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Soft Mobility Network for the Enhancement and Discovery of the Rural Landscape: Definition of a Masterplan for Alto Ferrarese (Italy)

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Abstract: The rural landscape can provide a wide range of cultural ecosystem services to humans through direct and in situ interactions. The benefits provided depend on the quality of the landscape, but also on the real possibility for people to access and enjoy it. One of the best ways is to do it in a "slow" way, namely active and non-motorized, through a soft mobility network. The goals of the study are: (i) to develop a methodology to plan a soft mobility network that enhances existing infrastructures and maximizes the cultural ecosystem services provided by rural landscapes; (ii) to validate the methodology in the Alto Ferrarese territory through defining a soft mobility masterplan at the supra-municipal scale. The method is made up of three phases: analysis, with the inventory of the resources to be connected and the paths that could potentially be used; assessment, with the evaluation of the suitability of the paths to realize the soft mobility network; and planning, with the definition of the masterplan for the study area. The application resulted in a proposed network of 525.2 km, hierarchized in a primary and a secondary network, and proved that the methodology is effective to maximize the use of existing paths (81% of the proposed network), and to connect the elements of interest (98.5% of the resources are within a distance of 500 m, and 86.4% within a distance of 100 m).

Keywords: soft mobility network; planning; rural tourism and recreation; rural landscape; cultural ecosystem services

Citation: Senes, G.; Parretta, C.; Fumagalli, N.; Tassinari, P.; Torreggiani, D. Soft Mobility Network for the Enhancement and Discovery of the Rural Landscape: Definition of a Masterplan for Alto Ferrarese (Italy). *Land* **2023**, *12*, 527. https://doi.org/10.3390/land12030527

Academic Editor: Alejandro Javier Rescia Perazzo

Received: 13 January 2023
Revised: 15 February 2023
Accepted: 20 February 2023
Published: 22 February 2023

1. Introduction

The environment and its natural components, through chemical, physical, biological and, more generally, ecological processes, provide irreplaceable support to the quality of life of humans and basic factors for sustainable economic development [1]. These processes provide the so-called ecosystem services (ESs), defined according to the Millennium Ecosystem Assessment (MEA) as "the set of direct and indirect benefits that humans derive from ecosystems" [2]. Based on this report, ecosystem services are classified into: (1) supporting services (such as soil formation, nutrient cycling and photosynthesis); (2) regulatory services (such as climate regulation, rainfall, waste, pollination and prey–predator relationships); (3) provisioning services (i.e., those services that provide nutritional and other resources, such as food and water, fibers and energy); (4) cultural services (i.e., those services that provide aesthetic, religious and cultural value) [3]. The main contribution of the MEA report is that it shows the link between the concept of ecosystem conservation and the direct and indirect socio-economic benefits that need to be conserved and, above all, redeveloped [2]. Similarly, at the European level, the work on environmental accounting undertaken by the European Environmental Agency (EEA) defined a common international classification of ecosystem services (CICES) [4]. According to this classification, three groups of ESs are identified: (i) provision (food, water, raw materials, etc.); (ii) regulation and maintenance (of the physical, chemical and biological conditions of the soil, water, air and habitats); (iii) cultural (spiritual, identity, aesthetic and cultural values, recreation and tourism) [5].

ESs, therefore, play an important role in interconnecting the social and ecological components of communities, providing benefits to both humans and ecosystems [6]. Through the planning and management of various social and ecological components, resilient systems can be maintained that provide ecosystem services in a sustainable manner [7].

Rural areas have been widely studied in relation to their "provisioning" ESs and, especially in recent years, also for their "regulating" ones. There is still a lack in the research related to the "cultural" ESs of the rural landscape, even though the European Landscape Convention [8] states that the rural landscape is the bearer of a diverse range of values, which are expressed through its ability to provide a plurality of ESs [9,10].

Cultural ESs are related to the capacity of the natural (or human modified) landscapes to provide benefits to humans through direct and in situ interactions or indirect and remote ones. The first type of interactions can be physical and experiential (active or immersive and passive or observational) or intellectual and representative ones (investigation, education, culture or heritage, aesthetic). On the other hand, the indirect interactions can be spiritual or symbolic or with a non-use value [4].

One of the best ways for human beings to benefit from direct and in situ interactions is to enjoy the landscape in a "slow" way [8]. In the last two decades, there has been a growing diffusion of and attention to soft mobility, namely active and non-motorized mobility (walking, cycling, etc.) as a healthy way to engage in both recreation and tourism and daily mobility, being able to discover, enjoy and appreciate the rural and urban landscape [11,12].

This growing demand for slow mobility is leading to an increase in the supply of soft mobility infrastructures at all territorial levels, finally even in Italy. For example, the Ministry of Sustainable Infrastructure and Mobility in 2017 approved the National System of Touristic Cycle Routes ("6000 km of quality cycling routes, for everyone, reserved exclusively for non-motorized journeys to enjoy the Italian landscape among natural and archaeological beauties" [13]). Still in 2017, the Ministry of Culture published the Atlas of Walking Paths, "Cammini" in Italian, "to valorize the network of historical, naturalistic, cultural and religious paths, a slow mobility network capable of promoting forms of sustainable tourism and enjoy the Italian landscapes [14]".

More recently, the Soft Mobility Atlas project was launched by the Italian Alliance for Soft Mobility (a network of 39 Italian national associations) and Rete Ferroviaria Italiana (the owner and manager of the Italian railway network, and related stations) [15].

Moreover, at the regional level, regions and provinces are making plans in order to realize and/or increase the networks of soft mobility infrastructures for low-speed travel and active mobility and tourism, integrating cycle routes, networks of paths, trails and greenways, in connection with touristic and local railway lines, in order to promote intermodal trips and limit, as much as possible, the use of private cars [16].

Soft mobility networks can be (or, better, should be) integrated into the so-called green infrastructure (GI) [17], that can be defined, according to the European Commission, as "a strategically planned network of high quality natural and semi-natural areas with other environmental features, which is designed and managed to deliver a wide range of ecosystem services and protect biodiversity in both rural and urban settings" [18]. In this sense, soft mobility networks could provide a continuous, interconnected public recreational green space for people to enjoy nature and the landscape in the open air [19] and benefit from the cultural ESs [20]. While GIs form natural vegetation corridors that become new habitats for wildlife, improve air and water quality, reduce flood flows and provide a range of other regulating ESs in both urban and rural environments [7,21]. This green and soft mobility network connects parks, neighborhoods, and private and public areas, and improves quality of life through outdoor recreational activities [22], which can have a positive impact on well-being [23], increase social interaction and inclusion [24] and encourage sustainable human interactions with nature [25].

As anticipated previously, despite the importance of assessing the ESs related to soft mobility and GIs [26], they have been investigated using "sectorial approaches". Ferrini et al. [27] studied the relationship between GIs and other spatial components considering vegetation variability (structure, composition, distribution and management). Tahvonen [28] described the integration of water and vegetation to improve stormwater management, using a scalar approach. Other studies have examined the relationship between GI and other land cover [29], landscape models [30], zoning [31,32] and socio-demographic variables [33]. Similarly, although the ESs of GIs are scientifically recognized [34], the integration of these concepts into planning processes is still a relatively unpracticed field of experimentation [35,36].

Cultural ecosystem services (Cult_ESs) provided by "direct, in-situ and outdoor interactions with rural landscape" (CICES V. 5.1) can be enjoyed by humans only if they have direct access to such services through an infrastructure network. This is particularly true in rural areas, while in urban ones the compactness of the built-up areas guarantees better accessibility to Cult_ESs [37].

To this end, planners should define with which elements of the landscape humans should interact and through which infrastructures the human interaction should take place (Figure 1). A well planned and designed soft mobility network can better guarantee these interactions in a slow and active way [8], enhancing the benefits provided by the Cult_ESs with the benefits of active mobility and physical activity. For this purpose, the valorization and adaptation of existing paths can help to achieve the sustainable development goals, according to the "3Rs" principle: reduce, reuse and recycle.

