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A Collaborative Multi-Criteria Decision-Making Framework for the Adaptive Reuse Design of Disused Railways

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Abstract: With an increasing focus on sustainable development and the reuse of disused infrastructure, there is a pressing need for effective decision-making methods. This study explored the use of the PROMETHEE method within a collaborative decision-making framework to assess the adaptive reuse options for a disused railway in Sicily, Italy. Using a participatory paradigm, the research actively involves stakeholders in the assessment process. The collaborative PROMETHEE approach acts as a tool for multi-criteria decision analysis, facilitating the comparison and prioritization of different reuse alternatives based on predefined criteria. The research highlights the effectiveness of PROMETHEE in streamlining decision-making processes for adaptive reuse efforts, particularly in the context of integrated conversions of abandoned railways. By combining multi-criteria decision analysis with collaborative methods, the study contributed to the formulation of sustainable and socially responsible strategies for the valorization of disused railway infrastructure. The results underline the importance of collaborative decision-making processes and the instrumental role of PROMETHEE in assisting stakeholders in evaluating and selecting adaptive reuse options for disused railways, thereby, in turn, promoting the sustainable development of these sites.

Keywords: sustainable development; disused railways; greenways; adaptive reuse; multi-criteria decision support analysis; PROMETHEE

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Citation: Della Spina, L.; Lanteri, C. A Collaborative Multi-Criteria Decision-Making Framework for the Adaptive Reuse Design of Disused Railways. *Land* **2024**, *13*, 851. https://doi.org/10.3390/land13060851

Academic Editor: Alexandru-Ionuţ Petrişor

Received: 1 May 2024
Revised: 29 May 2024
Accepted: 11 June 2024
Published: 14 June 2024

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1. Introduction

Over the past few decades, significant changes in the territorial infrastructure system have redefined both urban and rural landscapes. The construction of new, more efficient roads and railways has often led to the closure of existing lines that have become obsolete, leaving thousands of kilometers of disused railways and abandoned stations. This phenomenon has sparked an international debate on the potential for sustainably repurposing these resources, promoting urban and territorial regeneration through the transformation of disused railways into pedestrian and cycling paths [1–8].

The cultural heritage (CH) of disused railways plays a significant role in the European framework for sustainable development policies and processes. The Faro Convention of 2005 highlighted CH as a fundamental right essential for human development and quality of life [9]. Additionally, the European Year of Cultural Heritage in 2018 revitalized the international debate, emphasizing the broad opportunities from CH revitalization [10]. Considering CH from a circular perspective underscores its potential for generating new cultural, environmental, social, and economic values [11,12]. Enhancing abandoned or "discarded" CH is crucial not only for promoting built capital but also for fostering cultural and social capital [13]. As such, CH serves as a catalyst for urban regeneration and local development, extending the life cycle of heritage, creating new value, and fostering community development [14]. The conversion of disused railways into greenways presents a unique opportunity to transform abandoned landscapes into areas of genuine beauty [15,16]. Furthermore, the adaptive reuse of the real-estate assets of disused railway stations represents a unique opportunity to enhance the cultural and historical landscape, improving the aesthetic and functional quality of the surrounding urban and rural areas [17–19]. These ancient stations, once vital hubs of local communities, can now be transformed into multifunctional spaces that retain their historic charm while adapting to modern needs. By integrating cultural, commercial, and recreational services, these structures can become dynamic landmarks within the urban fabric 2 [7,8,20].

In the cultural heritage context, former railway sites represent a network of assets intricately interwoven within human landscapes [15,16,21,22]. These sites are pivotal for urban regeneration and the development of new opportunities [23]. Heritage is not merely composed of individual entities but constitutes a system defining the essence of a place, facilitating residents' identification with their environment. This integrated approach is essential for strengthening interactions among physical, cultural, social, and economic aspects [15,24], fostering collaboration and cooperation [25,26]. Innovation is increasingly linked to connectivity [27] through the creation of physical and virtual platforms to identify intervention priorities. Finally, cultural heritage plays a key role in shaping perceptions, values, and social and economic processes [28].

Although the potential of this railway heritage as a tool for widespread landscape enhancement is acknowledged, and numerous projects for the enhancement and conversion of disused railway tracks have been implemented, particularly in the American and European contexts [1–4,6,8,20,28,29], there is still a clear lack of decision-making frameworks to aid effective decision making and participatory approaches to ensure the economic, social, and environmental sustainability of such projects. This study aimed to address this gap by proposing an innovative and collaborative multi-criteria decision-making framework [15,30–32].

Given the complexity of existing values inherent to CH and its context, the evaluation process emerges as a pivotal framework to facilitate dynamic, collaborative, and cooperative urban strategies, thereby influencing the development of new nodes within the multidimensional urban network. Reflecting on these considerations, integrated evaluation methods play a crucial role in capturing both quantitative and qualitative dimensions of CH, allowing for both the assessment of individual facets as well as overall evaluation [33,34].

In meeting these requirements, decision-making processes [15,32] concerning CH valorization can leverage multi-criteria methods to comprehensively consider diverse heritage aspects. Additionally, employing multi-actor methods becomes imperative as they allow for the incorporation of the varied interests and perspectives of public, private, and social actors [35–37]. Multi-criteria methods [38–41] are versatile and adaptable, finding application across different stages and levels—be they strategic, tactical, operative, or managerial—of the valorization process. By pursuing various objectives, these methods contribute significantly to strategic decision making, aid in formulating and identifying viable alternatives, facilitate the ongoing monitoring of development, and enable the assessment of outcomes.

In this context, this study proposed a multi-methodological process structured within a research–action project, developed through a scientific agreement between the Laboratory of Economic Assessments and Real Estate Appraisals (LaborEst) of the 'Mediterranea' University of Reggio Calabria (Italy), the Municipality, and the Association of Noto (Sicily, Italy), promoters of the project for the enhancement of the Noto–Pachino railway and its conversion into a greenway.

This project is closely linked to the 'Ferrovie Italiane Abbandonate' [42,43], which aims to preserve disused railway lines and transform them into a network of greenways. With the aim of identifying strategies for the valorization and sustainable reuse of abandoned cultural assets along the Noto–Pachino railway line in a territorial network perspective for the province of Syracuse (Noto, Sicily, Italy), a multi-methodological decision support approach has been implemented, integrating the analysis of the decision-making context, the involvement of stakeholders and citizens, the elicitation of preferences, and multi-criteria analysis. The decision support framework identifies ways of valorizing the abandoned or "discarded" and disused heritage with the aim of valorizing the landscape in which the Noto–Pachino railway line is inserted and defining methods of adaptive reuse of the disused stations along the line and identifying the best solutions for reusing functions [17–19].

The aim of the integrated project is to transform the old railway line into a greenway and repurpose the abandoned stations to promote the landscape's excellences, agriculture, sustainable tourism, territory resources, and outdoor activities, thus triggering sustainable economic development and widespread regeneration processes in the landscape. Crossing areas of great natural and scenic interest, the greenway project would have the opportunity to attract visitors from around the world, offering them a unique experience in the heart of Sicily and contributing to valorizing this unused heritage into vital resources for local communities [44–46].

Following a decision-making model inspired by Simon, an evaluative approach has been structured in three phases: the Intelligence phase, analyzing the decision-making context; the Design phase, co-designing intervention options; and the Choice phase, co-evaluating for the selection of the best option. The final results of this evaluative process will be conveyed to policymakers for their future strategic decisions. The innovative approach utilized entails the following components. (i) Integrated Planning: combining the physical rehabilitation of infrastructure with community involvement, ensuring that rehabilitated railway assets align with local needs and preferences. (ii) Participatory Processes: actively engaging stakeholders in the decision-making process, developing inclusive and sustainable projects. (iii) Iterative Decision-Making Process: the decision-making process is iterative and dynamic, allowing stakeholders to provide feedback and make changes throughout the process. This ensures flexibility and adaptability to evolving needs and circumstances. (iv) Circular Development: emphasizing recovery and reuse methods that promote economic sustainability, social inclusivity, and environmental respect.

The document is structured as follows. Section 2 offers a brief overview of European and Italian experiences in the valorization of disused railway heritage. Section 3 explains the methodology for selecting the best reuse options for the "discarded" station assets along the railway line under study. Section 4 describes the application of the PROMETHEE (Preference Ranking Organisational METHod for Enrichment Evaluation) methodology used for the case study. Finally, Section 5 discusses the results obtained and draws conclusions.

2. The European Approach to the Widespread Valorization of Disused Railway Heritage

In Europe, the approach to the valorization of disused railway assets focuses on the implementation of greenways, non-motorized routes that follow abandoned railway lines. These routes are seen as key tools for promoting sustainable tourism and soft mobility. Greenways offer several benefits, including safe use by a wide range of users, the regeneration of derelict areas, the promotion of the area, and the stimulation of the local economy through the creation of tourism and hospitality services.

European best practice highlights the importance of cooperation between public authorities, local communities, and civil society organizations in the planning and implementation of greenways. The Spanish experience of Vías Verdes [47] and the Portuguese experience of Ecopistas [48] show how a systemic and strategic approach can lead to significant results, including the valorization of historical elements such as stations and bridges along the routes.

The involvement of regional, provincial, and local authorities, as well as social participation, has been crucial to the success of these initiatives. The European Union provides financial support through programs such as Interreg [49] while associations such as the European Greenways Association (EGWA) [50] play an important role in promoting the transformation of railway lines into greenways.

The establishment of transnational networks of greenways, such as the Rever Med project [51], underscores the shared interest at the European level in safeguarding landscapes as a crucial resource for sustainable development. The EGWA stresses the importance of involving public administrations and railway companies in promoting these initiatives.

Finally, the creation of European awards for the best greenways experiences has helped spread good practice and inspire new innovative projects across Europe.

In the Italian context, the debate surrounding the valorization of greenways [52] emphasizes the importance of contextualizing the concept by considering the diverse territorial realities. Frequently, the term greenways is restricted to cycle paths, disregarding the possibilities presented by an integrated approach to soft mobility [53–55].

