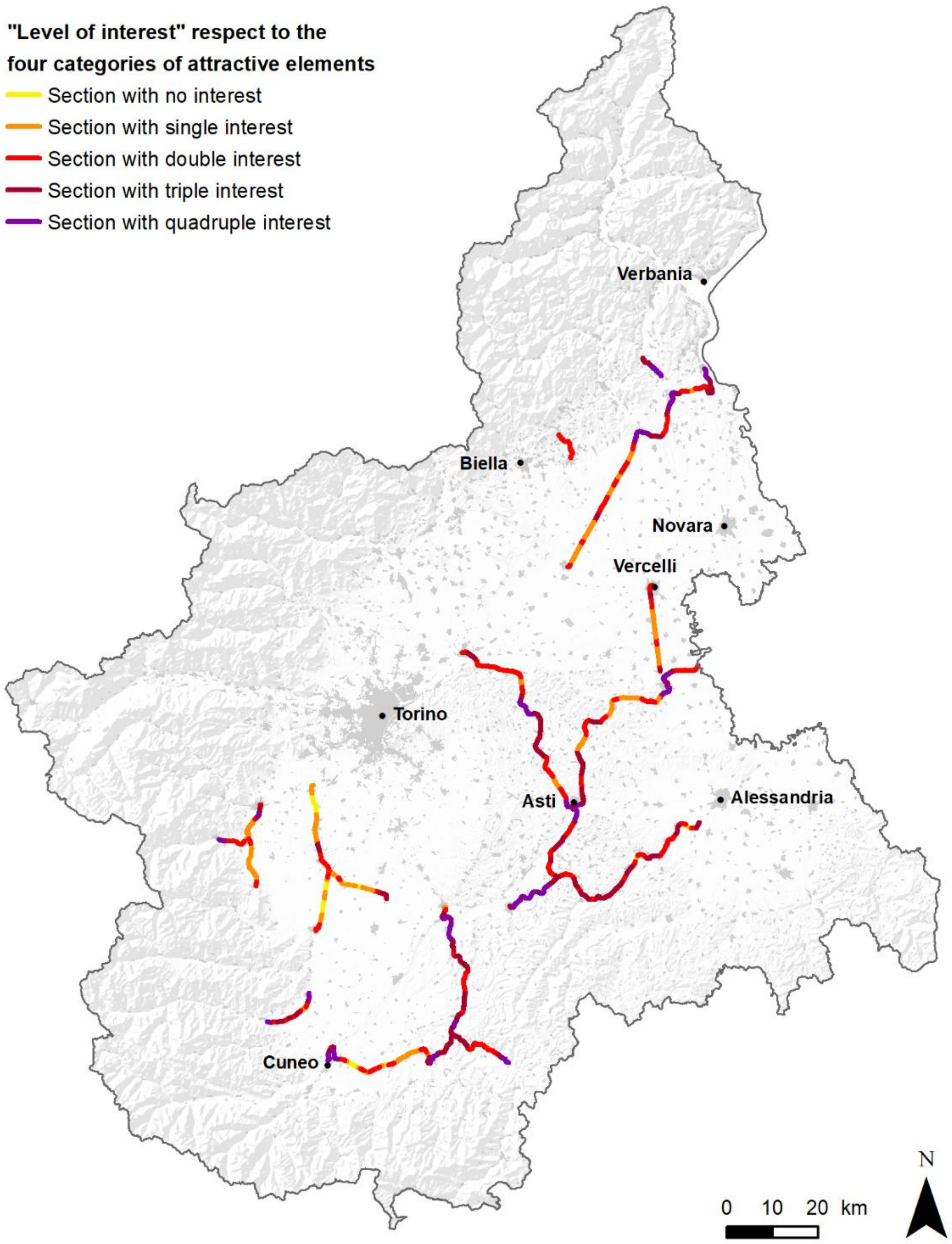

Figure 8 – Map for the cumulative level of interest of the disused railways in Piedmont.