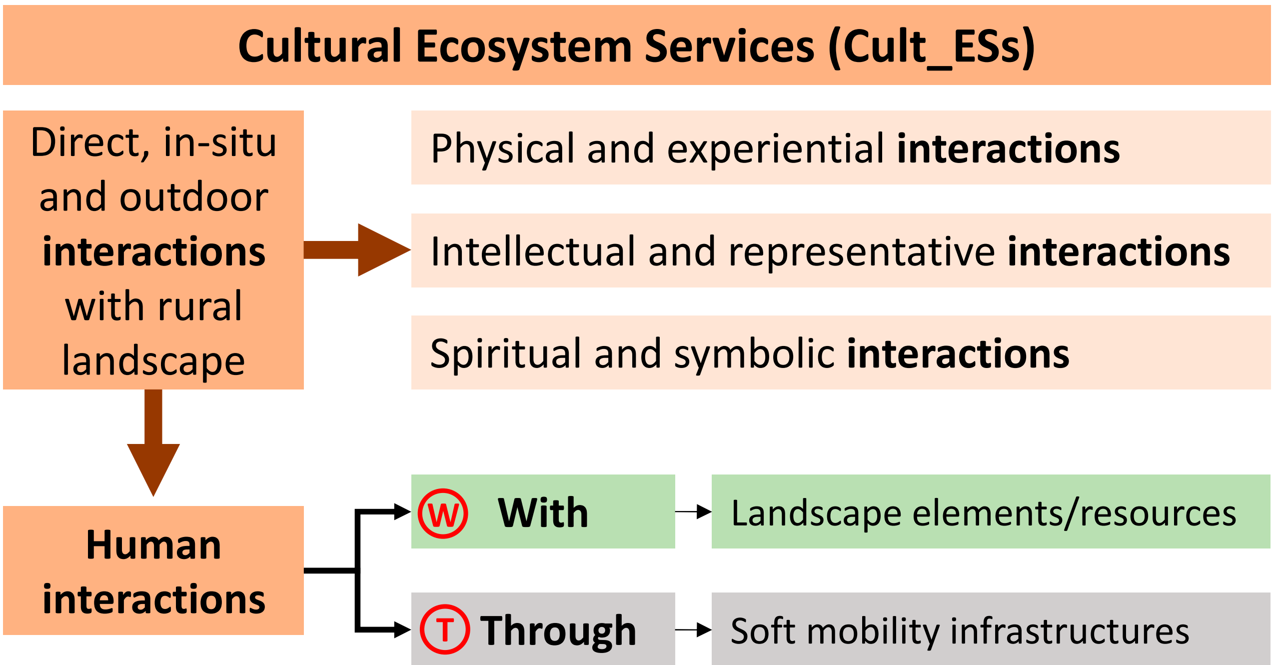

Figure 1. Conceptual framework of the planning goal for the enhancement of the cultural ecosystem services provided by the rural landscape (adapted by authors from CICES V. 5.1).

The evaluation of cultural ESs in the rural landscape is the area that has developed more recently, compared to the supply and regulatory groups, probably also due to the inherent difficulty in evaluating this type of service. In recent years, the scientific production concerning the evaluation of cultural ESs has certainly increased [38,39], but it has mainly focused on the urban context [40–42]. Unfortunately, on the other hand, the assessment of cultural ES in the rural landscape still suffers from a certain lack of scientific investigation [43], despite the fundamental role played by the rural territory in wide area planning (regional, provincial and park authorities).

Within this framework, the goals of the present work are: (1) to develop a methodology useful to plan a soft mobility network that is able to valorize existing infrastructures according to the "3Rs" rule of sustainability, that has recreational and touristic functions, and that maximizes the cultural ecosystem services provided by rural landscapes; (2) to validate the methodology in the Alto Ferrarese territory, defining a soft mobility masterplan at the supra-municipal scale. The supra-municipal scale is an intermediate level between the municipal and the provincial level, composed of a group of neighboring municipalities. It is the optimal scale in which detailed soft mobility infrastructure planning should take place, as the municipal level is too small while the provincial level could be too large.

2. Materials and Methods

The approach adopted for this study is inspired by the work of Toccolini et al. [44], which has provided, through several applications in Italy [45–47], valid and consistent results. Compared to these previous applications, the present study introduces the assessment of the "path value" and relative "corrective factors", useful for prioritizing the possible choices in the planning phase.

The general methodology [48,49] is divided into the following three phases (Figure 2):

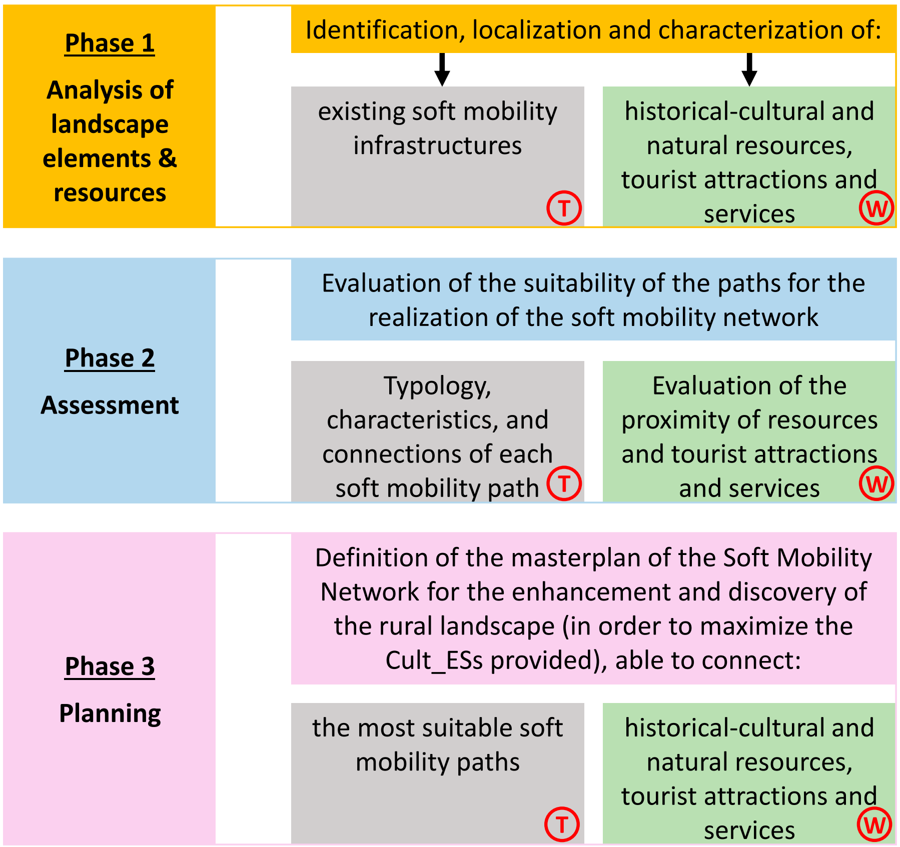

Figure 2. Methodology flow chart.

- Phase 1: Analysis of the landscape elements and resources that provides for the identification, localization, and characterization of the elements with (Ⓦ) which to enhance humans interactions (historical-cultural and natural resources, tourist attractions and services) and the existing paths through (Ⓣ) which people are supported to access the rural landscape that could potentially be used to build the soft mobility network.
- Phase 2: Assessment, which provides for the evaluation of the suitability of the paths for the realization of the soft mobility network, based, on the one hand, on the typology and characteristics of the soft mobility paths, and their connection with

national and regional routes (Ⓣ), and, on the other hand, on the proximity of the landscape resources and tourist attractions and services (Ⓦ).

- Phase 3: Planning, which provides for the definition of the masterplan for the soft mobility network of the study area, for the enhancement and discovery of the rural landscape (in order to maximize the Cult_ESs provided), is able to connect the historical-cultural and natural resources, and the tourist attractions and services (Ⓦ) through the most suitable soft mobility paths (Ⓣ).

The methodology has been applied to a case study in the Emilia-Romagna region, in order to validate the procedure.

The study area (Figure 3) is the "Union of Municipalities" of Alto Ferrarese in the Province of Ferrara, which includes five municipalities (Bondeno, Cento, Vigarano Mainarda, Terre del Reno and Poggio Renatico), in an area of about 413 km^2 with 76,000 inhabitants, located West of the city of Ferrara and South of the Po River.

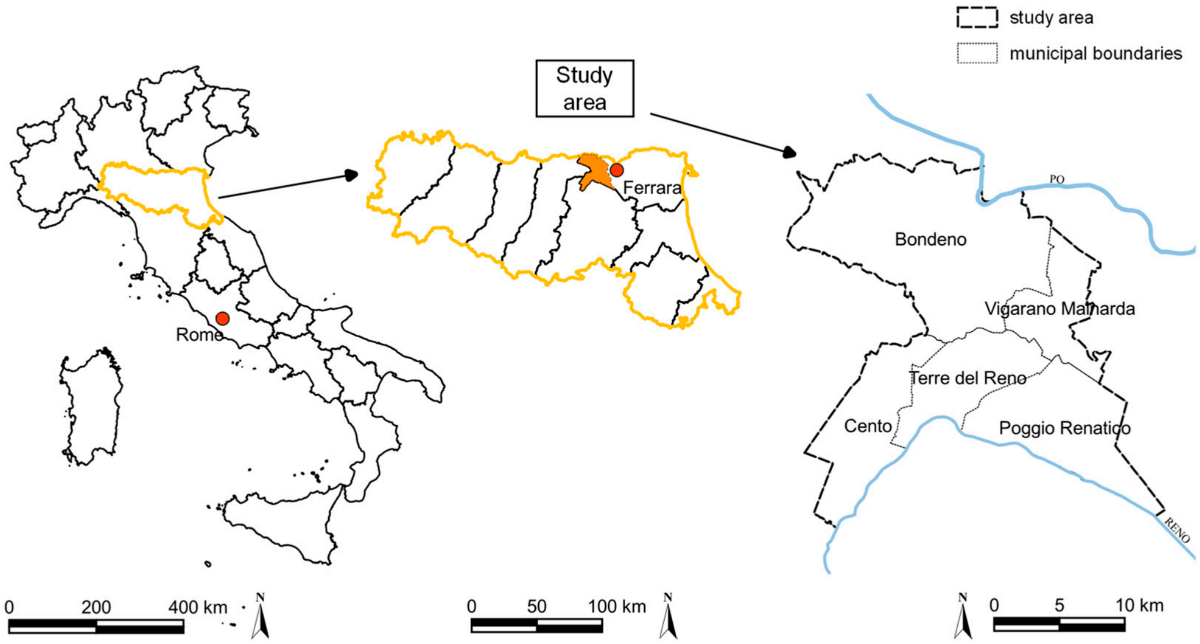

Figure 3. Case study area.