In Italy, the heritage of disused railway lines is considerable. It is estimated that Italy has approximately 8000 km of disused railways, with around 5100 km no longer in service and 2700 km underused, but there is no strategic vision for their valorization. A project to convert disused railway lines into greenways began in 2001, but a lack of ongoing support has limited progress. Abandoned railway stations have been given to local authorities and associations, but there is no structured planning for their redevelopment. The 2008 law established a fund for the valorization of disused railways, but no further action has been taken. The 2010 law on the valorization of railway assets has also not been implemented. However, some local initiatives have demonstrated the potential of reclaiming disused railway heritage for landscape enhancement and local development. To ensure the success of the valorization of greenways in Italy, an integrated vision and the continuous commitment of the institutions are needed. A transversal approach involving different disciplines and stakeholders is essential to maximize the environmental, economic, and social benefits of greenways.

After analyzing and comparing the international and Italian contexts, it is clear that a strategic vision and adequate planning are needed to support a widespread valorization process, similar to what has been achieved in Europe. The international experience shows the need for planning tools for the management of transformations, national plans, and common strategies, based on the partnership between institutional, social, and economic actors, with the involvement of the subjects that benefit from the valorization of the territory. In fact, the valorization process that the so-called "green paths" can implement must not be limited to the physical recovery of infrastructures and abandoned buildings, but must determine the environmental, economic, and social impact with a view to the sustainable development of the territory.

In the Italian context, there are several critical issues to be addressed, including the acquisition of brownfield sites, the fragmentation of territorial competences and the lack of economic resources and continuity in the political agenda. However, there is increasing attention to and awareness of the value of disused railway heritage, which is supported by associations and forums. It is essential that valorization choices are based on compatible interventions that guarantee the safety of users and the protection of the assets themselves. The profitability of new uses is crucial for the long-term management of reused assets. Finally, it is necessary for political decision-makers to recognize the value of this historical and cultural heritage and for there to be a continuing commitment to its management and valorization. Without this recognition, it is unlikely that it will receive adequate support for its recovery and sustainable use.

3. Materials and Methods

In the context of limited financial and human resources, the efficient allocation of resources has become a central issue in the effort to mitigate economic waste [56]. In particular, when addressing challenges related to transport infrastructure, it is crucial to assess and contrast alternative solutions in order to identify the most optimal project with the objective of maximizing net benefits. This process should consider a multitude of criteria [57,58]. Multi-criteria Decision Analysis (MCDA) methods have been demonstrated to be effective in identifying and addressing infrastructure issues that have previously been overlooked, as evidenced by the case of disused railways [59], which was the subject of this study.

Multi-criteria analysis represents a broad concept in operations research, encompassing a variety of formal approaches and methods [60]. This methodology assists decision-makers in dealing with problems characterized by multiple objectives and criteria, facilitating the development of a clear decision-making process, the prioritization of crucial issues, the selection of preferred actions, and the justification of choices made [38]. A variety of methodological approaches are available, each designed to adapt to specific types of problems. The objective is to facilitate the selection of the most appropriate decision-making strategy for each situation, thereby aiming for an optimal solution.

Following the decision-making model inspired by Simon [61], the evaluation approach was structured into three phases: the Intelligence, Design, and Choice phases. Such a model helps ensure that all stages of the decision-making process are addressed systematically and that final decisions are well informed and justified [62].

In the final phase of the evaluation process, it was particularly relevant to use a multi-criteria approach based on PROMETHEE to identify which of the stations located on the route were most suitable for the proposed new uses. The decision was made through a co-design and co-assessment process that involved a panel of stakeholders and experts. In the final-phase evaluation process, the expert panel expressed preference judgment and the defined relative importance of the evaluation criteria used to assess the performance of the reuse scenarios.

3.1. Intelligence Phase

The initial step in the decision-making process for the sustainable solutions of the project for the valorization and adaptive reuse [63,64] of disused railways was the analysis of the environmental context. This analysis aimed to frame the decision making of the project context and was based on the System Thinking Approach, which combines Hard System Analysis, Institutional Analysis, and Soft System Analysis [62]. This combination makes it possible to structure the evaluation as a learning process aimed at understanding the local specificities and viewpoints of the different categories of stakeholders involved, thus making it possible to identify issues relevant to a given decision problem. In this way, the development of intervention alternatives is based on an oriented knowledge that takes into account expert and common knowledge and, at the same time, takes into account the "complex values" recognized and shared by a community. In fact, Hard System Analysis enables the collection of objective information and data relevant to decision making [65], not only related to morphological and physical aspects but also to specific environmental, social, economic, and cultural conditions of the study context. This enables the identification of context-aware strategies that are sensitive to the contexts in which they are implemented. Concurrently, through the application of Soft System Analysis, an objective understanding of the study context was integrated with that provided by local stakeholders and the local community. This was achieved through the utilization of the technique of Institutional Analysis. Given the peculiarities of the territorial context and its widely recognized cultural significance, an adequate recognition process of the value of the abandoned heritage was essential to identify its complex system of values to be preserved and enhanced through a conscious reuse project [65]. To this end, the most relevant natural and built heritage assets that characterized the landscape of the project area were analyzed by integrating different cognitive approaches: historical research, interviews with local experts, and field surveys [66].

The final results of the System Thinking Approach were then organized in a SWOT matrix (Strengths, Weaknesses, Opportunities, Threats), which helps develop an effective knowledge of the territorial and socio-economic context under investigation. This provides a solid basis for the development of strategies and alternatives. The advantages of implementing this decision-making phase are as follows: firstly, it allows for the identification of general aspects related to environmental, economic, social, regeneration, mobility, and service factors; secondly, it enables the formulation of clear objectives; and thirdly, it allows for the definition of criteria for evaluating possible solutions. Consequently, it provides a solid basis for designing context-aware reuse strategies and alternatives.

3.2. Design Phase

In this phase, potential alternatives and solutions were devised to address the issue identified in the Intelligence phase. Various options were investigated and action plans were formulated to achieve the established objectives. The alternatives considered included specific strategies, plans, or actions that could be considered in the subsequent decision-making process.

This phase of the methodological framework also made use of stakeholder involvement as a fundamental reference point. Indeed, the interaction with the local community of the study landscape, conducted through questionnaires and interviews, allowed for the identification of drivers for valorization strategies and sustainable adaptive reuse that aligned with their expectations. Additionally, it enabled the understanding of the social perception of the cultural values of the landscape, thus identifying the most relevant ones to be preserved and enhanced in order to develop a widely shared and supported project aimed at designing alternative scenarios. In detail, the alternative scenarios of the reuse project were derived from the SWOT and stakeholder analysis and were selected by applying the Scenario Building methodology [67] by exploiting the potential and development factors of the project area through sustainable tourism, the promotion of traditional culture, and the creation of economic synergies.

3.3. Choice Phase

The alternative scenarios of the reuse project developed in the design phase were evaluated using the PROMETHEE approach, as proposed by Brans and Vincke (1985) [68–71]. This robust multi-criteria approach belongs to the family of outranking methods and provides a systematic framework for evaluating and ranking alternative options according to a set of evaluation criteria.

In consideration of the various strengths, it was determined that PROMETHEE would be an appropriate method for the decision-making problem under study. The method was selected primarily due to its ease of comprehension and reliability, as it is represented by meaningful parameters, both quantitative and qualitative [72]. Furthermore, PROMETHEE is capable of supporting multi-actor evaluation and group decision making and provides a useful tool for debate and consensus building. Therefore, PROMETHEE is particularly useful for complex decisions where preferences are not easily quantifiable and where decisions have to consider multiple aspects simultaneously.

The operational steps of the PROMETHEE method are as follows. The result is the assessment of the degrees of preference between alternatives and the aggregation of these preferences to establish a complete ranking of alternatives.

Step 1: Impact matrix. This is a double-entry matrix, mxn, showing the effect that each alternative (m) has on the different (n) criteria considered in the decision-making process. Each cell of the matrix indicates the degree of impact that an alternative has on a specific criterion. This matrix incorporates both cardinal (quantitative) and ordinal (qualitative) data to comprehensively represent the evaluation criteria.

Step 2: Preference function for each criterion. Six distinct types of 'preference functions' [73,74] may be selected to express the relative preference of each pair of potential alternatives (a, b) with respect to each criterion.

In the context of decision analysis, preference functions play a pivotal role in determining the relative importance of the differences between the alternatives under consideration. There are various types of preference functions, each suited to specific situations and evaluation criteria. The principal preference functions include the following:

- Type I (habitual preference function) is the simplest case, and in this, there is no defined threshold. Preferences are evaluated without the introduction of indifference or preference limits.
- Type II (U-shaped preference function) is commonly used for qualitative criteria and requires a single indifference threshold to be established.

- Type III (linear preference function): preference increases in a linear manner up to a pre-determined preference threshold, beyond which there is no further increase in preference. This preference threshold must be determined according to the characteristics of the criterion in question.
- Type IV (level preference function): this function applies when both an indifference threshold and a preference threshold are present. The preference remains constant until the preference threshold is reached, above which it increases. It is essential that both thresholds are set according to the nature of the criterion being evaluated.
- Type V (V-shaped preference function) is a variant of the linear preference function in which the indifference threshold is set to zero. The preference gradually increases until it reaches the preference threshold, beyond which there is no further increase.
- Type VI (Gaussian preference function) offers an alternative to the linear version with a smoother curve that follows a normal distribution. The standard deviation is required to define the shape of the curve.

Step 3: Calculation of the Global Preference Index π(a,b).

This step aggregates the individual preference grades into a global preference measure for each alternative across all criteria, taking into account the weights assigned to each criterion. This facilitates a holistic evaluation. The overall preference index, π(a,b), is calculated using the following formula:

$$\pi(\mathrm{a},\mathrm{b}) = \sum\nolimits_{j=1}^{n} Pj(a,b)wj \quad (1)$$

The preference function, P(a,b), is defined as the degree of preference of (a) over (b), where π(a,b) is the weight of criterion j, wj, and n is the number of criteria. The weight of criterion j, wj, is defined as a value between 0 and 1:

$$\sum\nolimits^{n} wj = 1 \quad (2)$$

Step 4: Calculation of the positive Φ^{+}(a) and negative Φ^{-}(a) outranking flows for each alternative (where m is the number of alternatives). Both flows are calculated on the basis of the preference degrees obtained above, considering all pairwise comparisons.

