V. Ferretti and A. Degioanni

How to support the design and evaluation of redevelopment projects for disused railways? A methodological proposal and key lessons learned

Article (Accepted version) (Refereed)

Original citation:
Degioanni, A. and Ferretti, V. (2017) *How to support the design and evaluation of redevelopment projects for disused railways? A methodological proposal and key lessons learned.* Transportation Research Part D: Transport and Environment, 52 (A). pp. 29-48. ISSN 1361-9209

DOI: 10.1016/j.trd.2017.02.008

How to support the design and evaluation of redevelopment projects for disused railways? A methodological proposal and key lessons learned

Ferretti V[a*]., Degioanni A[b].

[a] Department of Management, London School of Economics and Political Science, Houghton Street, WC2 2AE, UK. Phone: +44 2079556794, E-mail: V.Ferretti@lse.ac.uk [*]corresponding author
[b] Technical University of Turin. Corso Duca Degli Abruzzi, 24. 10138 Turin (Italy)

Abstract

Finding a new use for neglected infrastructures, such as disused railways, provides an opportunity for low carbon travel experiences as reconversion policies promote new uses, arrest decay processes and re-establish continuity in the environmental system, using existing linear infrastructures. Nevertheless, the decision of what to do in order to reuse abandoned railways represents a complex decision making problem, involving heterogeneous impacts and stakeholders. Within this context, Multi Criteria Analysis techniques can be used to synthesize stakeholders' preferences by accommodating conflicting and incommensurable impacts. The present study thus uses Multi Criteria Analysis to answer a real demand for transportation systems' planning coming from the Piedmont Region Authority in Italy, where 12 passenger railway lines have recently been abandoned and replaced by bus services.

The main objective of the study is to develop a methodological framework able to support collaborative planning and decision-making processes related to the requalification of disused railways in mixed urban and rural contexts.

The ultimate objective is to provide a robust recommendation to the Regional Authority with reference to the best requalification option for the abandoned railway line under analysis. The contribution brought by the study is twofold and refers to: (i) improved operability of the proposed tools obtained by combining visualization analytics with consolidated preference elicitation protocols for assessing multiple impacts and (ii) the provision of a replicable working tool for policy makers. The study has thus an innovative value and may increase the use of Decision Analytics to support the evaluation of environmental impacts of different transportation systems.

Keywords: disused railways; greenways; Decision Analysis; Multi Attribute Value Theory; Multiple Criteria Analysis; impacts' aggregation.

1. Introduction

The gradual increase in private mobility, dating back to the second half of the last century in western countries, has caused the shutdown of several secondary railway lines which are rarely used and therefore little profitable to any institution, either owner or manager (Guerrieri and Ticali, 2012).

The disused railways are potential new pathways and the abandoned stations provide available spaces for new activities, supporting sustainable local development and regeneration processes. Consequently, disused railway sites are becoming a focus of redevelopment projects in many European countries (Bertolini and Spit, 1998). First, the economically attractive location of such sites, close to or even within the central districts of cities, gives them a potentially high land value. Second, they often account for the largest, well connected development areas within European metropoles (Bertolini and Spit, 1998). Third, such railway brownfields benefit from their relatively small reclamation costs compared with former heavy metal industry areas. Last, the economic demand to develop such sites has been intensified by the reorganization or privatization of national railway groups, thereby leading to the spin-off of major real estate enterprises responsible for the development of these inner city brownfields. For these reasons railway brownfields are of major interest to urban redevelopment projects (Altherr et al., 2007).

Within this context, the identification and evaluation of feasible alternatives for the requalification of disused railways is not an easy task. It is indeed an inherent multi-attribute problem, characterized by many different dimensions pursuing heterogeneous and often conflicting objectives. Moreover, decision-making in this context is often complicated by (i) multiple stakeholder views that call for a participative decision process able to include different perspectives and facilitate the discussion, (ii) long time horizons which add further structural uncertainty to the decision making process, (iii) the irreversible allocation of scarce public resources, and (iv) the need for legitimation and accountability of both results and processes (Tsoukiàs et al., 2013).

Multicriteria Decision Aiding (MCDA; Figueira et al., 2005) which nowadays represents a consolidated approach to decision making in many different contexts, including the analysis of transportation systems (e.g. Colorni et al., 1999; Filippo et al., 2007; Karlson et al., 2016; Vreeker et al., 2002), can play a fundamental role in supporting the design and evaluation of competing alternatives against a set of heterogeneous and conflicting objectives to be achieved (e.g. Ferretti, 2013).

A solution that seems particularly successful worldwide for the functional upgrade of the disused road patrimony consists in the conversion of railways into greenways dedicated to "soft mobility" (i.e. walking and cycling routes). The following reasons support the success of this type of requalification measure: i) separation of railway sediment from the ordinary road network; ii) reduced number of intersections with the road network; iii) moderate longitudinal slopes; iv) long straight roads and large horizontal radii; v) width compatibility between the railway platform and that for cyclists and pedestrians; vi) interconnection between urban centers and routes passing often through areas of great natural value, hardly accessible by alternative modes of transport; and vii) links with other public transport services (Guerrieri and Ticali, 2012).