It is a flat area located in the Po valley and characterized by a dense network of irrigation canals. The actual morphology has been determined by the extensive reclamation works carried out to regulate the water. From a geomorphological point of view, the study area is marked by a typical lowland layout, with some evidence of paleo or active riverbeds (the 'Dossi') that represent the only "elevated" landscape signs of the historical evolution of the territory.

The land use of the study area is almost entirely agricultural, and it is still possible to observe some signs of an ancient form of collective ownership of the land in the 'Partecipanze' system of Cento.

Natural areas, usually connected to the presence of water, are fragmented, and represent relicts of flora and fauna that have now disappeared in the rest of the territory due to the transformations produced by the reclamation works.

In recent decades, the population of the area has been decreasing, as in other Italian agricultural areas. Tourism can represent a possibility to interrupt this trend.

All the data used have been processed using the ArcGIS software (version 10.8.1).

2.1. Phase 1: Analysis

The analysis phase allows for the identification, localization and characterization of both the resources to be connected (historical-cultural and natural resources, tourist attractions and services) and the existing paths in the study area [45]. The information was mainly obtained by consulting the geographical databases available from the Province of Ferrara and the municipalities. Some of the data were, instead, acquired on the GIS through the digitization of aerial photos by the authors.

2.1.1. Resources

Historical-cultural and natural resources, tourist attractions and services of the study area have been identified and mapped. They represent, on the one hand, the destination of travel along a route and, on the other, they characterize and qualify their presence along the route itself [45]. The typology, quantity and quality of the resources are directly related to the cultural ecosystem services provided by the rural landscape crossed by the soft mobility network that connects them, and that can be enjoyed by the people that use it on a daily basis (e.g., to reach places of work or study) or for recreational and touristic purposes.

Given the focus of the study, only the elements of interest in the rural areas have been considered, while the urban centers have been considered only as a possible origin for the trip. The elements of interest mapped are: (1) historical-architectural and cultural elements (such as UNESCO sites, villas, historical palaces, castles, fortresses, churches, monuments and museums); (2) signs of the historical evolution of the territory related to the landscape and human activities (such as signs of the reclamation of the lower Ferrara plain, or the 'Dossi' and 'Partecipanze' system); (3) natural resources (such as protected areas, forests, ecological corridors, etc.); (4) elements of the rural landscape that can represent an attraction or a service for tourists and visitors (such as rural accommodation and facilities, farmhouses, farms with direct sales, educational farms, certified historic villages); (5) international and national cycle and/or pedestrian historic routes that can bring tourists to the study area or that can be reached by the residents.

Finally, the urban centers in the study area have been mapped too.

2.1.2. Existing Paths Potentially Usable for the Creation of the Soft Mobility Network

The network of existing soft mobility paths that can connect or cross the mapped resources and elements of interest have been identified and mapped in detail, using available databases, remote data and on-site surveys, registering all the physical characteristics related to the potential users (pedestrians, cyclists, horseback riders, skaters, etc.) [45].

In some cases, the collection of data and mapping have been extended beyond the municipal boundaries, in order to be able to incorporate the network into a larger-scale system and connect it with existing national cycle and/or pedestrian routes.

The different typologies of paths have been mapped: (1) paths physically separated from ordinary roads (such as marked bicycle and pedestrian paths not along ordinary roads, non-vehicular agricultural roads); (2) dedicated paths on the roadway but physically separated from ordinary traffic (such as cycle paths separated by kerbs or barriers); (3) cycle lanes separated only with road markings; (4) low-traffic roads, such as minor rural roads with limited traffic (that can be or are already used for cycling), which can be useful for completing the soft mobility network.

Several characteristics of the paths have been surveyed, such as the type of surface, the presence of dangerous sections, the state of maintenance, the accessibility and practicability of the paths for different user groups, the coincidence with national cycle or pedestrian paths. All these characteristics were referred to each single homogeneous stretch [44].

Moreover, in order to improve the tourist-recreational function of the network and the intermodality, equipped rest areas, car parking lots, railway stations and existing and planned piers along navigable rivers and canals have been mapped too.

2.2. Phase 2: Assessment

The objective of this phase is to evaluate the existing routes based on their suitability for the realization of the soft mobility network [45]. The inventoried paths were assessed with regard to both their physical characteristics and the surrounding landscape conditions.

Each typology of path has been evaluated for the capacity to attract users and allow them to enjoy the landscape and benefit from the relative cultural ESs. Based on this evaluation, a related score, the "path value", has been calculated.

The assessment of the surrounding landscape was based on several elements able to increase or decrease its value: the land use crossed by the path, the presence of historical and cultural elements or UNESCO sites, and the belonging of the paths to a historic or national route. These surrounding landscape conditions have been considered as a "corrective factor" of the "path value".

The Emilia-Romagna land-use classification, consistent with the CORINE Land Cover project, has been used. A correction factor has been attributed to each land-use class: positive (+0.1) if it constitutes an added value to the routes in terms of landscape perception, negative (−0.1) if it constitutes an unfavorable character, null (0) if it has mainly a neutral impact. The attribution of these correction factors to existing routes was based on the concept of visual landscape interference [47,50]. According to this concept, an 'area of influence' was defined to reflect the physical limit of perception of the landscape crossed by a potential user. A study of the literature made it possible to identify an area of influence of 200 m that takes into account the almost entirely flat character of the study area as well as the speed of route users [47]. On this basis, a 200 m buffer around the existing paths was calculated and then intersected with the land use layer. For each stretch of the existing paths, the prevailing land use and the relative correction factor have been calculated.

The same procedure has been applied to consider the presence of areas of historical, cultural, and tourist-recreational importance and the proximity of international and national cycle and/or pedestrian historic routes. After all correction factors (minus and plus) have been assigned, a total score for each stretch of the existing paths has been calculated.

2.3. Phase 3: Planning

The objective of this phase is to define the overall masterplan of the future soft mobility network, in order to maximize the cultural ESs provided by the rural landscape, allowing people to discover and enjoy it. The network planned should connect the historical-cultural and natural resources, and the tourist attractions and services making the most of the existing paths of greatest value. To this end, several criteria have been defined in order to prioritize the possible choices.

The first criterion is related to the resources to be connected. Since the planned network has a predominantly tourist-recreational purpose, maximum importance was given to the connection between urban centers and the elements of interest.

These elements have been classified according to their importance. The primary resources include: cultural, historical and natural features (UNESCO sites, historic towns, certified villages, castles fortresses and towers, the main religious buildings, villas, museums, historic settlements and the main areas of natural interest); intermodal connections (existing and planned dockings, and railway stations); and the main tourist routes through the study area. The primary resources are those recognized at national or international level, based on the indications of the Italian Ministry of Culture and the most important tourist organizations (e.g., Touring Club Italiano).

The secondary resources include the other elements of historical-architectural or cultural interest that are not of primary importance, such as accommodation and tourist facilities, farmhouses, educational farms, and farms with direct sales, which are fundamental for completing the territory's tourist-recreational proposal. The secondary resources have been identified on the basis of indications from regional or provincial tourist organizations.

The second criterion concerns the path's score and the network linearity. The routes that use existing stretches as much as possible have been preferred [51], and, among these, are the ones with the highest score. At the same time, the selection aims to avoid winding routes that excessively lengthen the distances to be covered [52,53]. A high route score incorporates the criteria of separation from vehicular traffic (and thus of road safety), pleasantness and well-being mentioned above, and maximizing the possibility for the users to benefit from the cultural ecosystem services provided by the surrounding rural landscape. According to [53], compared to a road without cycling infrastructure, tourists are willing to double their cycling time in order to cycle on a cycle path fully segregated from traffic, and to increase it by 40–50% in order to cycle on a road with a cycle lane.

The classification of resources allowed for the defining of a "primary network", connecting the primary resources, and a "secondary network", connecting the primary network with the secondary resources.

For the definition of the network proposal, the suitable existing paths (both for the primary and secondary network) have been selected and potential sections for completing the network identified.

3. Results and Discussion

3.1. Results of the Analysis Phase

The analysis phase made it possible to identify and map 160 elements of interest (Table 1 and Figure 4). Most of these elements are signs of the historical evolution of the territory, especially hydraulic artefacts (41 in total), placed predominantly in the North of the study area, where the land reclamation mostly occurred. Another sign is the meaningful existence of historical landscape elements, such as the 'Dossi' (evidence of paleo or active riverbeds) and the 'Partecipanze' (the historical agricultural settlement system). There is also a relevant presence of farmhouses and rural accommodation (48 in total) to serve as attractions or services for tourists and visitors. Historical-architectural and cultural buildings are few (19 in total) and are mostly located around the UNESCO site.

Table 1. Elements of interest in the study area.