The positive outranking flow expresses how well alternative (a) is outranking all others:

$$\Phi^{+}(\mathrm{a}) = \frac{1}{m-1} \sum\nolimits_{x\epsilon A} \pi(\mathrm{a},\mathrm{x}) \quad (3)$$

The negative outranking flow indicates the extent to which alternative (a) is outranked by all other options:

$$\Phi^{-}(\mathrm{a}) = \frac{1}{m-1} \sum\nolimits_{x\epsilon A} \pi(\mathrm{x},\mathrm{a}) \quad (4)$$

Step 5: Calculate the net exceedance flows Φ(a) to define the complete ranking of alternatives. The higher the net flow is, the better the alternative will be. This calculation provides a complete measure of net preference for each alternative, guiding the final ranking process.

$$\Phi(a) = \Phi^{+}(a) - \Phi^{-}(a) \quad (5)$$

Ultimately, the PROMETHEE II method produces a comprehensive ranking of alternatives based on their net outranking flows, providing decision-makers with valuable insights into the relative merits of each option. This systematic approach facilitates informed decision making by synthesizing complex multi-criteria evaluations into a concise and actionable ranking.

In conclusion, the PROMETHEE method is an important resource for evaluation and decision making in complex, multi-criteria contexts such as this. Its numerous applications, including its recent foray into urban planning, demonstrate its potential and flexibility in addressing real-world decision-making challenges.

4. Application

4.1. The Case Study

The multi-methodological approach was tested on a disused railway line rehabilitation project located in Sicily in southern Italy.

The Noto–Pachino railway, also known as the 'Ferrovia del Vino' (Wine Railway), stands out as one of the most distinctive railway routes with significant historical and cultural significance. Spanning 27.5 km in length, it was inaugurated in 1935 and ceased operations in 1986. This railway connected the splendid Baroque capital of Noto with Pachino, the southernmost station on the peninsula, traversing unique landscapes between the sea and the Mediterranean scrub, while passing by the archaeological site of the ancient Greek city of Eloro and the Roman villa of Tellaro. Beyond Noto Bagni, the railway journeyed through the Vendicari Nature Reserve and Fauna Oasis and then proceeded through the territory of the seaside village of Marzamemi. Continuing along the route, it passed by the Grotta di Calafarina, an archaeological site of significant importance due to its numerous artifacts spanning various historical periods, particularly from the Early Bronze Age. Pachino served as the final destination: its station is recognized as the southernmost in Italy and Europe for standard gauge lines.

Identified in 2017 by Ferrovie dello Stato among the 18 disused routes of greatest value in Italy, today, the historical restoration of the Noto–Pachino line for tourism purposes has been funded by the Ministry of Culture's Supplementary Fund as part of the interventions outlined by the National Recovery and Resilience Plan (PNRR), with a total investment of 40 million euros. This financing has been made possible through the support of 'Fondazione Fs Italiane' and 'Rete Ferroviaria Italiana (FS Group)'.

To date, a significant portion of the railway remains abandoned and exhibits signs of deterioration. Previous proposals, outlined in the 2010 'Piano della mobilità non motorizzata in Sicilia' [75], explored various possibilities for reusing the disused railway, including tourism or recreational purposes. These proposals highlight the potential of the abandoned railway not only as a historical testament to Sicily's railway heritage but also as a resource for enhancing the territory and its cultural attractions.

In addition to serving as a significant historical artifact in Sicily's railway transport history, the Noto–Pachino railway presents substantial opportunities for valorization and reconversion. Indeed, traversing a landscape of extraordinary beauty and rich in diverse natural resources and cultural heritage, this route lends itself to conversion into a greenway, a slow mobility route [76–78].

This idea is based on the intrinsic compatibility between the characteristics required by greenways and those of existing railway tracks, making disused railway routes ideal for conversion into paths for soft mobility. The project proposal involves converting the existing track into a greenway, as well as recovering and adaptively reusing the eight station buildings located along the route, which are currently in an abandoned state. The conversion project of the old track into a greenway and the adaptive reuse of the stations would not only allow for the preservation and further enhancement of the surrounding natural landscape but also offer an opportunity to promote agriculture, sustainable tourism, and outdoor activities capable of triggering sustainable economic development and widespread regeneration processes in the area. Crossing areas of great naturalistic and landscape interest, the greenway could attract hikers, cyclists, and outdoor enthusiasts from around the world, offering them a unique experience in the heart of Sicily, rich in history and culture.

4.2. The PROMETHEE Approach to Adaptive Reuse

In the context of decision-making studies, the economic assessment of plans and projects plays an important role as it enables the ranking of alternative intervention scenarios on the basis of both technical elements and empirical experience as well as the visions and preferences of the actors and experts involved in order to identify feasible and sustainable solutions that are coherent and shared, where both the legitimacy of the choices and the decision on the allocation of scarce and limited public resources on strategic projects to be implemented are of crucial importance.

The objective of the MCDSA assessment through the PROMETHEE method was to determine the most suitable location for the implementation of each of the four functional scenarios selected in the integrated project. The PROMETHEE assessment supports the Decider Makers (DMs) in defining the optimal locations of the functional scenarios based on the characteristics of the buildings and thus aims to determine which of these buildings and assets located in the stations are the most suitable to accommodate the proposed new reuse destinations according to the four selected functional scenarios.

In the evaluation of the four selected functional scenarios, we begin by defining the criteria representing the different performance dimensions for the alternatives considered. Three categories of criteria were first identified: economic, environmental, and urban. Four experts and key actors were involved in the decision-making process, each representing a specific decision scenario for each reuse project. Each functional decision scenario identified was associated with an expert, with specific expertise in relation to the proposed new reuse destination, whose judgement was crucial to ensure the relevance and accuracy of the assessments. In the evaluation, each expert incorporated his or her preferences on the relative importance of the evaluation criteria, reflecting his or her specific priorities and objectives, and made judgements on the performance of each station in relation to a specific use.

The end result of PROMETHEE was a final ranking in which each expert identified which station had the best characteristics to accommodate the functional scenario associated with its expertise. This approach enabled a detailed and contextualized assessment of disused railway stations, providing a solid basis for the planning and implementation of adaptive reuse and urban and territorial regeneration projects.

4.2.1. Scenario Definition

Scenario definition is a pivotal stage in MCDSA as it enables a spectrum of potential future outcomes or situations to be contemplated within the context of the study.

The four alternatives for the adaptive reuse of the stations' built heritage, described below, reflect realistic uses identified and selected through the first two Intelligence and Design phases of the described multi-methodological process. The aim of these alternatives is to enhance and promote a sustainable tourism offer and trigger circular economic development in the study area.

In particular, during the Intelligence phase, the analyses conducted aimed to delineate the decision-making context of the reuse project using the System Thinking Approach. The integration of the Hard Systems Analysis and Soft Systems Analysis approaches enabled the structuring of the multiple dimensions of the decision-making context for the reuse of the Noto–Pachino railway. This process entailed the collection of pertinent objective data on a range of territorial aspects, including population, economy, tourism, transport, infrastructure, landscape, and cultural heritage. Indicators were extracted from a variety of sources, including official documents, statistical data, traditional cartographic analyses, institutional databases, open-source web databases, historical research, interviews with local experts, and field surveys [42,43,79–83].

At the same time, in order to integrate the 'objective' knowledge of the decision-making context acquired through Hard System Analysis with that deriving from Soft System Analysis, 'soft data' were collected through the definition of a map of the stakeholders and the community of the place [37,84] according to the Institutional Analysis technique [62]. Soft System Analysis represents an effective approach in complex situations characterized by the interaction of numerous elements and the presence of different points of view on a specific problem. The stakeholder map comprised a primary group of institutions and experts who exercise a considerable influence on collective decisions due to their knowledge, expertise, strategic position, and representativeness. The second group comprised operators in the tourism and production sectors, as well as associations, who have a high degree of interest and significant influence in decisions (operators in the dominant economic sectors). Finally, the third group comprised citizens and tourists, recipients of public policies, who have a high degree of interest but low influence. It is therefore of the utmost importance to involve them in the formulation of such policies.

The results of the System Thinking Approach for the analysis and definition of the decision-making context were organized in a SWOT matrix, which provided a solid basis for the design of coherent and context-aware development strategies for the decision-making context under study. In addition, a comprehensive and systematic process was conducted to select criteria representative of all relevant aspects of the project. This process consisted of the following—(i) literature review: the selection of criteria was based on best practices in similar projects; (ii) consultation workshop: the criteria emerging from the literature review were discussed and verified for their relevance and applicability to the context of the Noto–Pachino railway with stakeholders and experts and a SWOT matrix tool was used to facilitate discussion and link the elements of the matrix to the evaluation criteria; (iii) criterion validation: an analysis of stakeholder feedback was conducted to accurately reflect existing interests and hierarchies; (iv) editing and confirmation: based on the feedback received, the criteria for evaluating the performance of the alternatives were refined and confirmed; and (v) editing and confirmation: based on the feedback, the criteria for evaluating the performance of the alternatives were verified and confirmed.

In the Design phase, alternative reuse scenarios were configured consistently with the local development prospects and the value system of the decision-making context of the Intelligence phase. This activity was carried out by surveying the opinions of stakeholders and experts using two distinct tools: a questionnaire administered on social media and interviews with key actors representative of each stakeholder group. The interviews were structured according to specific techniques of the Soft Systems methodology.

The final reuse scenarios, described below, represent the visions of stakeholders and experts according to a shared development strategy. Finally, the scenarios were validated through meetings with the promoting association the project, the actors representing each group of stakeholders, and the team of experts involved in the final choice, coordinated by the research group of the “Mediterranea” University.