The analysis of accessibility by train has shown (Table 10) that about 50% of the selected abandoned railway lines (233 km) has $AI_i > 0.4$, while only 18% (84 km) has $AI_i > 0.6$. Almost 90% of the abandoned railway sections (417 km) are located within 20 km from one or more active railway stations ($AI_i > 0$). Finally, the analysis of the relationships with the residential areas showed (Table 11) that the theoretical population residing within an area of 2 km from the selected abandoned railway lines is more than 567,000 inhabitants, with an average of 1,223 inhabitants per km. All the lines have PI>0, but about 40% (181 km) has PI<0.1, while only 44% (204 km) has PI>0.2 and even only about 100 km (21%) has PI>0.4. Figure 9 shows the spatial analyses of AI and PI.

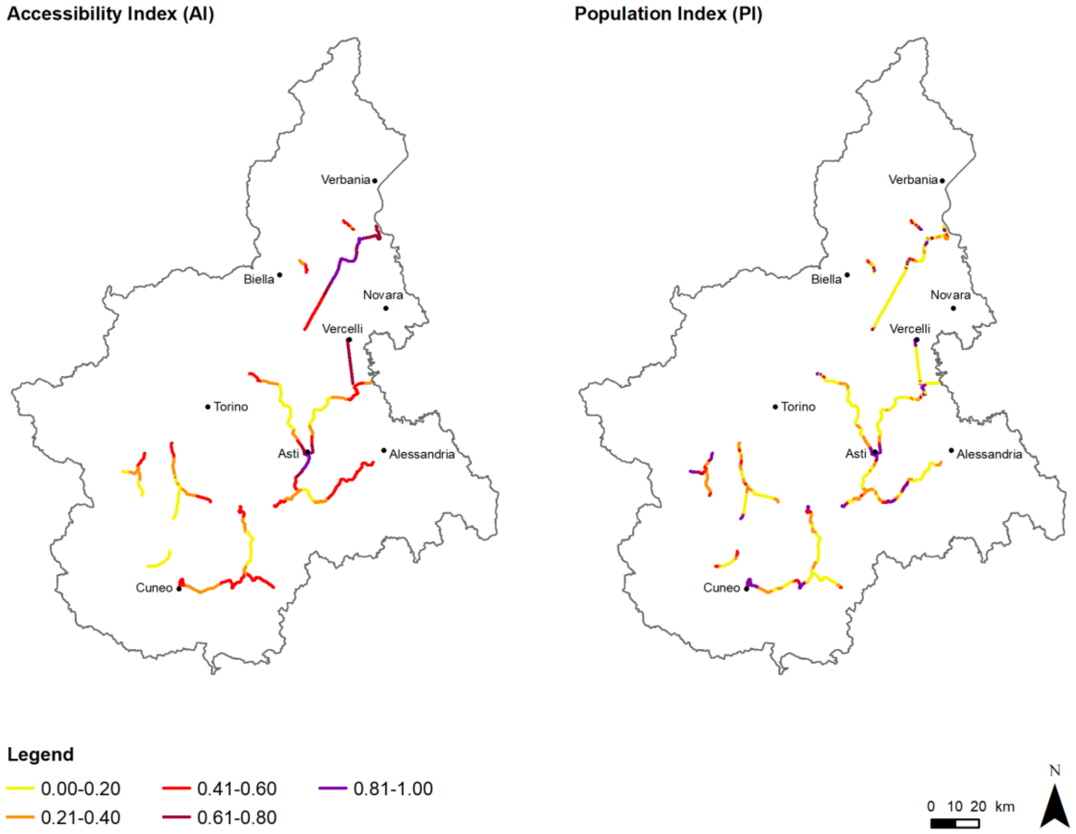

Figure 9 – Maps for Accessibility Index (AI) and Population Index (PI) in Piedmont.

51 *Table 11 – Accessibility and population along the selected disused railway lines.*