Class	Type	Quantity	
		Number	Hectares/km
Historical-architectural and cultural elements	UNESCO site	1	13,176 ha
	Fortress and castles	4	
	Historical palaces and villas	3	
	Museums	1	
	Religious buildings	6	
	Other places of interest	5	
Signs of the historical evolution of the territory	Ferrara city	1	
	Certified villages	2	
	Historical settlements	3	
	Hydraulic artefacts	41	
	'Dossi'	15	
	'Partecipanze' system		2218 ha
Rural landscape elements as attractions or services for tourists and visitors	Educational farms	3	
	Farms with direct sales	19	
	Farmhouses	12	
	Accommodation and hospitality facilities	14	
	Protected areas	4	
Natural resources	Nature reserves	2	978 ha
	Protected wildlife areas	6	1304 ha
	Forests	6	201 ha
	Areas of landscape-environmental interest	7	3257 ha
International and national cycle and/or pedestrian historic routes	'VenTo' cycle route	1	19 km
	'Sole' cycle route	1	0 km
	Way of St. Antony	1	11 km
	'Romea Germanica' way	1	0 km

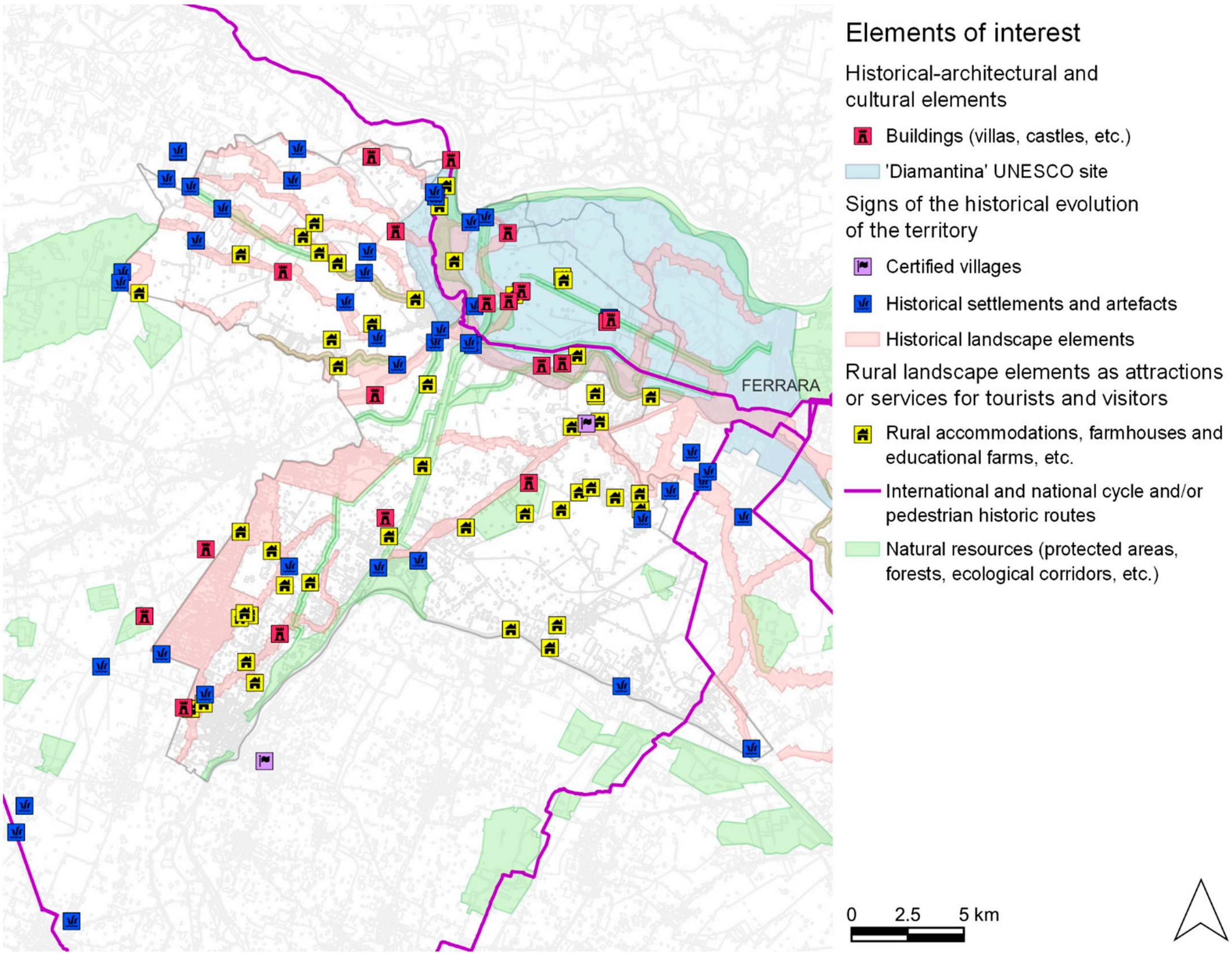

Figure 4. Elements of interest mapped in the study area.

The study area has a prevalent agricultural land use (82% of the total surface) and, like most of the territories in the Po Valley, has a small number of natural areas. These areas are relicts of the flora and fauna that has now disappeared in the rest of the territory and are mainly found near rivers and canals. With regard to national/international cycle/pedestrian routes, the area is crossed by the national touristic cycle route 'VenTo' (that connects Venice to Turin) and by the pedestrian pilgrim route 'the Way of Saint Antony'. The study area is also close to the 'Sole' national touristic cycle route (southwest) and the international pedestrian pilgrim route the 'Romea Germanica Way' (far west, crossing the city of Ferrara). These routes are crucial for the connection of the study area with the larger-scale active tourism network.

Overall, the dispersed spatial distribution of the elements of interest will require the planning of a widespread soft mobility network within the study area to reach them all.

The survey of the study area revealed an extension of 565.6 km of existing paths potentially usable for the creation of a soft mobility network, with another 106 km of pathways in the close surroundings (Figure 5). These paths are sufficiently diffused across all the study area, even though their concentration is greater in the southwest (Cento municipality), due to the higher urbanization and consequent presence of settlements and roads.

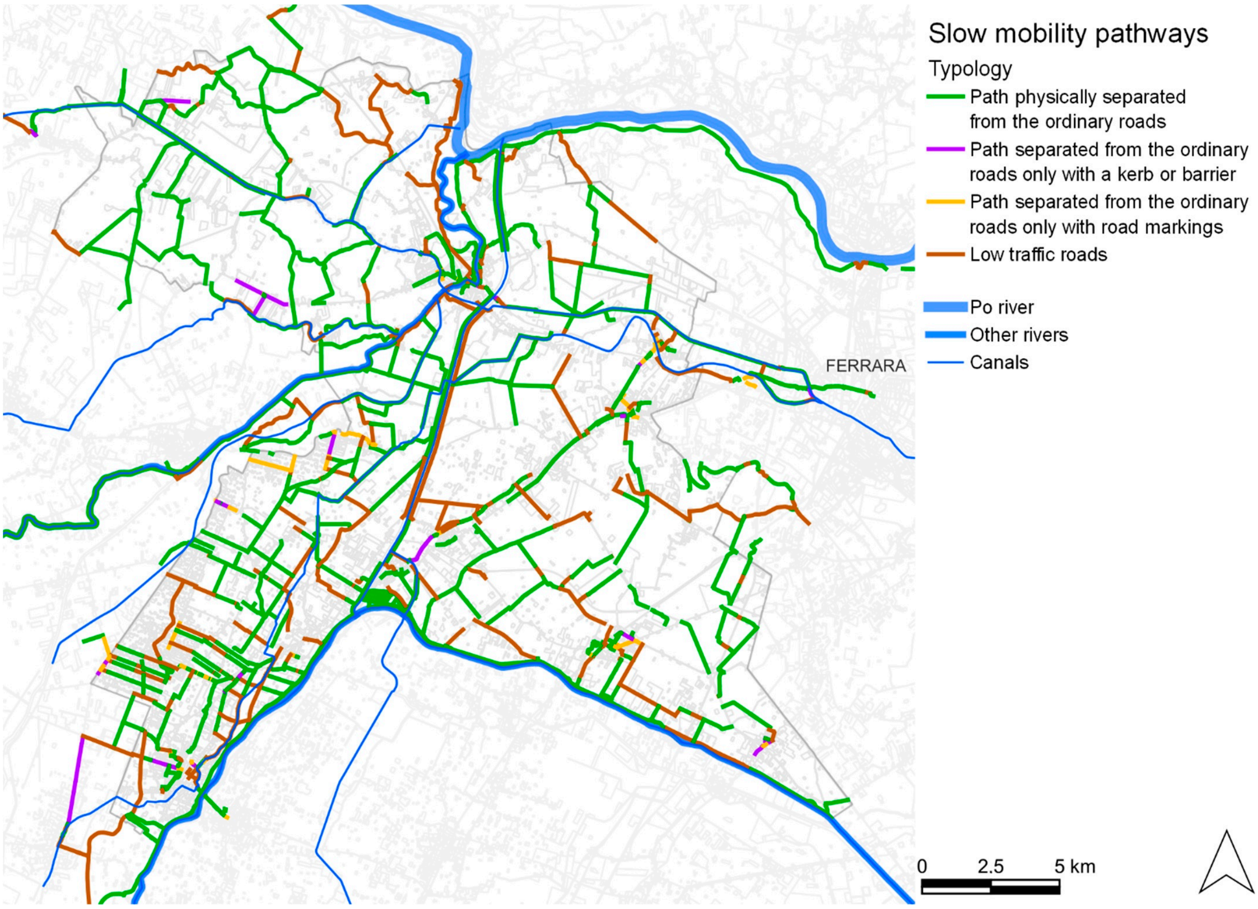

Figure 5. Existing paths surveyed in the study area.