1. Center for Advanced Agricultural Training: The scenario proposes the establishment of a center of excellence dedicated to agricultural research and development. This center offers specialized training programs tailored to meet the needs of farmers, agronomists, and industry professionals, emphasizing the implementation of sustainable agricultural practices, the adoption of cutting-edge technologies, and the efficient management of natural resources. Serving as a focal point for both local and international farming communities, the center facilitates the exchange of knowledge through the organization of conferences, workshops, and expert meetings. Additionally, it serves as a training hub with the aim of promoting traditional agricultural techniques, local products, initiatives focused on environmental sustainability, the pivotal role of agriculture in ensuring food security, and environmental awareness campaigns.
2. Bike Hotel: The proposed scenario aims to promote cycling tourism by offering services and facilities for cyclists and eco-friendly travelers, encouraging the use of bicycles for both urban and extra-urban travel. Disused railway stations and adjoining spaces would be transformed into cozy and functional facilities for cyclists, including rooms for overnight stays and reception services, toilets, bicycle maintenance and repair areas, luggage storage, and common areas for socializing and relaxing. In addition, additional services such as bicycle rental, tour guides, customized itineraries, refreshment points, secure parking and relaxation areas, and laundry services for cyclists would be available. This scenario aims not only to promote sustainable tourism but also to revitalize rural areas and create economic opportunities for local communities, thus contributing to a healthier and more conscious environment for both visitors and host communities.

3. Sustainable Tourism destination: This scenario is a strategic center for the management, promotion, and development of tourism in the region. The objective is to promote activities related to the long-term sustainability of tourism activities and the well-being of local communities. The destination is configured as a welcoming and well-organized place designed to be a reference point for tourists wishing to explore the region and its attractions. The project aspires to establish an integrated tourist information center with the objective of enhancing the activities and resources of the surrounding area, promoting local initiatives, events, festivals, fairs, and typical products. The tourist center is conceived as a dynamic and multifunctional environment whose activities are aimed at both promoting sustainable and responsible tourism as well as enhancing the resources and potential of the local area. In collaboration with local authorities, professional associations, and non-profit organizations, the center could serve as a platform for the dissemination of knowledge and the instigation of behavioral change among visitors with the objective of fostering sustainable tourism practices and responsible tourism. This would contribute to the economic, social, and environmental advancement of the region.
4. Center of Regional Agri-food Excellence: This proposed functional scenario proposes the establishment of an innovative multifunctional center dedicated to the promotion of the territory and the valorization of local products. The objective is to unite several farms within a cooperative with the aim of relaunching the region's food and wine potential and facilitating local agricultural producers. The center comprises an exhibition hall and a sales outlet that presents a diverse range of fresh and wholesome products directly from the member farms. This enables visitors to purchase and sample local, zero-kilometer specialties, thereby creating a meeting point for the community and visitors interested in the region's gastronomy and culinary culture. Through a series of food and wine events, tastings, themed dinners, and culinary workshops, producers and consumers engage in the exchange of knowledge, thereby promoting the local gastronomic culture and creating an authentic and engaging experience for visitors.

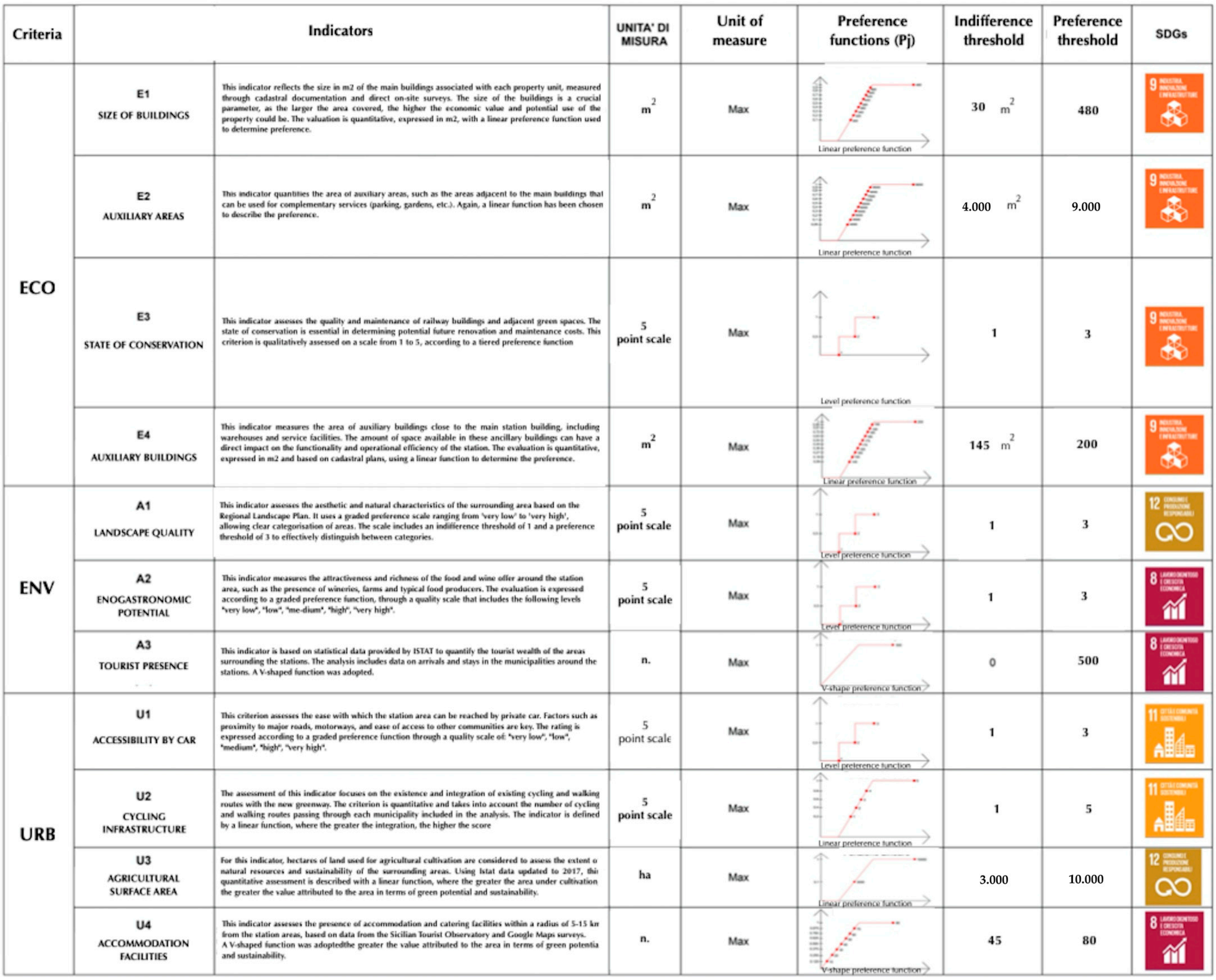
4.2.2. Description of Evaluation Criteria

In their application to the case study, the selected criteria reflect the different dimensions of the problem in order to meet the needs and objectives of the project, and their choice and selection was guided by an analysis of the study context with the active involvement of stakeholders.

The selected criteria were also formulated in a clear and objective manner, allowing for a fair and comparable evaluation of the alternatives and ensuring that each of them contributed uniquely to the overall assessment of the alternatives.

The SWOT and Stakeholder Analyses used in the stages of the multi-methodological approach helped identify the main drivers of change and the key issues to be considered when evaluating the alternatives.

The selected criteria address relevant aspects of the decision problem according to the Sustainable Development Goals (SDGs) [85], i.e., environmental, urban, and economic qualities, and provide a sound basis for the evaluation of alternatives. These criteria were then further explored to arrive at a set of measurable indicators to assess the impact of the alternatives under consideration. Finally, a preference function was assigned to each indicator, including relative indifference (q) and preference (p) thresholds, to help decision-makers determine the point at which one alternative becomes preferable to the others (Figure 1).



Criteria	Indicators		UNITA' DI MISURA	Unit of measure	Preference functions (Pj)	Indifference threshold	Preference threshold	SDGs
ECO	E1 SIZE OF BUILDINGS	This indicator reflects the size in m2 of the main buildings associated with each property unit, measured through cadastral documentation and direct on-site surveys. The size of the buildings is a crucial parameter, as the larger the area covered, the higher the economic value and potential use of the property could be. The valuation is quantitative, expressed in m2, with a linear preference function used to determine preference.	m^2	Max	Linear preference function	30 m^2	480	9
	E2 AUXILIARY AREAS	This indicator quantities the area of auxiliary areas, such as the areas adjacent to the main buildings that can be used for complementary services (parking, gardens, etc.). Again, a linear function has been chosen to describe the preference.	m^2	Max	Linear preference function	4.000 m^2	9.000	9
	E3 STATE OF CONSERVATION	This indicator assesses the quality and maintenance of railway buildings and adjacent green spaces. The state of conservation is essential in determining potential future renovation and maintenance costs. This criterion is qualitatively assessed on a scale from 1 to 5, according to a tiered preference function	5 point scale	Max	Level preference function	1	3	9
	E4 AUXILIARY BUILDINGS	This indicator measures the area of auxiliary buildings close to the main station building, including warehouses and service facilities. The amount of space available in these ancillary buildings can have a direct impact on the functionality and operational efficiency of the station. The evaluation is quantitative, expressed in m2 and based on cadastral plans, using a linear function to determine the preference.	m^2	Max	Linear preference function	145 m^2	200	9
ENV	A1 LANDSCAPE QUALITY	This indicator assesses the aesthetic and natural characteristics of the surrounding area based on the Regional Landscape Plan. It uses a graded preference scale ranging from 'very low' to 'very high', allowing clear categorisation of areas. The scale includes an indifference threshold of 1 and a preference threshold of 3 to effectively distinguish between categories.	5 point scale	Max	Level preference function	1	3	12
	A2 ENOGASTRONOMIC POTENTIAL	This indicator measures the attractiveness and richness of the food and wine offer around the station area, such as the presence of wineries, farms and typical food producers. The evaluation is expressed according to a graded preference function, through a quality scale that includes the following levels "very low", "low", "me-dium", "high", "very high".	5 point scale	Max	Level preference function	1	3	8
	A3 TOURIST PRESENCE	This indicator is based on statistical data provided by ISTAT to quantify the tourist wealth of the areas surrounding the stations. The analysis includes data on arrivals and stays in the municipalities around the stations. A V-shaped function was adopted.	n.	Max	V-shape preference function	0	500	8
URB	U1 ACCESSIBILITY BY CAR	This criterion assesses the ease with which the station area can be reached by private car. Factors such as proximity to major roads, motorways, and ease of access to other communities are key. The rating is expressed according to a graded preference function through a quality scale of: "very low", "low", "medium", "high", "very high".	5 point scale	Max	Level preference function	1	3	11
	U2 CYCLING INFRASTRUCTURE	The assessment of this indicator focuses on the existence and integration of existing cycling and walking routes with the new greenway. The criterion is quantitative and takes into account the number of cycling and walking routes passing through each municipality included in the analysis. The indicator is defined by a linear function, where the greater the integration, the higher the score	5 point scale	Max	Linear preference function	1	5	11
	U3 AGRICULTURAL SURFACE AREA	For this indicator, hectares of land used for agricultural cultivation are considered to assess the extent o natural resources and sustainability of the surrounding areas. Using Istat data updated to 2017, thi quantitative assessment is described with a linear function, where the greater the area under cultivation the greater the value attributed to the area in terms of green potential and sustainability.	ha	Max	Linear preference function	3.000	10.000	12
	U4 ACCOMMODATION FACILITIES	This indicator assesses the presence of accommodation and catering facilities within a radius of 5-15 km from the station areas, based on data from the Sicilian Tourist Observatory and Google Maps surveys. A V-shaped function was adoptedthe greater the value attributed to the area in terms of green potentia and sustainability.	n.	Max	V-shape preference function	45	80	8