Railway line	Length	AI>0	AI>0.2	AI>0.4	AI>0.6	AI>0.8	PI>0	PI>0.2	PI>0.4	PI>0.6	PI>0.8
	km	**%**	**%**	**%**	**%**	**%**	**%**	**%**	**%**	**%**	**%**
Airasca-Moretta-Saluzzo	33.4	73%	37%	17%	0%	0%	100%	63%	21%	6%	5%
Gozzano-Alzo	5.9	84%	84%	84%	0%	0%	100%	41%	41%	19%	9%
Asti-Castagnole delle Lanze	20.1	100%	100%	89%	61%	44%	100%	54%	23%	21%	19%
Bastia Mondovì-Mondovì	11.8	93%	93%	62%	0%	0%	100%	49%	41%	38%	37%
Biella-Ponte Cervo-Castellazzo-Valle Mosso	6.4	100%	100%	52%	0%	0%	100%	31%	23%	11%	7%
Bra-Bastia Mondovì-Ceva	50.0	86%	62%	29%	0%	0%	100%	32%	11%	5%	5%
Bricherasio-Barge	11.5	93%	34%	0%	0%	0%	100%	100%	15%	0%	0%
Busca-Dronero	12.5	0%	0%	0%	0%	0%	100%	44%	28%	0%	0%
Cantalupo-Nizza Monferrato-Castagnole delle Lanze-Alba	59.6	100%	86%	58%	0%	0%	100%	61%	25%	18%	13%
Vercelli-Casale Popolo	19.2	100%	100%	100%	71%	0%	100%	16%	14%	13%	11%
Cavallermaggiore-Moretta	15.3	100%	77%	36%	0%	0%	100%	41%	0%	0%	0%
Chivasso-Asti	51.3	78%	51%	30%	11%	5%	100%	34%	14%	13%	12%
Mondovì-Cuneo	30.2	100%	100%	40%	0%	0%	100%	76%	42%	36%	30%
Mortara-Casale Monferrato-Asti*	55.5	91%	66%	38%	9%	4%	100%	30%	20%	17%	16%
Pinerolo-Bricherasio-Torre Pellice	16.4	100%	79%	36%	0%	0%	100%	100%	80%	48%	34%
Santhià-Rovasenda Alta-Romagnano Sesia-Borgomanero-Arona	65.0	100%	100%	100%	75%	34%	100%	18%	11%	8%	5%
Total (km)	464.1	**417**	**345**	**233**	**84**	**34**	**464**	**204**	**99**	**68**	**55**

Total (%)	**100%**	**90%**	**74%**	**50%**	**18%**	**7%**	**100%**	**44%**	**21%**	**15%**	**12%**

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4.2 Phase three: scenario building and prioritization

In this subsection, we report on the results of phase three attaining scenario building and the construction of the GSI, a “global index” considering all the elements of interest illustrated so far. As Table 12 shows, the GSI value in Scenario 2 is higher for all the lines, except for the “Gozzano-Alzo” line. The GSI average value for Scenario 2 is 17% higher than that for Scenario 1. Furthermore, the GSI value for Scenario 2 is more than 40% higher than that for Scenario 1 for three lines: Airasca-Moretta-Saluzzo, Bricherasio-Barge, and Pinerolo-Bricherasio-Torre Pellice. As for the single sections, the GSI value for Scenario 2 is greater than the one of Scenario 1 for almost 370 km (almost 80%). Only for just over 15 km the GSI value is the same in both the scenarios. In Figure 10, the maps of the disused railway lines in Piedmont classified for Greenway Suitability Index (GSI) value are shown, for: Scenario 1, prevalent use for tourist purposes, Scenario 2, prevalent use for recreational purposes and daily travel, “Scenario 0”, all the weights for all the aspect are equal, “Average Scenario”, calculated as the weighted average of Scenario 1 and 2.

Table 12 – Greenway Suitability Index (GSI) for the selected disused railway lines in Piedmont, calculated for two defined scenarios (1- prevalent use for tourist purposes, 2- prevalent use for recreational purposes and daily travel) and for a "Scenario 0" (all weights are equal) and for an "Average Scenario", calculated as the weighted average of Scenario 1 and 2 (weighted sum divided for the length of the lines).