According to the results in Table 2, 68.7% (388.3 km) of the paths are physically separated from ordinary roads, but the majority of them (309.8 km) are non-vehicular agricultural roads. The existing infrastructures specifically dedicated to soft mobility (cycle and cycle-pedestrian paths, cycle and cycle-pedestrian lanes) are only 74.6 km (13.2% of the total paths surveyed), to which it is possible to add 18.7 km of trails in the rural areas and 7.7 km of pedestrian zones in the urban centers.

The existing paths are predominantly (51.5%) located on a dedicated roadway, segregated from traffic. Even though they stretch for less than 100 km, there are paths placed on canal towpaths, on riverbanks or nearby them, that could become significant from a scenic point of view.

The 39.4% of the paths have an impervious surface (sealed pavement): 155 km of low-traffic roads, 45.4 km of cycle and footpaths and all cycle and footpath lanes fall into this class. Moreover, almost the totality of paths (94.7%) are more than 2 m wide and flat (98.9%).

Although the study area is not included in the major national and international tourist circuits, the investigation of the territory underlines the presence of elements of interest that are adequate in both number and spatial distribution to promote active recreation and tourism and the related cultural ESs. The choice of such study area demonstrates that the methodology developed is able to adequately valorize rural areas, even if not for outstanding natural beauty.

Table 2. Classification of the surveyed paths.

	Characteristic	Length (km)	Length (%)
Typology	Path physically separated from the ordinary roads	388.3	68.7%
	Cycle-pedestrian path	47.7	8.4%
	Cycle path	4.4	0.8%
	Trail	18.7	3.3%
	Non-vehicular agricultural road	309.8	54.8%
	Pedestrian zone	7.7	1.4%
	Path separated from the ordinary roads only with a kerb or barrier	9.9	1.8%
	Cycle-pedestrian lane	8.1	1.5%
	Cycle lane	1.8	0.3%
	Path separated from the ordinary roads only with road markings	12.6	2.3%
	Cycle-pedestrian lane	11.6	2.1%
	Cycle lane	1.0	0.2
	Low-traffic road	154.7	27.2%
Location	On canal towpath	42.2	7.5%
	On riverbank	41.1	7.2%
	Nearby canal or river	16.4	2.9%
	On sidewalk	11.1	2.0%
	On dedicated roadway (segregated from traffic)	291.0	51.5%
	On ordinary roadway	23.0	4.0%
	In urban areas	40.5	7.2%
	In suburban areas	100.3	17.7%
Surface	Sealed pavement	222.7	39.4%
	Porous pavement with grass strip	61.9	10.9%
	Porous pavement: hard	185.6	32.8%
	Porous pavement: soft	95.1	16.8%
	Other pavements (wood, metal)	0.2	0.0%
Width	<1 m	1.3	0.2%
	1–2 m	28.7	5.1%
	>2 m	535.4	94.7%
Level	Raised above the surrounding area	0.6	0.1%
	On a bridge	3.5	0.6%
	Underpass	0.2	0.0%
Slope	Sloping	5.8	1.0%
	Flat	559.6	98.9%
Accessibility	Free	533.8	94.4%
	Restricted	19.5	3.5 %
	Prohibited	12.0	2.1%

In fact the area may provide recreation, spiritual, educational and cultural benefits as well as sense of place and identity. In particular, the connection with the urban centers, or their proximity to the resources, satisfies the recreational needs of residents and tourists, and also may promote the establishment of tourist facilities, as well as local handicraft shops and shops selling local food products [54]. The categories of elements, necessary to understand the landscape adequately [55], are in line with the cultural objective of the study [56] and they may contribute to define similar planning methods. As most of the elements surveyed are signs of the historical evolution of the territory, farmhouses and rural accommodation, one might think of defining thematic itineraries for tourists that allow the identity of the territory to be discovered and enhanced [57].

Considering that soft mobility allows for sustainable fruition enhancing the territory without altering its landscape and environmental characteristics [58], existing linear paths were chosen to connect the rural resources, in line with the literature and best practices [45,47,56,57], as it minimizes any environmental and cultural impact on the landscape [59] and involves a low investment cost [45]. The survey reveals a high number of paths existing inside the study area and in the close surroundings. Most of them are physically separated from the ordinary roads and therefore demonstrate a high degree of suitability to be used in a soft mobility network as they might guarantee road safety and pleasure [45]. At the local level, the accurate survey of routes contributes to filling the gaps in outdated municipal and provincial plans.

3.2. Results of the Assessment Phase

In this phase we assessed the capacity of the existing paths to allow users to enjoy the rural landscape and the relative cultural ecosystem services provided, calculating the relative "path value", which depends on its typology ("path score") and the surrounding landscape ("corrective factors").

Regarding the paths, almost 73% of them have a score greater than 1 (Table 3). Regarding the land use crossed by the paths, 61.3% are "neutral", not presenting elements of particular value, while as many as 1607 ha (24.6%) present a positive corrective factor, and only 920 ha (14.1%) have a negative impact (Table 3).

Table 3. Different path typologies and land-use classes in the study area.

Typology of the Path	**Path Score**	**Total Length**	
		(km)	**(%)**
Path physically separated from the ordinary roads	2	388.3	68.7%
Path separated from the ordinary roads only with a kerb or barrier	1.6	9.9	1.8%
Path separated from the ordinary roads only with road markings	1.2	12.6	2.3%
Low-traffic roads	1	154.7	27.2%
Land Use	**Corrective Factor**	**Total Area**	
		(ha)	**(%)**
Dumps, industrial and commercial areas, residential areas, construction sites, quarries, airports and heliports, railways and motorways, roads, energy and communication plants, amusement parks.	−0.1	920	14.1%
Sparse residential areas, arable land, livestock settlements, nurseries, uncultivated areas, cemeteries, golf courses and sports facilities, campsites and hotels, roadside green areas.	0.0	3999	61.3%
Woods, poplar and other wood crops, meadows, orchards and vineyards, horticultural crops, parks and urban green areas, rivers and canals, vegetated areas (shrubs and trees), wetlands, water bodies, villas.	+0.1	1607	24.6%
		6526	100.0%

The overall "path value" (ranging from 0.9 to 2) is calculated according to Formula (1):

$$PV_{[0.9-2.4]} = PS_{[1.0-2.0]} + LUCF_{[-0.1-+0.1]} + HLCF_{[0;\ 0.1]} + TRCF_{[0;\ 0.1]} \quad (1)$$

where (Table 4):

Table 4. Scores and indexes used for the assessment phase.

Typology of the Path		Path Score	Index
Path physically separated from the ordinary roads		2	*PS*
Path separated from the ordinary roads only with a kerb or barrier		1.6	
Path separated from the ordinary roads only with road markings		1.2	
Low-traffic roads		1	
Surrounding Landscape Elements	**Criteria**	**Corrective Factor**	**Index**
Land use Dumps, industrial and commercial areas, residential areas, construction sites, quarries, airports and heliports, railways and motorways, roads, energy and communication plants, amusement parks.	mainly negative	−0.1	*LUCF*
Sparse residential areas, arable land, livestock settlements, nurseries, uncultivated areas, cemeteries, golf courses and sports facilities, campsites and hotels, roadside green areas.	mainly neutral	0	
Woods, poplar and other wood crops, meadows, orchards and vineyards, horticultural crops, parks and urban green areas, rivers and canals, vegetated areas (shrubs and trees), wetlands, water bodies, villas.	mainly positive	+0.1	
Historical landscape elements and signs and UNESCO sites	crossed not crossed	+0.1 0	*HLCF*
International and national cycle and/or pedestrian historic routes	part of not part of	+0,1 0	*TRCF*

PV is the composite "path value";

PS is the "path score", ranging from 1 to 2 and defined by the 'typology of the path';

LUCF is the land use corrective factor (ranging from −0.1 to +0.1) resulting from the land use assessment;

HLCF is the historical landscape corrective factor, ranging from 0 to 0.1;

TRCF is the touristic route corrective factor, ranging from 0 to 0.1, for the paths that are part of the "VenTo" cycle route.

The overall "path value" (*PV)* has then been normalized to a 0–1 interval, according to the following Formula (2).

$$NPV_{[0-1]} = \frac{(PV - PV_{min})}{(PV_{max} - PV_{min})} \quad (2)$$

where:

NPV is the "normalized path value", ranging from 0 to 1;

PV_{min} is equal to 0.9;

PV_{max} is equal to 2.4.

As shown in Figure 6, almost 400 km of the existing paths (69.4%) fall into the two highest value classes of normalized path value, and a good percentage (36.5%, equal to 206.6 km) with a value greater than 0.75.

Figure 6. Normalized path value (NPV) of the existing paths.

The distribution and interconnection of the paths with a high *NPV* (>0.75) in the study area are shown in Figure 7. These paths are mainly located in the northern part of the study area, but they are sparse and discontinuous. Similarly, even considering the high–medium *NPV* paths (from 0.50 to 0.75), it is not possible to guarantee the continuity of the network. Therefore, the proposed soft mobility network will also have to incorporate paths with a lower NPV. On the other hand, the existing paths appear to be suitable to connect most of the elements of interest.