ECO - Economic criteria ENV - Environmental criteria URB - Urban Planning criteria

Figure 1. Description of evaluation criteria.

In the context of the study, each criterion was articulated through specific indicators that aimed to provide a detailed measure of the physical and contextual characteristics and condition of the properties located within the stations being assessed. Each indicator was carefully selected and measured to ensure an accurate and objective assessment, thus facilitating informed and strategic decisions in the context of railway property management and development. For the economic criteria, each indicator was carefully selected and measured to ensure an accurate and objective assessment of the real estate around each station, thereby facilitating informed and strategic decisions in the context of railway property management and development. For the Environmental Criteria, each indicator provides an in-depth understanding of how the surrounding environment influences and enhances the value and use of railway property, enabling professionals to make informed decisions based on tangible environmental factors. For the Urban Criteria, specific indicators are essential to assess the potential for integration and connectivity of stations into the wider infrastructure and environmental and service fabric, providing a sound basis for planning and development decisions.

Below is an overview of the indicators for each of the economic, environmental, and urban criteria.

Economic criteria:

- E1. Size of Buildings (SB): This indicator reflects the size in m^2 of the main buildings associated with each property unit, measured through cadastral documentation and direct on-site surveys. The size of the buildings is a crucial parameter, as the larger the area covered is, the higher the economic value and potential use of the property could be. The valuation is quantitative, expressed in m^2, with a linear preference function used to determine preference.
- E2. Auxiliary Areas (AA): This indicator quantifies the area of auxiliary areas, such as the areas adjacent to the main buildings, that can be used for complementary services (parking, gardens, etc.). Again, a linear function was chosen to describe the preference.
- E3. State of Conservation (SC): This indicator assesses the quality and maintenance of railway buildings and adjacent green spaces. The state of conservation is essential in determining potential future renovation and maintenance costs. This criterion is qualitatively assessed on a scale from 1 to 5, according to a tiered preference function.
- E4. Auxiliary Buildings (AB): This indicator measures the area of auxiliary buildings close to the main station building, including warehouses and service facilities. The amount of space available in these ancillary buildings can have a direct impact on the functionality and operational efficiency of the station. The evaluation is quantitative, expressed in m^2 and based on cadastral plans, using a linear function to determine the preference.

Environmental criteria:

- A1. Landscape Quality (LQ): This indicator assesses the aesthetic and naturalistic characteristics of the area surrounding the buildings, taking as a reference the Regional Landscape Plan, which catalogues the different landscape qualities of the territory. The evaluation is expressed according to a graded preference function, through a quality scale that includes the following levels: "very low", "low", "medium", "high", and "very high". The choice of a graded function makes it possible to clearly categorize the different areas, with an indifference threshold of 1 and a preference threshold of 3, which makes it possible to distinguish between the different categories in a meaningful way.
- A2. Enogastronomic Potential (EP): This indicator measures the attractiveness and richness of the food and wine offer around the station area such as through the presence of wineries, farms, and typical food producers. The evaluation is expressed according to a graded preference function, through a quality scale that includes the following levels: "very low", "low", "medium", "high", and "very high".
- A3. Tourist Presence (TP): This indicator is based on statistical data provided by ISTAT to quantify the tourist wealth of the areas surrounding the stations. The analysis includes data on arrivals and stays in the municipalities around the stations. A V-shaped function was adopted.

Urban criteria:

- U1. Accessibility by Car (AC): This criterion assesses the ease with which the station area can be reached by private car. Factors such as proximity to major roads, motorways, and ease of access to other communities are key. The rating is expressed according to a graded preference function through a quality scale: "very low", "low", "medium", "high", and "very high".
- U2. Cycling Infrastructure (CI): The assessment of this indicator focuses on the existence and integration of existing cycling and walking routes with the new greenway. The criterion is quantitative and considers the number of cycling and walking routes passing through each municipality included in the analysis. The indicator is defined by a linear function where the greater the integration is, the higher the score is.
- U3. Agricultural Surface area (AS): For this indicator, hectares of land used for agricultural cultivation are considered to assess the extent of natural resources and sustainability of the surrounding areas. Using ISTAT data updated to 2017, this quantitative assessment is described with a linear function wherein the greater the area under

cultivation is, the greater the value attributed to the area in terms of green potential and sustainability will be.

- U4. Accommodation Facilities (AF): This indicator assesses the presence of accommodation and catering facilities within a radius of 5–15 km from the station areas based on data from the Sicilian Tourist Observatory and Google Maps surveys. A V-shaped function was adopted.

4.2.3. Description of Criterion Weights

The Rating Analytic Hierarchy Process (AHP), as established by Saaty in 1990 [86], is a structured technique designed for organizing and analyzing complex decisions. It is particularly useful where subjective judgments need to be systematically evaluated and integrated with empirical data. This method was employed to define the weights of the criteria in the PROMETHEE approach.

Operationally, interviews were conducted with four selected experts, each possessing specific expertise in the proposed functions for the adaptive reuse of buildings. Each expert was asked to quantify their judgments on the importance of criteria and sub-criteria (indicators) in terms of relative importance and to compare these elements in pairs using a scale of absolute judgments. After confirming the consistency and acceptability of the judgments regarding the weights, these weights were normalized to produce an overall ranking that reflected the extent to which one element dominated another in relation to a given attribute.

The final Rating AHP evaluation determined the vector of local weights for the criteria and sub-criteria on a percentage scale, which was utilized in the PROMETHEE evaluation process.

For Scenario 1, Center for Advanced Agricultural Training, an expert with specific expertise in the field of agronomy and solid experience in programs, and technical advice on agriculture for environmental sustainability, was involved.

For Scenario 2, Bike Hotel, an expert in cycle tourism, affiliated with FIAB (Italian Cyclists' Federation), with specific skills in the reception of cyclists and the promotion of cycle tourism, was involved. The selected expert also has solid experience in the hotel sector, in the organization of cycling events, and in effective strategies to attract cyclists and tourists.

For Scenario 3, Sustainable Tourist Destination, a manager of a local association was involved, with strong experience in managing sustainable tourism projects and promoting the area. The expert also has solid experience in organizing thematic excursions and designing exhibition and promotional spaces.

Finally, scenario 4, The Center of Regional Agri-food Excellence, involves an agricultural entrepreneur with experience in rural development and with knowledge and experience in the use of agricultural resources for tourism purposes, linked to both the needs and challenges of rural communities as well as the internal dynamics of agricultural cooperatives.

An analysis of the weights of the four experts involved reveals a variety of perspectives (Figures 2 and 3).

We considered Urban planning and Environmental criteria to be the most important, with a preference for indicators relating to Agricultural Surface area (AS) and Enogastronomic Potential (EP).

The expert in cycling tourism prioritized Environmental and Urban planning criteria, giving particular emphasis to indicators concerning Environmental Quality, Enogastronomic Potential (EP), and Accommodation Facilities (AF).

The manager sustainable tourism expert identified Urban planning criteria as constituting the most significant factor, showing a preference for indicators related to Accommodation Facilities (AF) and Cycling Infrastructure (CI). Environmental criteria followed closely, particularly indicators related to Tourist Presence (TP) and Landscape Quality (LQ).

The entrepreneur involved in rural development and agricultural cooperatives regarded Economic criteria as paramount, with a particular emphasis on the availability of

Ancillary Areas (AA) surrounding the station and the Size of the Buildings (SB) being of the utmost importance.