Railway line	**Length**	**Scenario 1**	**Scenario 2**	***Difference between Scenario 1 and 2***		**Scenario 0**	**Av. Sc. 1-2**	**Sc2 > Sc1**		**Sc2 = Sc1**		**Sc2 < Sc1**	
	km	**GSI/km**	**GSI/km**	***Value***	***%***	**GSI/km**	**GSI/km**	**km**	**%**	**km**	**%**	**km**	**%**
Airasca-Moretta-Saluzzo	33.4	0.131	0.228	*-0.097*	***-42.50%***	0.180	0.179	31.16	93.3%	0.26	0.8%	1.99	6.0%
Gozzano-Alzo	5.9	0.432	0.426	*0.006*	*1.28%*	0.444	0.429	1.70	28.7%	0.42	7.0%	3.82	64.3%
Asti-Castagnole delle Lanze	20.1	0.370	0.450	*-0.080*	*-17.81%*	0.443	0.410	18.01	89.5%	1.23	6.1%	0.88	4.4%
Bastia Mondovì-Mondovì	11.8	0.434	0.458	*-0.023*	*-5.08%*	0.446	0.446	9.70	82.5%	0.51	4.4%	1.55	13.2%
Biella-Ponte Cervo-Castellazzo-Valle Mosso	6.4	0.259	0.370	*-0.111*	*-29.95%*	0.357	0.315	6.35	99.5%	0.03	0.5%	0.00	0.0%
Bra-Bastia Mondovì-Ceva	50.0	0.315	0.330	*-0.015*	*-4.53%*	0.361	0.322	35.80	71.5%	1.80	3.6%	12.44	24.9%
Bricherasio-Barge	11.5	0.117	0.271	*-0.154*	***-56.92%***	0.220	0.194	11.52	99.8%	0.02	0.2%	0.00	0.0%
Busca-Dronero	12.5	0.148	0.216	*-0.069*	*-31.78%*	0.186	0.182	12.54	99.9%	0.01	0.1%	0.00	0.0%
Cantalupo-Nizza Monferrato-Castagnole delle Lanze-Alba	59.6	0.321	0.393	*-0.073*	*-18.53%*	0.386	0.357	45.00	75.5%	2.77	4.7%	11.81	19.8%
Vercelli-Casale Popolo	19.2	0.303	0.346	*-0.043*	*-12.47%*	0.354	0.324	14.68	76.6%	0.98	5.1%	3.51	18.3%
Cavallermaggiore-Moretta	15.3	0.123	0.194	*-0.071*	*-36.82%*	0.170	0.158	14.57	95.1%	0.10	0.7%	0.64	4.2%
Chivasso-Asti	51.3	0.282	0.323	*-0.040*	*-12.45%*	0.335	0.302	34.21	66.6%	1.74	3.4%	15.38	30.0%
Mondovì-Cuneo	30.2	0.333	0.416	*-0.083*	*-19.96%*	0.374	0.374	25.76	85.2%	1.52	5.0%	2.96	9.8%
Mortara-Casale Monferrato-Asti*	55.5	0.308	0.338	*-0.030*	*-8.98%*	0.345	0.323	41.04	74.0%	3.04	5.5%	11.38	20.5%
Pinerolo-Bricherasio-Torre Pellice	16.4	0.243	0.459	*-0.216*	***-47.02%***	0.361	0.351	16.34	99.8%	0.03	0.2%	0.00	0.0%

Santhià-Rovasenda Alta-Romagnano Sesia-Borgomanero-Arona	65.0	0.325	0.375	*-0.050*	*-13.25%*	0.399	0.350	51.19	78.8%	1.19	1.8%	12.56	19.3%
Sum	**464.1**							**369.56**	**79.6%**	**15.66**	**3.4%**	**78.92**	**17.0%**
Average		**0.288**	**0.349**	***-0.061***	***-17.48%***	**0.345**	**0.318**						