The criteria proposed by the present study for the identification of the most suitable paths to enhance the cultural ESs of the rural landscape [54], are based on previous studies related to land-use suitability [60–62], the user's visual perception and landscape assessment [63,64]. According to these studies, natural land uses are more favorable than artificial ones and, in particular, the highest scores were recorded for areas with woodlands and water bodies. At the same time, the main cultural elements of the rural landscape were taken into account, relying on cultural ESs studies [5,38,43,65]. This evaluation also makes it possible, once the network is defined, to verify that the routes actually meet the requirements of road safety, well-being and promotion of the area.

The assessment revealed that most parts of the study area have a "neutral" land-use corrective factor. Despite the low level of naturalization in the study area, attributing a positive value to water courses resulted in a good positive percentage of land use, due to their significant presence. The land-use assessment, together with the other values for the surrounding landscape elements and the typology of the paths, resulted in a significant number of total paths with a high *PV*. This highlights the potential of the Alto Ferrarese rural area for the enhancement of cultural ESs and the development of a soft mobility network.

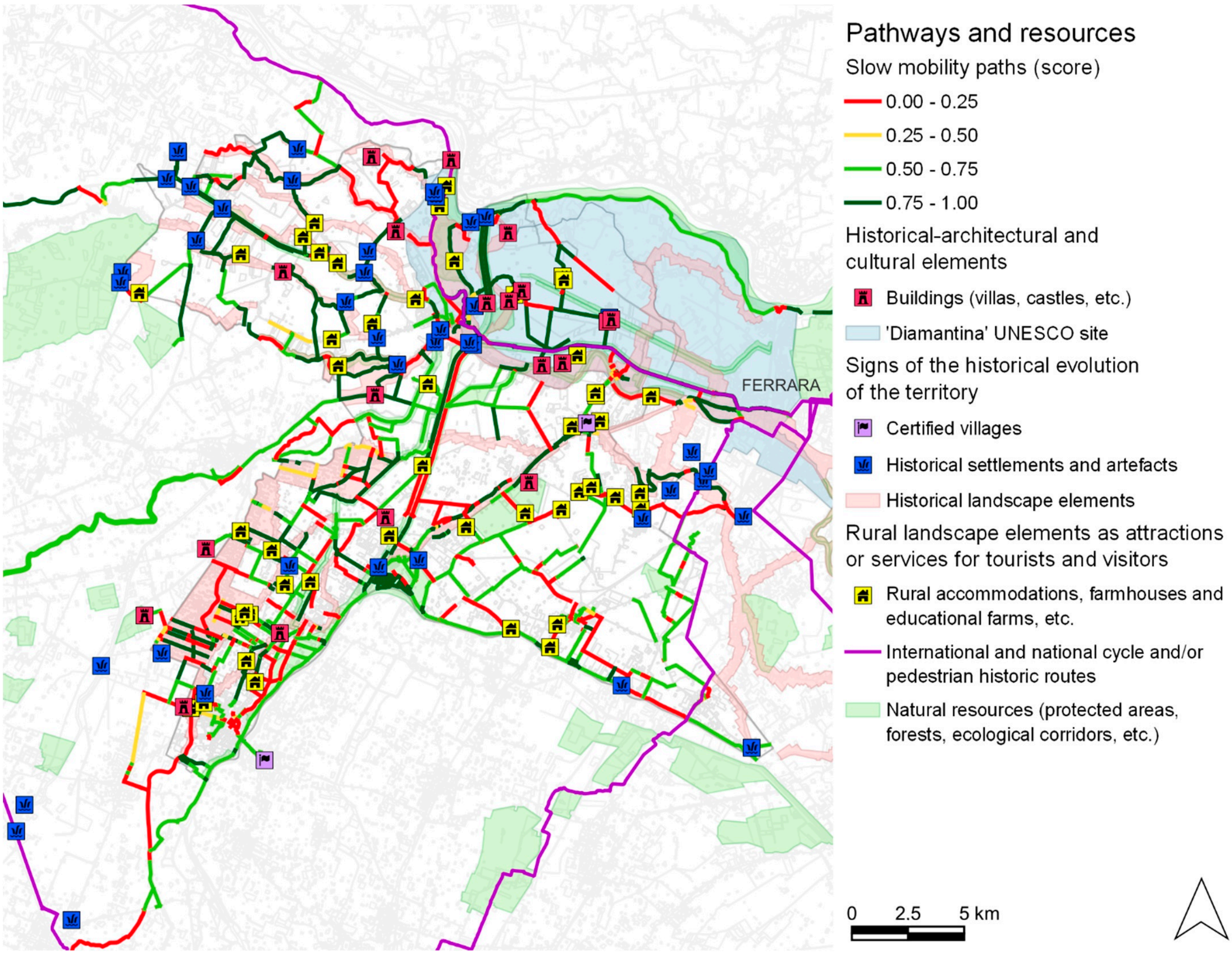

Figure 7. *NPV* of existing paths and landscape resources.

3.3. Results of the Planning Phase

As anticipated in the previous paragraph, the goal of this phase was to define the general masterplan of the future soft mobility network, in order to maximize the cultural ESs provided by the rural landscape allowing people to discover and enjoy it.

The study proposes a network, hierarchized into a primary and secondary network, that is sufficiently developed within the territory to be used by a large number of potential users. The network is able to connect almost all the elements of interest within the territory so that users can enjoy a greater number of rural resources and environmental heritage sites (i.e., cultural ESs). The masterplan has defined a "primary network" that connects the primary resources (35.6% of the total resources), and a "secondary network" that connects the primary network to the elements of interest that are of secondary importance (54.9%).

The general masterplan provides a soft mobility network of 525.2 km, 68% of which (356.2 km) constitutes the primary network, while the remaining 32% (169 km) constitutes the secondary network (Table 5).

Table 5. Characteristics of the proposed soft mobility network.

		Primary Network Length (km)	Primary Network Length (%)	Secondary Network Length (km)	Secondary Network Length (%)
	Total network	356.2	100.0%	169.0	100.0%
	Existing paths	294.7	82.7%	131.2	77.6%
	Missing paths	61.5	17.3%	37.8	22.4%
Typology	Path physically separated from the ordinary roads	209.0	70.9%	90.7	69.2%
	Cycle-pedestrian path	34.1	11.6%	5.4	4.1%
	Cycle path	2.6	0.9%	0.1	0.1%
	Trail	6.2	2.1%	1.8	1.4%
	Non-vehicular agricultural road	163.9	55.6%	82.1	62.6%
	Pedestrian zone	2.2	0.7%	1.3	1.0%
	Path separated from the ordinary roads only with a kerb or barrier	4.7	1.6%	2.7	2.0%
	Cycle-pedestrian lane	3.2	1.1%	2.7	2.0%
	Cycle lane	1.5	0.5%	0.0	0.0%
	Path separated from the ordinary roads only with road markings	7.6	2.6%	1.8	1.3%
	Cycle-pedestrian lane	7.4	2.5%	1.6	1.2%
	Cycle lane	0.2	0.1%	0.2	0.1%
	Low-traffic road	73.4	24.9%	36.0	27.4%
Location	On canal towpath	27.0	9.2%	1.3	1.0%
	On riverbank	40.3	13.7%	0.0	0.0%
	Nearby canal or river	8.6	2.9%	0.0	0.0%
	On sidewalk	2.9	1.0%	2.7	2.1%
	On dedicated roadway	137.7	46.7%	86.8	66.2%
	On ordinary roadway	12.2	4.1%	4.3	3.3%
	In urban areas	15.4	5.2%	10.1	7.7%
	In suburban areas	50.5	17.1%	25.9	19.7%
Surface	Sealed pavement	121.6	41.3%	43.6	33.2%
	Porous pavement with grass strip	31.4	10.7%	18.5	14.1%
	Porous pavement: hard	85.5	29.0%	50.2	38.2%
	Porous pavement: soft	56.0	19.0%	18.8	14.4%
	Other pavements (wood, metal)	0.2	0.1%	0.0	0.0%
Width	<1 m	0.2	0.1%	0.0	0.0%
	1–2 m	8.1	2.7%	5.8	4.4%
	>2 m	286.4	97.2%	125.4	95.6%
Level	Raised above the surrounding area	0.2	0.1%	0.0	0.0%
	On a bridge	2.3	0.8%	0.7	0.5%
	Underpass	0.2	0.1%	0.0	0.0%
Slope	Sloping	2.8	0.9%	1.2	0.9%
	Flat	291.9	99.1%	130.0	99.0%
Accessibility	Free	275.8	93.6%	123.3	93.9%
	Restricted	11.1	3.8%	5.8	4.4%
	Prohibited	7.8	2.6%	2.1	1.6%

The method proposed allowed for making the most of the existing paths, so much so that 81.1% (425.9 km) of the overall proposed network is made up of existing paths and only 99.3 km is needed to complete it and obtain a full network. Most of these “missing paths” have limited extension (Figure 8) and can be implemented with different types of solutions, depending on the budget available.