Agronomist expert	CENTER FOR ADVANCED AGRICULTURAL TRAINING	CRITERIA	ECONOMIC				ENVIRONMENTAL			URBAN PLANNING			
		Weight criteria	0.2				0.35			0.45			
		INDICATORS	SB	AA	SC	AB	LQ	EP	PT	AC	CI	SA	SR
		Weight indicators	0.40	0.30	0.10	0.20	0.25	0.40	0.35	0.30	0.20	0.35	0.15
		Weight Indicators final	0.08	0.06	0.02	0.04	0.09	0.14	0.12	0.14	0.09	0.16	0.07

Cycling tourism expert	BIKE HOTEL	CRITERIA	ECONOMIC				ENVIRONMENTAL			URBAN PLANNING			
		Weight criteria	0.25				0.4			0.35			
		INDICATORS	SB	AA	SC	AB	LQ	EP	PT	AC	CI	SA	SR
		Weight indicators	0.50	0.30	0.20	0.15	0.30	0.45	0.25	0.20	0.25	0.20	0.35
		Weight Indicators final	0.13	0.08	0.05	0.04	0.12	0.09	0.14	0.07	0.09	0.07	0.12

Sustainable tourism expert	SUSTAINABLE TOURISM DESTINATION	CRITERIA	ECONOMIC				ENVIRONMENTAL			URBAN PLANNING			
		Weight criteria	0.2				0.35			0.45			
		INDICATORS	SB	AA	SC	AB	LQ	EP	PT	AC	CI	SA	SR
		Weight indicators	0.15	0.25	0.35	0.25	0.35	0.25	0.40	0.20	0.25	0.25	0.30
		Weight Indicators final	0.13	0.08	0.05	0.04	0.12	0.09	0.14	0.09	0.11	0.11	0.14

Rural and agricultural expert entrepreneur	CENTER REGIONAL AGRI-FOOD EXCELLENCE	CRITERIA	ECONOMIC				ENVIRONMENTAL			URBAN PLANNING			
		Weight criteria	0.5				0.25			0.25			
		INDICATORS	SB	AA	SC	AB	LQ	EP	PT	AC	CI	SA	SR
		Weight indicators	0.35	0.25	0.15	0.25	0.30	0.45	0.25	0.35	0.15	0.35	0.25
		Weight Indicators final	0.18	0.13	0.08	0.13	0.08	0.11	0.06	0.09	0.04	0.09	0.06

Figure 2. Weights criteria and indicators as judged by experts.

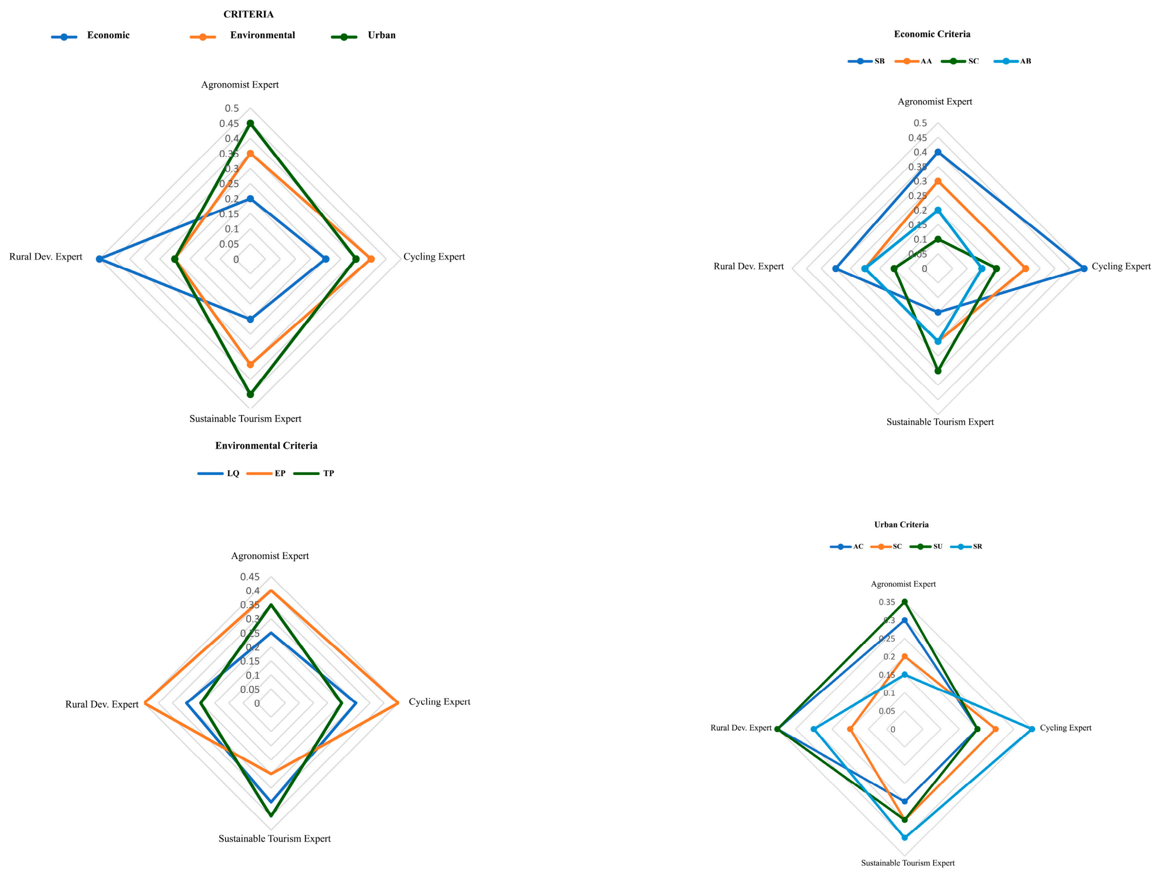


Figure 3. Weights: criteria and indicators as judged by experts.

4.2.4. Performance Matrix

According to the PROMETHEE approach, the evaluation started with the creation of a performance matrix (Figure 4) that organized the evaluation criteria and indicators into four groups according to a hierarchical structure [87]. Each evaluation criterion was oriented in a positive direction as the alternative might be preferable to the others if the associated indicator had a higher value (impacts to be maximized) or a lower value (impacts to be minimized). The unit of impact measurement was specified for each indicator, with values calculated for each alternative, based on the specific characteristics of the stations, buildings, and ancillary areas within each station. Figure 1 describes the evaluation criteria used in applying the PROMETHEE method to the case study. Based on the characteristics and values associated with the criteria and indicators, different types of preference functions (linear, level, or V-shaped), each with one or two threshold types (indifference and/or preference), were used to evaluate the performance of the alternatives.

	ECONOMIC				ENVIRONMENTAL			URBAN PLANNING			
	E1 SIZE OF BUILDINGS	E2 AUXILIARY AREAS	E3 STATE OF PRESERVATION	E4 AUXILIARY BUILDINGS	A1 LANDSCAPE QUALITY	A2 FOOD AND WINE POTENTIAL	A3 TOURIST PRESENCE	U1 ACCESSIBILITY BY CAR	U2 BICYCLE SYSTEM	U3 AGRICULTURAL AREA	U4 ACCOMMODATION FACILITIES
UNITS OF MEASUREMENT	mq	mq	5 pt	mq	5 pt	5 pt	n°	5 pt	5 pt	Ha	n°
MAX/MIN	MAX	MAX	MAX	MAX	MAX	MAX	MAX	MAX	MAX	MAX	MAX
PREFERENCE FUNCTION	LINEAR	LINEAR	LEVEL	LINEAR	LEVEL	LEVEL	V-shape	LEVEL	LINEAR	LINEAR	V-shape
(q)	300	4000	1	180	1	1	0,00	1	1	3000 Ha	50
(p)	480	9000	3	500	3	3	500,00	3	5	10000 Ha	80
1. NOTO	560	4100	ALTO	215	MOLTO ALTO	MEDIO	550,000.00	MOLTO ALTO	MOLTO BASSO	26696.31	98
2. FALCONARA IBLEA	286	3500	MEDIO	0	ALTO	BASSO	550,000.00	MOLTO ALTO	0	26696.31	50
3. NOTO MARINA	450	2000	MEDIO	143	BASSO	MOLTO BASSO	550,000.00	MEDIO	0	26696.31	77
4. NOTO BAGNI	280	350	MEDIO	0	MEDIO	MOLTO BASSO	550,000.00	ALTO	0	26696.31	75
5. ROVETO BIMMISCA	270	6500	MOLTO BASSO	190	ALTO	ALTO	550,000.00	MEDIO	0	26696.31	17
6. SAN LORENZO LO VECCHIO	340	9500	MOLTO BASSO	145	MOLTO ALTO	MOLTO ALTO	550,000.00	ALTO	0	26696.31	40
7. MARZAMEMI	360	1800	MOLTO BASSO	160	BASSO	MOLTO ALTO	12,000.00	MEDIO	MOLTO BASSO	2462.7	86
8. PACHINO	480	17000	MEDIO	610	MOLTO BASSO	ALTO	12,000.00	ALTO	MEDIO	2462.7	126

Figure 4. Performance matrix of alternatives.

Subsequently, the Normalized Matrix was derived from the performance matrix (Figure 5). This process involves normalizing the collected data to ensure comparability and eliminating scale differences among different criteria. The normalized data are subsequently employed to construct the performance matrix, where each row represents an alternative and each column represents a criterion. Within this matrix, the cell corresponding to the intersection of a particular alternative and criterion contains the normalized value representing the alternative's performance relative to that criterion.

	ECONOMIC				ENVIRONMENTAL			URBAN PLANNING			
	E1 SIZE OF BUILDINGS	E2 AUXILIARY AREAS	E3 STATE OF PRESERVATION	E4 AUXILIARY BUILDINGS	A1 LANDSCAPE QUALITY	A2 FOOD AND WINE POTENTIAL	A3 TOURIST PRESENCE	U1 ACCESSIBILITY BY CAR	U2 BICYCLE SYSTEM	U3 AGRICULTURAL AREA	U4 ACCOMMODATION FACILITIES
1. NOTO	1.00	0.22	1.00	0.35	1.00	0.50	1.00	1.00	0.00	1.00	0.74
2. FALCONARA IBLEA	0.05	0.18	0.66	0.00	0.75	0.25	1.00	1.00	0.00	1.00	0.30
3. NOTO MARINA	0.62	0.09	0.66	0.23	0.25	0.00	1.00	0.00	0.00	1.00	0.55
4. NOTO BAGNI	0.03	0.00	0.66	0.00	0.50	0.00	1.00	0.50	0.00	1.00	0.53
5. ROVETO BIMMISCA	0.00	0.36	0.00	0.31	0.75	0.75	1.00	0.00	0.00	1.00	0.00
6. SAN LORENZO LO VECCHIO	0.24	0.54	0.00	0.24	1.00	1.00	1.00	0.50	0.00	1.00	0.21
7. MARZAMEMI	0.31	0.01	0.00	0.26	0.25	1.00	0.00	0.00	0.00	0.00	0.63
8. PACHINO	0.72	1.00	0.66	1.00	0.00	0.75	0.00	0.50	1.00	0.00	1.00

Figure 5. Normalized impact matrix.