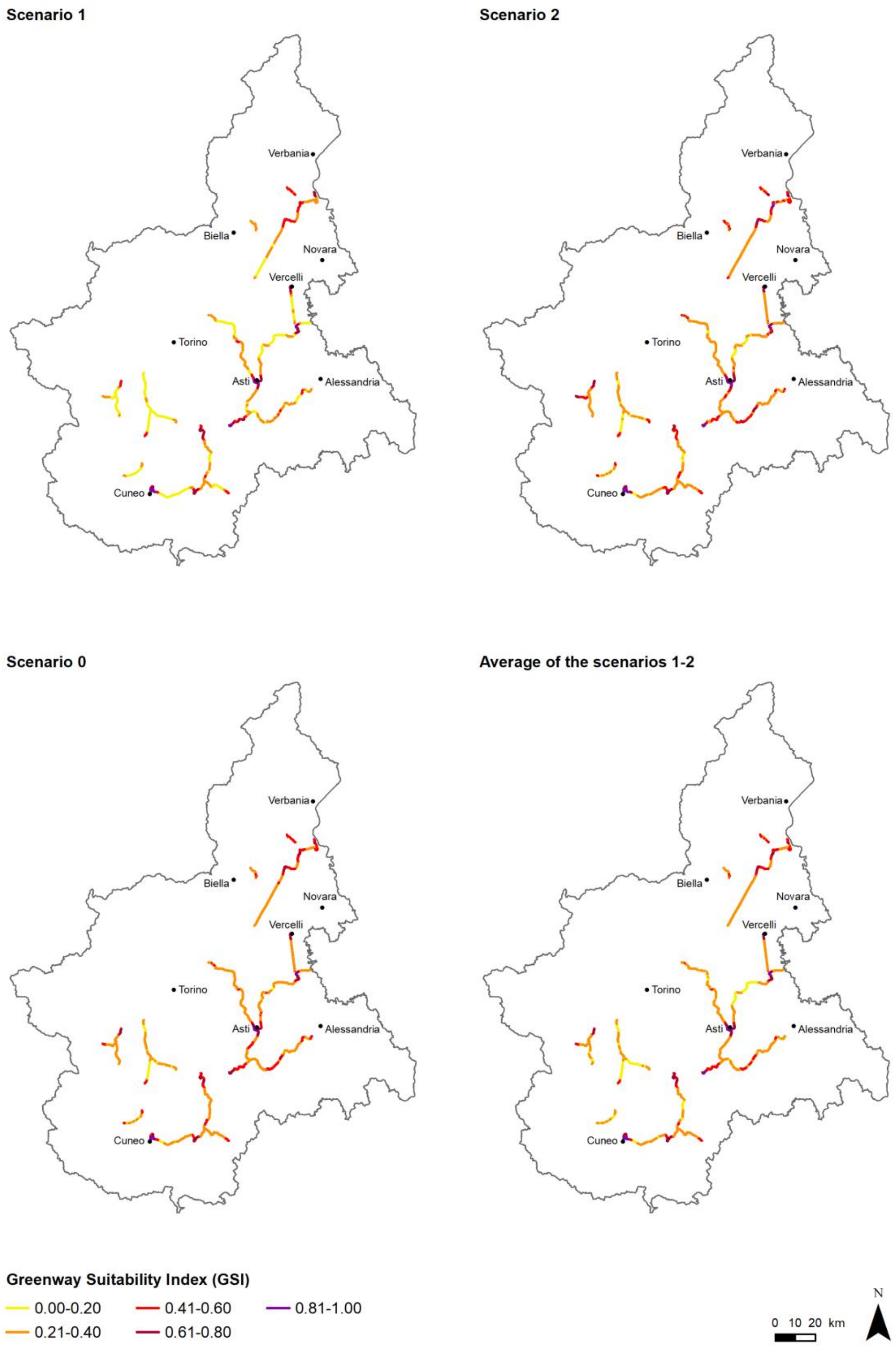

Figure 10 – Spatial analyses of the Greenway Suitability Index (GSI) of the selected disused railway lines in Piedmont for scenario 1 (prevalent use for tourist purposes), 2 (prevalent use for recreational purposes and daily travel), 0 (all weights equal), and 1-2 (weighted sum divided for the length of the disused railways).

As indicated in Table 13, only few sections present a GSI greater than 0.8: 2.5% in the Scenario 1 and 2.9% in the Scenario 2. Overall, the most significant differences between the two scenarios are in the low GSI classes. Almost 57% (about 264 km) in the Scenario 1 hypothesis presents a GSI value greater than 0.2, while almost the 86% (about 398 km) is in the same situation in Scenario 2. This big difference is clearly due to the not so great diffusion of touristic attractions in the surroundings of the disused railways lines.

From the class of GSI greater than 0.4, the overall differences between the two scenarios are very limited. In fact, the factors with greater weight in the two scenarios ("Historical-Cultural resources" and "Traditional food and local wine" in scenario 1 and "Population" in scenario 2) are concentrated in the main urban centers and their surroundings.