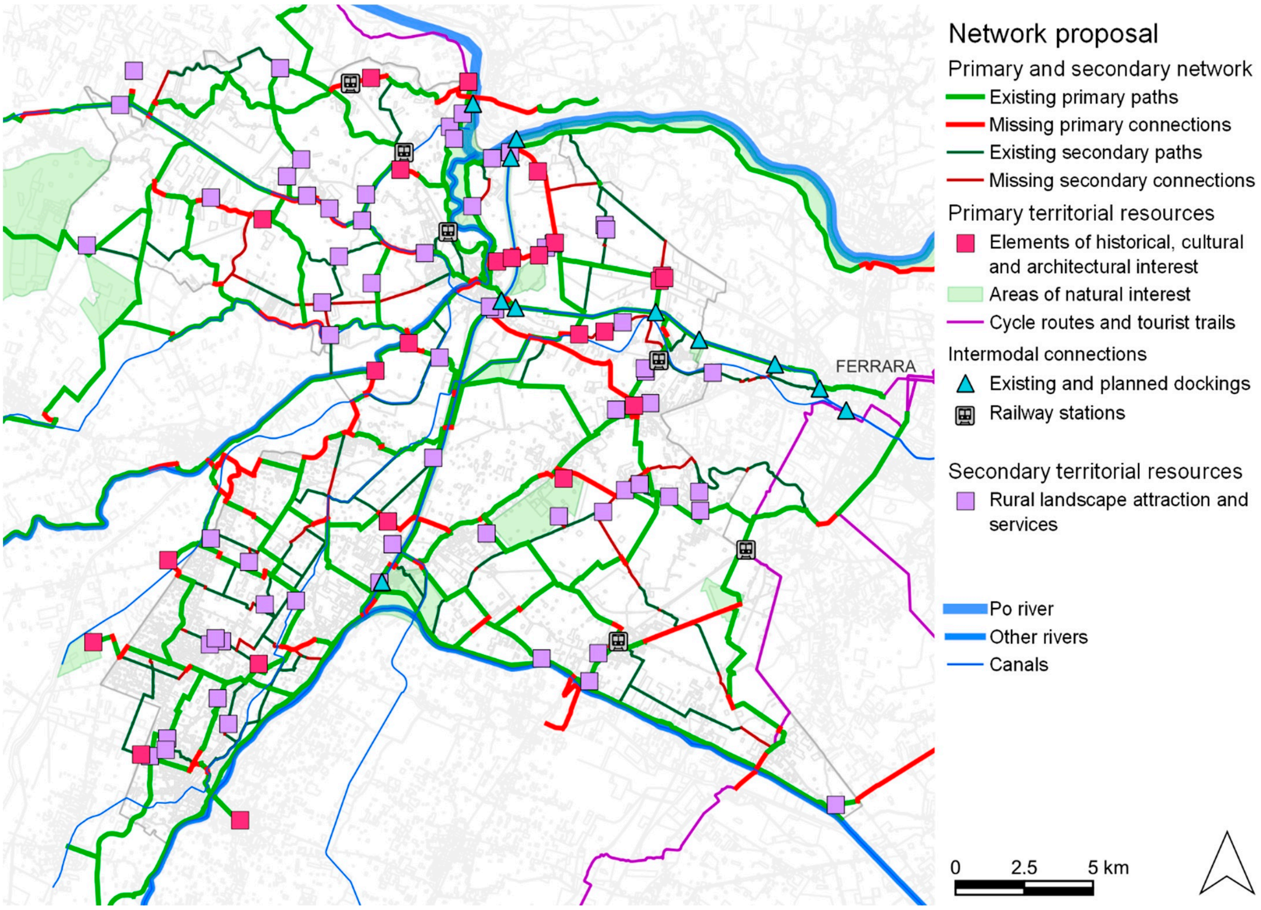

Figure 8. The proposed soft mobility network.

The methodology proved to be effective to maximize the use of the existing paths. In these terms, the study emphasizes the fundamental role of the re-use of existing infrastructure for sustainable spatial planning. This result is very important because, before building new infrastructures for soft mobility, it is preferable to enhance the existing ones, and then plan punctual interventions to reconnect the existing network and to connect rural areas with urban centers [51].

Approximately a quarter of the existing paths (140 km) surveyed in Phase 1 have not been included in the proposed network, for the following reasons: (i) they have a low score and there are higher-scoring paths that connect the same points of interest; (ii) they have limited accessibility or other characteristics that limit their use; (iii) they are isolated routes or difficult to connect with others; (iv) they do not constitute functional connections and are winding.

Their exclusion from the proposed masterplan does not reduce their importance in terms of conservation and improvement. Once the network has been defined at the supra-municipal level, in fact, these stretches can contribute to the definition of the municipal network.

The proposed network is made up of:

- 77.1% of the existing paths "on dedicated roadways" segregated from traffic (224.5 km from a total of 291 km surveyed),
- 77.4% of the existing paths along or near canals and rivers (77.2 km from a total of 99.7 km surveyed), and
- 79.4% of the existing non-vehicular agricultural roads (246 km from a total of 309.8 km surveyed).

The developed methodology allowed us to take into consideration the most important parameters found in the literature. The use of soft mobility infrastructures segregated from traffic is considered the most important factor for active recreation and tourisms [52]. According to [53], if active tourists can choose between a road without cycle lanes, a road with cycle lanes and a cycle lane segregated from traffic, all other characteristics being equal, they will choose the segregated facility about 75% of the time, the road with cycle lanes 18% of the time, and the road without cycle facilities 7% of the time.

Moreover, the rural environment and the scenery of the landscape are two of the most important characteristics that active tourists request to enjoy their experience [52]. Paths along or nearby canals and rivers are a great added value [51].

This is confirmation that the method used in the present study allowed for the valorization of a greater part of the existing infrastructures that offer good safety and landscape value. Moreover, the utilization of the agricultural roads for recreation and touristic purposes allows for the combination of safety for the users [66] with the saving of economic resources, whilst at the same time making the rural landscape more accessible.

The calculation of the "path value" and the relative "correction factors" has allowed, compared to the previous methodologies presented in the literature, the identification of the most suitable existing stretches and the appropriate prioritization of those choices.

Regarding the proposed primary network, 82.7% (294.7 km) is made up of existing paths and only 61.5 km of "missing paths" are needed to complete it.

Almost 71% of the existing paths in the primary network are physically separated from the ordinary roads (allowing a good level of safety). Only about 50 km are cycle and/or pedestrian dedicated infrastructures, while more than half (55.6%) are non-vehicular agricultural roads. The valorization of such a type of paths with other functions than agricultural production is in line with the new vision of rural development and allows the rural landscape to provide more cultural ecosystem services to humans. The predominant location (46.7%) is on dedicated roadways and 76 km (25.8%) are along a water course (river or canal). Moreover, 99.1% of the paths are flat, allowing the easy fruition by users of all abilities. Ease of use, reduced physical effort [66] and flat gradients [52,53] are key attributes that increase a tourist's preference for soft mobility infrastructures.

There are still some paths with restricted access or located on private property (6.4%) that need a more precise assessment in the network feasibility study.

Regarding the secondary network, 77.6% (132.2 km) of the proposed network is made up of existing paths. The characteristics of the secondary network are similar to those of the primary network (Table 5), except for a lower percentage of cycle-pedestrian paths (4.1% versus 11.6%) and a greater percentage (62.6% versus 55.6%) of non-vehicular agricultural roads.

Furthermore, the overall proposed soft mobility network demonstrated very good connection capacity with the elements of interest taken into account (Figure 9). Approximately 97.3% of the main resources are within a distance of 500 m from the principal network, and 61.1% are within a distance of 100 m. In particular, 60% of the elements of historical-architectural and cultural interest are within 100 m, while the remaining 40% are within 500 m. Moreover, the elements of natural interest are all within 100 m of the principal network.