4.2.5. Evaluation Matrices

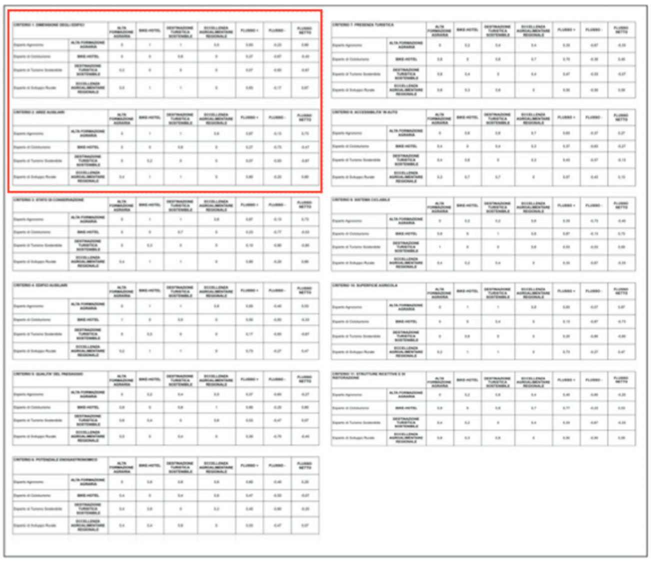
In order to apply the PROMETHEE method, the software Visual PROMETHEE 1.4 (VP Solutions, 2013) was utilized; this offers the capacity to calculate two distinct rankings that provide a comprehensive overview of the preferences of the alternatives under consideration.

The PROMETHEE I 'partial ranking' is based on two preference flows, positive Flows (F+) and negative Flows (F−). This ranking is useful when the two preference streams lead to conflicting results, allowing for incomparability between the shares. In contrast, the 'complete ranking' PROMETHEE II is based on the net preference stream F, which provides an overall view of preferences without considering contrasts between preference streams.

In order to determine the final ranking of the alternatives, 11 pairwise comparison matrices were constructed for each of the eight stations. These matrices were constructed based on the experts' preferences. The F+ and F− were then calculated for each pairwise comparison matrix in order to determine the Net Flow.

Figure 6 shows the eleven pairwise comparison matrices for the Noto station and a detail of the two alternative comparison matrices for the first two economic criteria—E1: Size of Buildings and E2: Auxiliary Areas—together with the matrix with the calculation of preference flows (F+, F− and Net Flow) for the economic criterion E1: Size of Buildings.

NOTO station_Matrices pairwise comparison



Criterion E1. Dimensions of Buildings (DB)		ATC	BHo	STD	RAF
Agronomist Expert	ATC	0	1	1	0.5
Cycling Expert	BHo	0	1	0.8	0
Sustainable Tourism	STD	0.2	0	0	0
Rural Development	RAF	0.5	1	1	0

Adaptive reuse alternatives:
ATC Agricultural Training Centre
BHo Bike Hotel
STD Sustainable Tourism Destination
RAF Regional Agri-Food centre of excellence

Criterion E2. Auxiliary Areas (AA)		ATC	BHo	STD	RAF
Agronomist Expert	ATC	0	1	1	0.6
Cycling Expert	BHo	0	0	0.8	0
Sustainable Tourism	STD	0	0.2	0	0
Rural Development	RAF	0.4	1	1	0

NOTO station_Matrices pairwise comparison and and calculation of preference flows

Criterion E1. Dimensions of Buildings (DB)		ATC	BHo	STD	RAF	Flow +	Flow -	Net Flow
Agronomist Expert	ATC	0	1	1	0.5	0.83	-0.23	0.60
Cycling Expert	BHo	0	0	0.8	0	0.27	-0.67	0.40
Sustainable Tourism	STD	0.2	0	0	0	0.07	-0.93	0.87
Rural Development	RAF	0.5	1	1	0	0.83	-0.17	0.67

Adaptive reuse alternatives:

ATC Agricultural Training Centre
BHo Bike Hotel
STD Sustainable Tourism Destination
RAF Regional Agri-Food centre of excellence

Figure 6. NOTO station: matrices of valuation and calculation of preference flows.

4.2.6. Discussion of the Final Results Obtained from the PROMETHEE Approach

The results of the evaluation using the PROMETHEE method are presented in Figure 7, which displays the final assessment of each expert and the final ranking for each functional scenario.

Agronomist Expert

Station	Agricultural Training Centre			
	F+	F-	F	RANK
PACHINO	0.32	-0.11	0.21	1
NOTO	0.18	-0.11	0.07	2
SAN LORENZO	0.18	-0.20	-0.02	3
ROVERETO BIMMISCA	0.15	-0.20	-0.05	4
MARZAMEMI	0.05	-0.28	-0.23	5
NOTO MARINA	0.14	-0.28	-0.14	6
FALCONARA IBLEA	0.06	-0.27	-0.21	7
NOTO BAGNI	0.10	-0.27	-0.17	8

Sustainable Tourism Expert

Stations	Sustainable Tourism Destination			
	F+	F-	F	RANK
FALCONARA IBLEA	0.27	-0.08	0.19	1
MARZAMEMI	0.24	-0.06	0.18	2
NOTO BAGNI	0.23	-0.09	0.14	3
NOTO MARINA	0.16	-0.10	0.06	4
PACHINO	0.21	-0.16	0.05	5
SAN LORENZO	0.14	-0.18	-0.04	6
ROVERETO BIMMISCA	0.12	-0.16	-0.04	7
NOTO	0.04	-0.28	-0.24	8

Cycling Expert

Stations	Bike Hotel			
	F+	F-	F	RANK
ROVERETO BIMMISCA	0.38	-0.04	0.34	1
NOTO MARINA	0.34	-0.06	0.28	2
FALCONARA IBLEA	0.30	-0.04	0.26	3
NOTO BAGNI	0.28	-0.08	0.20	4
SAN LORENZO	0.21	-0.09	0.12	5
NOTO	0.23	-0,20	0.03	6
PACHINO	0,17	-0.14	0.03	7
MARZAMEMI	0.01	-0.34	-0.33	8

Rural Development Expert

Stations	Regional Agro-Food Centre of Excellence			
	F+	F-	F	RANK
NOTO	0.37	-0.04	0.33	1
PACHINO	0.24	-0.08	0.16	2
SAN LORENZO	0.19	-0.11	0.08	3
MARZAMEMI	0.10	-0.11	-0.01	4
ROVERETO BIMMISCA	0.19	-0.20	-0.01	5
NOTO MARINA	0.12	-0.22	-0.10	6
NOTO BAGNI	0.06	-0.44	-0.38	7
FALCONARA IBLEA	0.06	-0.46	-0.40	8

Figure 7. Final assessment of each expert and ranking for each functional scenario.

For the expert agronomist, the Pachino station was deemed the most suitable for the Agricultural Training Center scenario, given its large surface area and the presence of auxiliary spaces, in line with the economic requirements expressed by the expert.

The cycling expert assessed that the Roveto Bimmisca station, favorably located along existing cycle routes and boasting a considerable surface area, is an ideal location for a Bike Hotel. In second place was the Noto Marina station.

According to the Sustainable Tourism Expert, the Falconara Iblea station is the best choice for a Sustainable Tourist Destination, with its compact size being a significant factor. The Marzameni station was also rated positively, ranking second in terms of accessibility and attractiveness for visitors throughout the year.

Regarding the Rural Development Expert, who attached great importance to the economic viability of agricultural cooperatives and available space, the Noto station is the most suitable to be converted into a Regional Agrifood Centre of Excellence (F 0.33), closely followed by the Pachino station.

After calculating the ranking of the best-performing stations for each reuse destination using the PROMETHEE method, a sensitivity analysis was conducted to test the stability of the evaluation model outputs and to study how the ranking of the scenarios is influenced by variations in input data. In this application paper, the sensitivity analysis considers the change in the weights of different criteria. While in the initial Scenario 1 (Figure 7), the scores of the criteria and indicators were weighted according to the experts' ratings and priorities, in the new Scenario 2, all criteria were assigned the same weight. The results of the sensitivity analysis and the comparison between the two scenarios (Figure 8) confirm the stability of the results. The comparison between the two scenarios highlights that the initial ranking remained unchanged, indicating that the best-performing stations for specific reuse destinations remain so regardless of the weighting of the criteria.

Station	Center for Advanced Agricultural Training	
	Scenario 1	Scenario 2
NOTO	0.13	0.21
PACHINO	-0.02	0.07
ROVETO BIMMISCA	-0.02	-0.05
SAN LORENZO	-0.03	-0.02
MARZAMEMI	-0.22	-0.23
NOTO MARINA	-0.22	-0.14
FALCONARA IBLEA	-0.25	-0.21
NOTO BAGNI	0.27	-0.17

Station	Sustainable Tourist Destination	
	Scenario 1	Scenario 2
FALCONARA IBLEA	0.27	0.19
NOTO BAGNI	0.21	0.14
MARZAMEMI	0.13	0.18
NOTO MARINA	0.06	0.06
SAN LORENZO	-0.02	-0.04
ROVETO BIMMISCA	-0.03	-0.04
PACHINO	-0.12	0.05
NOTO	-0.38	-0.24

Station	Bike Hotel	
	Scenario 1	Scenario 2
ROVETO BIMMISCA	0.34	0.34
NOTO MARINA	0.29	0.28
FALCONARA IBLEA	0.23	0.26
NOTO BAGNI	0.11	0.20
SAN LORENZO	0.10	0.12
PACHINO	-0.01	0.03
NOTO MARINA	-0.02	0.03
MARZAMEMI	-0.26	-0.33

Station	Center of Regional Agri-food Excellence	
	Scenario 1	Scenario 2
PACHINO	0.21	0.16
NOTO	0.15	0.33
SAN LORENZO	0.12	0.08
BIMMISCA	-0.07	-0.01
MARZAMEMI	-0.10	-0.01
NOTO MARINA	-0.13	-0.10
NOTO BAGNI	-0.33	-0.38
FALCONARA IBLEA	-0.38	-0.40

Figure 8. The results of the sensitivity analysis.