As Swarbrooke (2002) suggests, "the most successful attractions tend to be those which have a densely populated catchment area as this maximizes the number of potential day-trippers", while, according to the literature, attractions in areas away from large populations need to have something special or unique (Prideaux, 2002; Freeman, 2013; Hardy, 2003; Harris & Masberg, 1997; Jacobsen, 1997; Leiper, 2003; Pearce, 1991; Roura, 2009; Swarbrooke, 2002) or have to produce unique experiences (Schänzel & McIntosh, 2000) to become touristic destinations. Moreover, this effect is also influenced by the accessibility of the resources in rural areas: the easier it is to access them, the greater the motivation of users to visit them. Otherwise, a poor accessibility has a deterrent effect (Taylor, 2015).

Table 13 – Greenway Suitability Index (GSI) classes for the disused railway lines in Piedmont, calculated for the two different scenarios: prevalent use for tourist purposes (Scenario 1) and prevalent use for recreational purposes and daily travel (Scenario 2).

Railway line	**Line length**	**SGI>0.2**				**SGI>0.4**				**SGI>0.6**				**SGI>0.8**			
		Scenario 1		**Scenario 2**		**Scenario 1**		**Scenario 2**		**Scenario 1**		**Scenario 2**		**Scenario 1**		**Scenario 2**	
	km	**km**	**%**	**km**	**%**	**km**	**%**	**km**	**%**	**km**	**%**	**km**	**%**	**km**	**%**	**km**	**%**
Airasca-Moretta-Saluzzo	33.4	4.4	13.2%	17.3	51.7%	1.7	5.1%	1.8	5.2%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%
Gozzano-Alzo	5.9	5.9	100%	5.9	100%	3.9	66.1%	2.4	40.5%	0.0	0.0%	0.5	8.4%	0.0	0.0%	0.0	0.0%
Asti-Castagnole delle Lanze	20.1	17.6	87.6%	20.1	100%	4.4	21.9%	8.8	44.0%	3.7	18.4%	3.7	18.6%	2.0	10.0%	2.4	11.9%
Bastia Mondovì-Mondovì	11.8	10.6	89.8%	11.8	100%	6.0	50.8%	5.8	48.9%	3.0	25.4%	4.3	36.7%	0.0	0.0%	0.0	0.0%
Biella-Ponte Cervo-Castellazzo-Valle Mosso	6.4	6.0	93.8%	6.4	100%	0.0	0.0%	1.4	21.7%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%
Bra-Bastia Mondovì-Ceva	50.0	33.5	67.0%	44.2	88.3%	12.7	25.4%	12.6	25.2%	7.2	14.4%	1.7	3.5%	0.0	0.0%	0.0	0.0%
Bricherasio-Barge	11.5	0.5	4.3%	8.8	76.5%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%
Busca-Dronero	12.5	3.2	25.6%	6.3	50.1%	0.0	0.0%	1.3	10.2%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%
Cantalupo-Nizza Monferrato-Castagnole delle Lanze-Alba	59.6	44.0	73.8%	57.6	96.6%	14.6	24.5%	24.4	40.9%	6.5	10.9%	5.4	9.1%	1.7	2.9%	1.6	2.7%
Vercelli-Casale Popolo	19.2	7.9	41.1%	19.2	100%	4.5	23.4%	3.0	15.8%	2.6	13.5%	2.1	11.0%	0.0	0.0%	0.0	0.0%
Cavallermaggiore-Moretta	15.3	1.9	12.4%	6.2	40.4%	0.0	0.0%	1.8	11.9%	0.0	0.0%	0.0	0.0%	0.0	0.0%	0.0	0.0%
Chivasso-Asti	51.3	29.3	57.1%	45.5	88.7%	8.3	16.2%	6.6	12.9%	4.1	8.0%	4.6	9.0%	1.7	3.3%	1.9	3.7%
Mondovì-Cuneo	30.2	12.5	41.4%	24.6	81.4%	11.0	36.4%	12.2	40.4%	6.7	22.2%	7.4	24.5%	4.4	14.6%	4.5	15.0%
Mortara-Casale Monferrato-Asti*	55.5	27.2	49.0%	43.2	77.8%	13.5	24.3%	12.8	23.0%	9.9	17.8%	8.8	15.8%	1.6	2.9%	1.6	2.8%
Pinerolo-Bricherasio-Torre	16.4	7.0	42.7%	16.4	100%	2.8	17.1%	9.1	55.5%	0.0	0.0%	4.4	26.8%	0.0	0.0%	0.0	0.0%