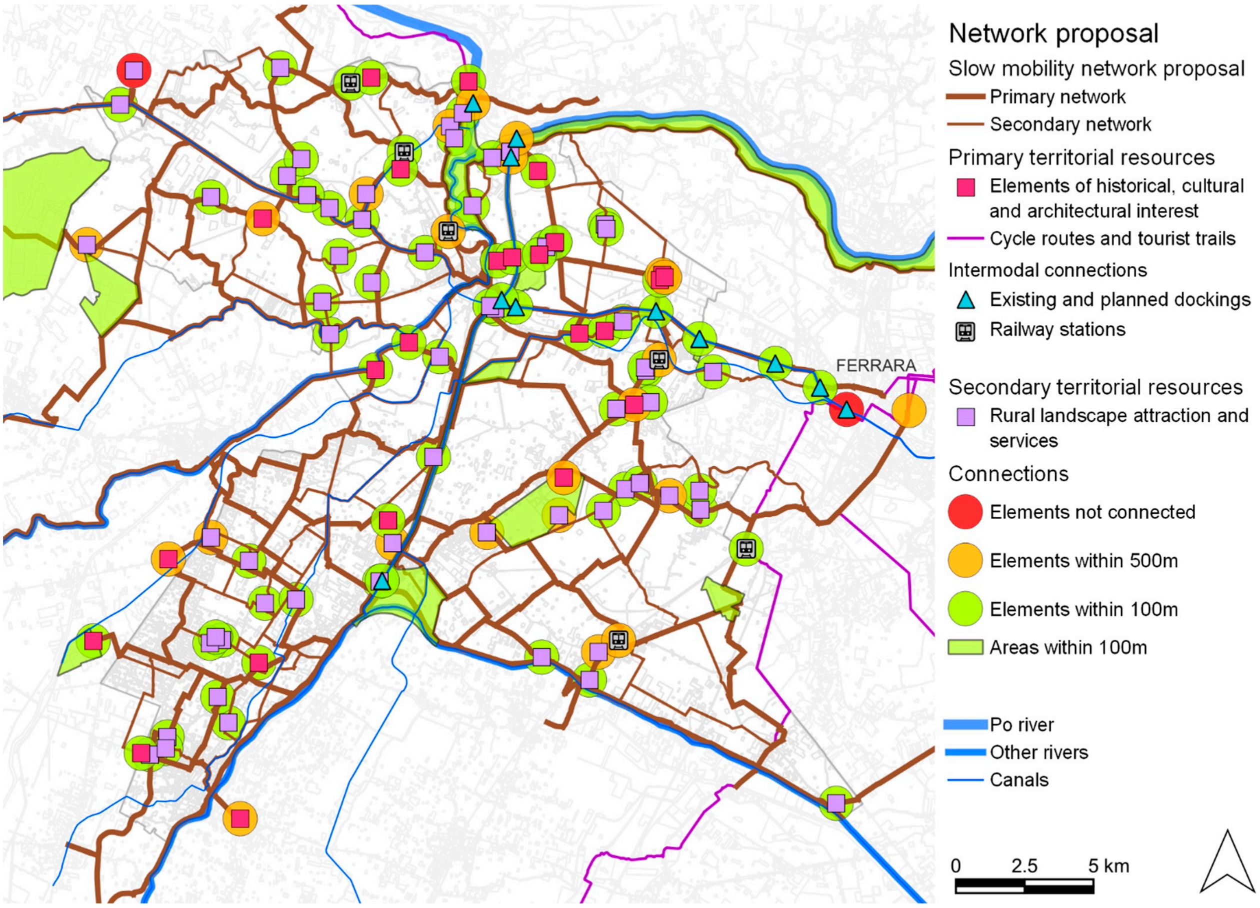

Figure 9. Connection capacity of proposed soft mobility network.

In addition, the overall proposed soft mobility network is close to the land/water intermodal nodes, allowing the paths to be part of a larger intermodal system that might promote the enjoyment and knowledge of the rural area. Specifically, 63.6% of the existing and planned dockings, as well as 50% of the railway stations, are within 100 m of the principal network. The remaining interconnection points would, in any case, be within 500 m.

The secondary elements of interest that would be connected by the proposed network correspond to 98.5% of the total. Among these, 86.4% are located within 100 m from the routes.

The developed methodology allowed us to take into consideration these other important parameters found in the literature on recreation and tourism active mobility: a network able to connect historical-cultural and natural resources [51], services [52] and accommodation [53], and the public transport network [67] is greatly appreciated. Moreover, the connection with a national/international cycle/pedestrian route (that is a more structured touristic product) contributes to the touristic/recreational attractiveness of neighboring rural areas, promoting local development and creating alternatives to tourist products linked to specific seasons [68].

Even though the masterplan for the soft mobility network did not take into consideration the municipal boundaries inside the study area, it has been useful to verify whether the distribution of the network in the municipalities would result balanced.

Due to the different land areas, the amount of km of network for each municipality presents a fair variability, ranging from 49.3 km in the municipality of Vigarano Mainarda to 210.3 km in Bondeno (Table 6). The distribution is more balanced if the "density" of the network is taken into consideration. The territorial density (km of the network divided per km^2 of the land area) is more balanced, with all the municipalities around the average value of 1.3 km/km^2. However, Cento is the only outlier; this is probably due to its higher level of urbanization. On the contrary, the density of the network per inhabitant (km/1000 inhabitants) reveals an unbalanced distribution that ranges from 3.1 km/1000 inhab. in Cento to 15.1 km/1000 inhab. in Bondeno.

Table 6. Distribution of the proposed soft mobility network in the municipalities of the study area.

Municipalities	Network (km)	Inhabitants * (n°)	Municipal Area (km^2)	Network Density (km/km^2)	Network per 1000 Inhabitants (km)
Bondeno	210.3	13,905	175.2	1.2	15.1
Cento	110.4	35,107	64.8	1.7	3.1
Poggio Renatico	89.1	9787	79.8	1.1	9.1
Terre del Reno	66.1	9826	51.3	1.3	6.7
Vigarano Mainarda	49.3	7590	42.3	1.2	6.5
Total	525.2	62.310	413.4	1.3	8.4

* Resident population in 2021.

The distribution is not balanced but follows the distribution of the elements of interest in the study area (Figure 9) that are not equally distributed among the municipalities.

The densities (per km^2 and per inhab.) of the proposed network are comparable with other similar situations (supra-municipal level in a rural area) in Europe [69].

The primary network, built on a supra-municipal scale, could enhance the natural and man-made landscapes and the historical-architectural heritage in the territory, creating a fruition network composed of tourist-cultural itineraries [57]. This scenario, being mainly suitable for the tourist-cultural fruition, simultaneously offers many opportunities for the development of the agri-food components (i.e., secondary resources) [70].

The secondary network, defined at a lower scale, could be considered as a place to buy agricultural products, to teach children and provide schooling on nutrition, and to entertain tourists and urban residents through cultural events organized by the rural community or by tertiary sector workers [54].

4. Conclusions

The rural landscape can provide a wide range of cultural ecosystem services to human beings. Among these, those deriving from direct, in situ and outdoor interactions with the landscape (the most important "division" of cultural ESs in the CICES classification) can be conveniently enjoyed through a slow fruition of the territory, thanks to a specifically planned soft mobility network that crosses the landscape connecting all the historical-cultural and natural resources.

The present study proposes a methodology to adequately plan the aforementioned soft mobility network for the sustainable fruition of the rural landscape, enhancing the existing paths to connect, at its best, the elements of interest, the urban centers, and the intermodal connections (dockings and railway stations).

The application of the proposed methodology to the study area (the rural area of Alto Ferrarese, in Italy), demonstrated its efficiency in simultaneously taking into account all the parameters and factors reported in the literature and considered in the assessment and planning phases. There is a wide range of scientific literature regarding the factors to be considered in soft mobility network planning. It is, however, focused on the urban environment and on mobility for commuting purposes. The methodology developed in the present study adapted what emerged from the literature to the rural environment and to soft mobility for touristic and leisure purposes, to identify all the parameters to be considered and to calculate the "path value".

The resulting outcome is a network proposal composed of the existing, more suitable, paths and the missing sections needed to complete the masterplan.

The masterplan proposed represents the basis for the next phase of detailed planning and design, with particular emphasis on specific sections of the network (i.e., the missing sections), in order to provide guidelines for the recovery of the different types of paths, and the detailed projects.

In this next phase, therefore, it will be necessary to carry out other specific field surveys to verify the critical situations detected in the masterplan, the intersection points with ordinary roads, and the stretches with limited accessibility, in order to verify the actual technical feasibility of the network and eventually propose possible alternative routes.

Moreover, it will be necessary to assess the economic impact on the territory and the local community of the investments required for the realization of the network, especially related to the missing sections that need to be built from scratch and which, consequently, require greater investment.

Finally, the methodology could be extended to all the municipalities in the province of Ferrara. From the political point of view, the proposal of a province-wide soft mobility network would be strategic and could foster collaboration and synergies between the different municipalities involved. Furthermore, it could stimulate and promote the establishment of participatory processes, which are necessary for the assessment of stakeholders' and residents' preferences [54].

Despite the limitations of the study due to the large scale of application and the relative availability of data, the methodology adopted is replicable and adaptable to other situations. The obtained results may be viewed as a demonstration of the validity of this method, and we hope they will be of interest to the municipal and provincial governments.

The calculation of the "path value", based on the physical characteristics of the route and the quality of the environment crossed, represents a step forward in the planning of such soft mobility networks. The applicability to other territorial contexts seems guaranteed: it is sufficient to apply the proposed methodology by adapting the parameters and evaluation criteria to new areas to obtain reliable results. Currently, some of the authors are applying the proposed methodology, with the appropriate corrections and additions, to the planning of a soft mobility network in a mountain area in Italy in view of the upcoming 2026 Winter Olympic Games.

Our biggest intended takeaway for the practice is quite simple: planning a soft mobility network for touristic-recreational purposes in rural areas is very different from planning an urban network for everyday mobility. The factors and criteria to be considered are different and concern both the infrastructure and the landscape crossed and connected. Only by keeping all the parameters in due consideration will it be possible to adequately use public financial resources for its implementation, obtaining all the promised benefits, both for the local economy and for public health.

Author Contributions: Conceptualization, C.P., G.S., N.F., P.T. and D.T.; methodology, C.P., G.S., N.F., P.T. and D.T.; investigation, C.P., G.S. and D.T.; data curation, C.P.; writing—original draft preparation, C.P. and G.S.; writing—review and editing, N.F., P.T. and D.T.; supervision, G.S. and D.T. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Data Availability Statement: Not applicable.

Acknowledgments: The authors acknowledge the project 'Metropoli di Paesaggio', led by the architecture firm Città della Cultura/Cultura della Città (Ferrara), for data supply and technical support.

Conflicts of Interest: The authors declare no conflict of interest.

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