5. Conclusions

The greenway phenomenon, originating in the United States and subsequently spreading to Europe, is increasingly recognized as a model for sustainable land development. It represents a linear territorial system that offers a range of recreational, ecological, and historical–cultural benefits [54,88]. The repurposing of disused railways and abandoned stations is particularly significant as it provides an opportunity to create new green infrastructure and enhance long-distance cycling networks such as the Eurovelo project. Eurovelo consists of 14 long-distance cycling routes spanning across Europe, extending to southern Italy [89].

The Italian Greenways Association, an organization dedicated to the promotion and development of greenways in Italy, has facilitated the transformation of several railway lines into cycling and walking routes for sustainable mobility and eco-friendly tourism. These routes are managed by the Association, which plays a key role in the planning, management, and promotion of greenways. The Association's efforts have contributed to the creation of a national network of safe and accessible routes for all.

In this context, the importance of evaluation and the utilization of a Multi-Criteria Decision Aid (MCDA) approach lies in its pivotal role in furnishing an organized set of information essential to inform decisions, thereby enabling each actor involved in the decision-making process to make well-considered decisions. The MCDA is therefore an effective tool for analyzing the complex structure of decision-making problems, considering the multiple dimensions involved. It is particularly useful for dealing with situations characterized by conflict and uncertainty, stimulating dialogue and communication between all the stakeholders involved in project decisions [90–92].

In the specific case of the evaluation applied to the case study of alternative proposals for the reconversion of the disused railway line between Noto and Pachino and the adaptive reuse of stations, it became evident that a practical and effective tool was required for the DMs and managers of the intervention to make a choice. To this end, an evaluation approach was developed that considers four alternatives for the adaptive reuse of disused stations between Noto and Pachino, representative of different possible scenarios.

The PROMETHEE approach guided the evaluation process, allowing the different proposals for adaptive reuse to be evaluated in a rigorous and transparent manner. The use of a dedicated software simplified the analysis and ensured a scientifically valid approach to the choice of the most suitable location, i.e., identifying which station performs best, due to specific characteristics, to host a specific function [93] according to the judgement of the experts involved.

In detail, the integrated project was developed with the objective of protecting and enhancing the numerous architectural and natural resources in the area. It was created through a process of co-design and co-assessment, which involved the reconversion of the disused railway line into greenways and the recovery of the eight disused stations located along the route, which were selected for new functions based on the territorial and economic needs of tourism development.

The newly identified functions, which were developed through a process of co-design and co-assessment in collaboration with stakeholders and a panel of experts, are also those capable of triggering a sustainable development that aims to enhance two of the study landscape's great strengths: tourism and agriculture. This will be achieved through the selection of activities dedicated to the creation of new services and the valorization of historical attractions, cultural opportunities, and the territory's wine and food potential.

Once the functional scenarios had been defined, the final evaluation and ranking phase, based on PROMETHEE, was conducted using a system of indicators that had been developed through the involvement of experts related to the selected functions. This allowed the ranking of the most suitable locations among the stations considered for the realization of the specific functions selected.

In conclusion, the application of the PROMETHEE method to the case study concerning the redevelopment of the railway line between Noto and Pachino demonstrated how this method can be effectively used in the decision-making process to evaluate alternatives and support DMs with informed and sustainable decisions concerning the locations of abandoned infrastructure.

The results obtained from the application of the PROMETHEE method formed the basis for the definition of a masterplan for the redevelopment project involving the entire railway line and for identifying the most suitable locations for the reuse of functions between the eight stations along the route (Figure 9).

The map provides a graphical representation of the results obtained from the application of the PROMETHEE method and a complete overview of the potential reuse destinations for the stations along the disused railway line. The map provides a clear indication of the optimal choices for each station, indicating the potential for the surrounding territory to be developed and enhanced. For instance, the Noto station has been identified as an optimal location for a Regional Agri-food Center of Excellence, which would leverage local agricultural resources and promote environmental sustainability and economic development in the sector. Similarly, the Pachino station has been designated as an Agricultural Training Center, underscoring the pivotal role this station could play in providing specialized training programs for agricultural professionals. This would contribute to the dissemination of best practices and innovation in the field. The Falconara Iblea station has been identified as a Sustainable Tourism Destination, suggesting potential for the development of tourism initiatives that showcase the cultural, scenic, and environmental heritage of the area. The Roveto Bimmisca station has been deemed an optimal location for a Bike Hotel, supporting the growth of cycle tourism and promoting a sustainable alternative to traditional modes of transport.

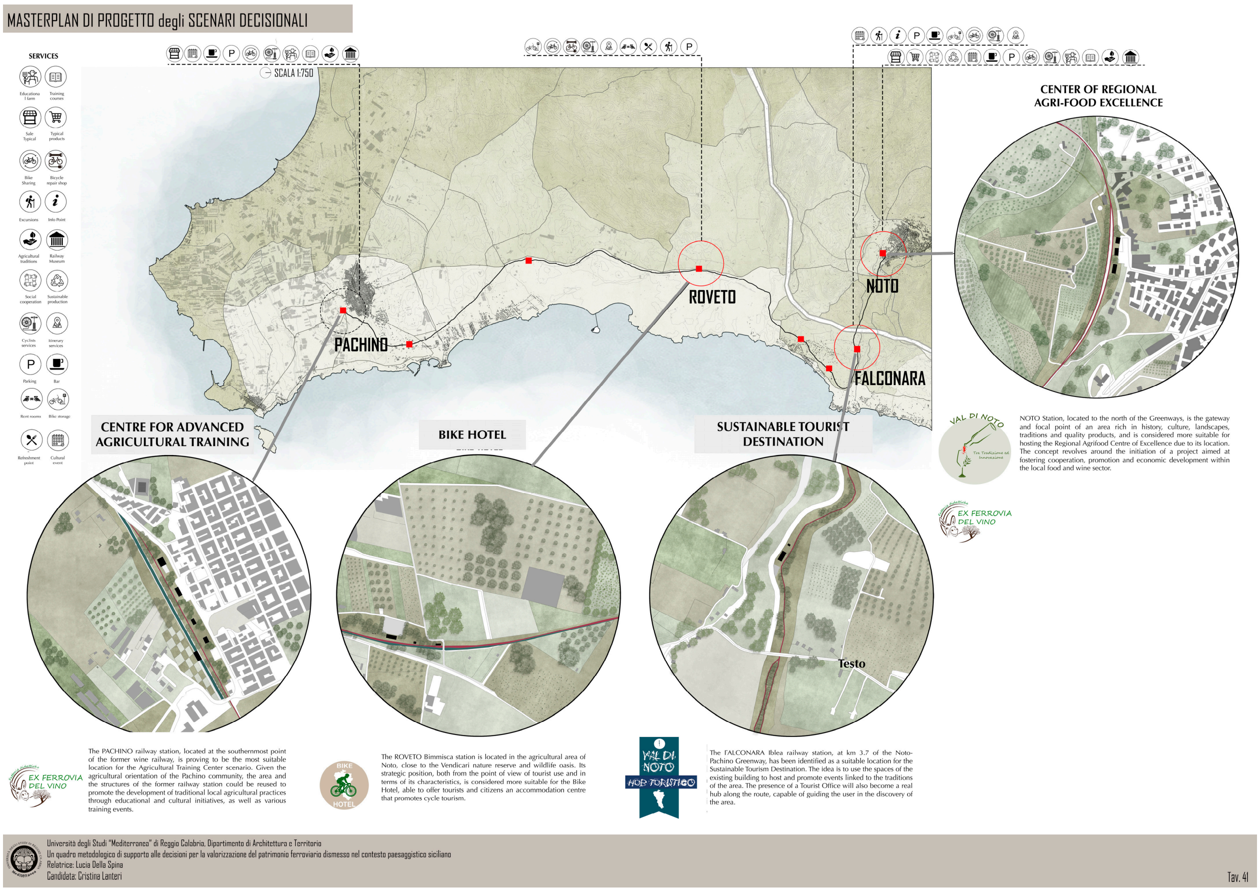


Figure 9. Project masterplan.

The advantages of utilizing the PROMETHEE method to inform location decisions for new adaptive reuse functions were corroborated by the outcomes observed [87,94]. Indeed, this method enables the effective comparison of alternative scenarios, thereby facilitating the decision-making process. The use of PROMETHEE II software has further streamlined the process, rendering it accessible even to less experienced users.

Furthermore, in this study, the PROMETHEE II method permitted the organization of focus groups in order to consider the opinions of the various experts involved in the decision-making process. This multi-actor approach proved to be particularly useful in determining the most appropriate allocation of stations according to different needs and types of investment and management. The weighting model used in the study proved to be effective by actively involving all experts involved in the decision-making process.

In conclusion, this study demonstrated the efficacy of a multi-criteria collaborative decision-making framework in supporting and facilitating tangible decisions in the real-world context. This is exemplified by the ability to resolve decision-making issues pertaining to the optimal location, where the exploration of the intricacies of diverse options is often constrained by financial resources and the availability of information. The research undertaken intends to systematize the multi-methodological approach used, developing a collaborative digital platform [95] to help policy makers in the valorization of cultural heritage. The platform will support an open GIS system, incorporate multi-objective decision support systems, and include online community engagement. Furthermore, in future developments of the study, one could think about the integration of multi-criteria decision-making models, such as the NAIADE method for the evaluation of compromise solutions, to be used together with the PROMETHEE method, and broaden the criteria to comprehensively evaluate the social, cultural, environmental, and economic dimensions of cultural heritage. Cultural heritage thus becomes an active node of a complex system, generating new values and positive impacts and encouraging the formation of new communities.

Author Contributions: Conceptualization, L.D.S.; methodology, L.D.S.; software, L.D.S.; validation, L.D.S.; formal analysis, L.D.S.; investigation, C.L.; resources, C.L.; data curation, C.L.; writing—original draft preparation, L.D.S.; writing—review and editing, L.D.S.; visualization, L.D.S.; supervision, L.D.S.; project administration, L.D.S. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Data Availability Statement: The original contributions presented in the study are included in the article, further inquiries can be directed to the corresponding author.

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

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