Pellice																	
Santhià-Rovasenda Alta-Romagnano Sesia-Borgomanero-Arona	65.0	52.2	80.3%	65.0	100%	18.0	27.7%	20.7	31.9%	2.6	4.0%	4.8	7.5%	0.0	0.0%	1.6	2.4%
Sum	**464.1**	263.7	**56.8%**	398.3	**85.8%**	101.4	**21.8%**	124.6	**26.9%**	46.3	**10.0%**	47.9	**10.3%**	11.4	**2.5%**	13.6	**2.9%**

The method developed has been designed to be applied to a regional or national scale, with the aim to provide land-use planners and decision makers with a tool able to maximize the utility of the always limited funds to invest, following a rigorous, transparent and participatory process (based on the stakeholder consultation and AHP). In this respect, the method allows firstly to sort the different sections of abandoned railways according to a priority score mirroring land-use planning objectives. In this way, decision-makers will be able to prioritize and concentrate the investments on those sections that show the highest GSI score. This procedure assigns a score to the individual sections but can also be applied to obtain a ranking of the entire railway lines (Figure 11), based on GSI value (Table 12).

Secondly, the method can also be used to attribute to each disused railway section a sort of "vocation" (i.e. touristic, commuting, etc.), in order to provide land use decision-makers with useful information for the planning process. The application of the method to the Piedmont region has also made it possible to carry out an "ex-post" evaluation of the recovery interventions already carried out. As can be seen in Figure 11, the two sections already recovered as greenways (Bricherasio-Barge and Airasca-Moretta) present in both scenarios a low value of GSI, even though in scenario 2 the value is higher. Looking at Figure 11, there are other lines that had more potentialities to be converted in greenways. The lack of a regional plan has, obviously, led to a choice which, although important at the local level, appears to be non-priority when viewed at regional level.

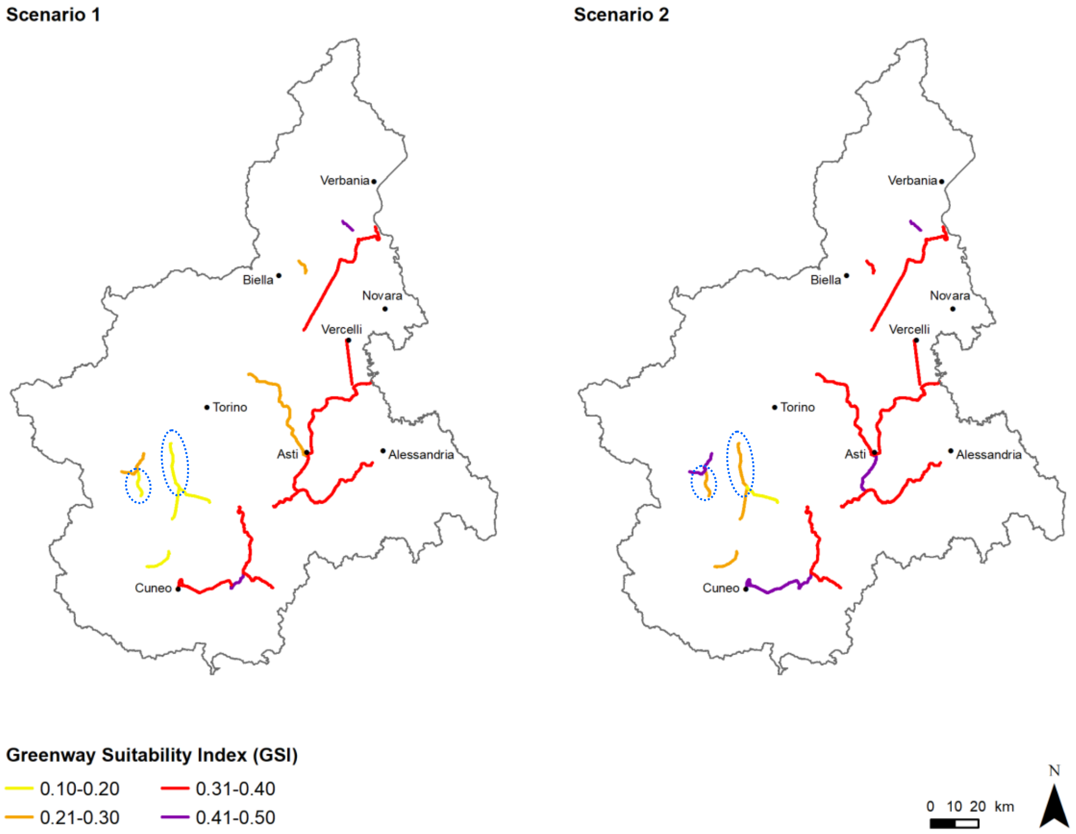

Figure 11 – Greenway Suitability Index (GSI) of the entire disused railway lines in Piedmont for scenario 1 (prevalent use for tourist purposes) and 2 (prevalent use for recreational purposes and daily travel).

The recovery as greenways of the abandoned railway lines should be integrated by the enhancement of the old stations for the creation of services for users and local communities. Supporting services, such as accommodation, bike rental and café, are very influential in determining the visitor’s experience (Taylor, 2015); moreover, considering disused railways and stations as integrated parts of a system can improve the greenways use (Ferretti & Degioanni (2017).

5. Conclusion

After 1950, the importance of railways declined with a significant percentage of the railway network closing from the 1960s onwards. All over the world, the railway heritage represents a potential value reusable to provide the new features that people communities demand, to support sustainable development and landscape regeneration processes. Disused railways can be converted into greenways dedicated to pedestrians, cyclists, skaters, horse riders and people with reduced mobility, and can be used for both leisure and tourism, and daily mobility. Moreover, through their conversion into greenways it’s possible to preserve old railway items, such as bridges, viaducts, tunnels, signals, distance markers, stations and auxiliary buildings; they are architectural and civil engineering elements of great value that can provide cultural experience for visitors and help to preserve the historical memory of the railway between the younger generation.

The growing interest and social demand for greenways often collides with the scarcity of public funds and recalls the need of choosing wisely among different alternative uses of public money. This triggers the urgency to provide analysts and decision-makers with tools able to evaluate each project in terms of its potential benefits and costs for local communities and its capacity to be attractive for users. This is a typical issue for land-use policy makers and planners and can be eventually tackled and solved at national or regional scale, rather than at the local one.

The objective of the study has been to provide a transferable working tool able to support decision-making and land-use planning processes (at regional or national scale) related to the conversion of disused railway lines into greenways in mixed urban and rural contexts. Only a few studies have investigated the development of tools to support decision makers in the choice of the best form of requalification of a disused railway and in the identification of disused railway lines suitable to a reconversion to greenways. In order to define a methodology to identify the priority abandoned railway lines to be converted into greenways, we built a framework including Geographical Information System to carry out spatial data analysis and analytic hierarchy process (AHP) for integrating the preferences of stakeholders in the assessment process. The methodology enables a straightforward analysis and assessment of, on one hand, the characteristics and actual conditions of the disused railways network and, on the other, their territorial and social context. The application of this methodology to the Italian region of Piedmont can represent an useful instrument for regional authorities, when they will decide to design the railway-to-greenways reconversion plan. For each section of disused railway, we calculate the Greenway Suitability Index (GSI), a global index obtained as a weighted sum of the importance of the different territorial characteristics (natural element, historical-cultural resources, traditional food and local wine, landscape/scenery, accessibility and population), in relation with specific scenarios.

The application demonstrated that the methodology can be used to calculate a sort of "priority score" considering stakeholder's preferences and allowing the land-use decision makers to concentrate the investments in a priority way. The methodology represents a transparent tool that decision makers can use -upon the definition of the goals of the planning process- to maximize the benefits of investments, directing the limited resources available towards interventions capable of attracting the greatest number of users. The implementation of the framework on a real and representative case of the heterogeneity of the Italian context proved to be effective for achieving the objectives and is replicable for other regions and countries, at it implies diffused GIS tools and easily available or collectable data. Finally, the proposed methodology makes it possible to understand the reasons why a specific disused railway line is potentially transformable in greenway or not, providing solid arguments in support of the suggested decisions.

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