The objective of this contribution is twofold. The first one is to provide a transparent and transferable methodological framework able to (i) support collaborative decision-making and planning processes related to the requalification of disused railways in mixed urban and rural contexts, (ii) provide insights on what needs to be improved on specific alternatives and (iii) provide justification and legitimation to the final recommendation. Indeed, public policy makers are often confronted with limited available resources and thus need tools and processes for studying competing options and selecting the best one. Moreover, both tangible and intangible impacts are likely to play a key role in the definition of the best solution and the tools thus need to be able to handle both types of information, as it is the case in MCDA. The methodological framework proposed in this paper is based on the use of MCDA and is thus able to support the negotiation among different stakeholders/ decision makers for a solution on how to tackle the functional requalification of disused railways, highlighting argument in favor and against the different options (as will be shown in Sections 3 and 4).

The second objective of the study is to investigate which role decision analytics can play to support heterogeneous impacts' aggregation in transportation planning, by discussing in particular the operability, the applicability and the transparency of the tools.

In particular, our study answers a real demand for mobility planning and management coming from the Piedmont Region in Italy, where 12 passenger railway lines have recently been abandoned and replaced by bus services. Despite the national characteristics of the territorial context under analysis, the topicality of the problem provides it with international relevance, as there are hundreds of thousands of kilometers of inactive railways and together with them station buildings that fall into disuse, thus increasingly constituting an important heritage asset worldwide.

The ultimate objective of the research is to provide a robust recommendation to the Regional Authority with reference to the best requalification option for the abandoned railway line under analysis (Section 4).

The study is intended to help urban as well as regional planners, policy and decision-makers, land managers and public organizations to understand, evaluate and manage complex territorial systems characterized by multiple values.

It is worth highlighting that this study has an innovative value due to the following reasons: (i) it tests a visual elicitation protocol for preference elicitation in order to facilitate the application of the Multi Criteria Analysis Approach in planning and design contexts with real stakeholders and decision makers, (ii) it uses facilitated modeling (Franco and Montibeller, 2010) throughout the whole decision making process, and (iii) it represents the first application of a Multi Attribute Decision Analysis approach (Fishburn, 1967) in the context of abandoned railway lines requalification, as well as one of the first applications of MCDA in the same context.

The contribution brought by the study is thus twofold and refers to: (i) improved operability of the proposed tools obtained by combining visualization analytics with a specific MCDA technique named Multi Attribute Value Theory (MAVT, Fishburn, 1967) and (ii) provision of a transferable working tool able to support planning and design processes of other abandoned railway lines to be recovered.

The remainder of the paper is organized as follows: Section 2 introduces the problem of disused railways and discusses the use of Multicriteria Analysis for dealing with it. Section 3 presents the methodological background of Multi Attribute Value Theory while section 4 illustrates the development of the framework proposed by the authors in order to answer a real demand for mobility planning and management coming from the Piedmont Region in Italy. Finally, Section 5 concludes the paper and discusses the opportunities for further developments of the research.

2. The problem of disused railways

Railways are a product of the industrial revolution that acquired, right from the beginning, a fundamental role, becoming the main mode of transport of raw materials and products. The railway network spread widely during the industrialisation process, suffering only a temporary pause caused by the increasing use of cars and the World War II bombings. Today, it is an efficient and fast mode of transport, to the extent that high-speed rail, on medium distances, is competitive to air travel. Moreover, it represents an environmentally friendly solution since it causes less pollution compared to other transport modes, it does not cause negative impacts on the landscape and it consumes less environmental resources. However, the current economic crisis has yield to the necessity of rail services reorganisation in rural and peripheral areas, resulting sometimes in their suppression and replacement with bus services. Therefore, it is urgent to consider the issues related to inactive railway lines as there are hundreds of thousands of kilometres of inactive railways and together with them station buildings that fall into disuse (Bertolini and Spit, 1998).

Many countries around the World have tackled the problem in creative and successful ways. In order to give a few examples, the following paragraph presents some of the solutions that have been

adopted worldwide for the management of this significant forgotten heritage. In 1983, the United States introduced the *Rail Banking* solution, a procedure that provides for the maintenance and preservation of the operational functionality of a railway line, in view of a possible reopening of the track. Alternatively, in periods of inactivity, public or private organisations can be temporarily granted the use of the railway line for recreational purposes. In Belgium, in 1997, the national railway system (SNCB) signed an agreement aimed at granting under concession almost 1,000 km of disused lines for 99 years, resulting in the creation of a network of greenways. Spain followed a similar strategy: 100 greenways were created and old stations were converted to new uses such as catering, bike rentals, railway engineering museums, etc. In Italy there have been only few and isolated projects aimed at the redevelopment and exploitation of disused railway lines, as, for example, the Savona-Ventimiglia line, which is a railway that has been relocated and partially reused as a greenway next to the sea.
Table 1 summarizes the relevant best practices available worldwide.

Table1 Some of the best practices for the requalification of abandoned railway lines worldwide

Country	Project
UK (London)	The city is planning to build bike paths in abandoned tube tunnels. The project from design firm Gensler (best Conceptual Project at the London Planning Awards 2015) would turn London's abandoned tube tunnels into living streets beneath the city, with parallel pedestrian paths and cycle ways with kinetic paving, which uses footfall and the friction created by bike tyres to generate electricity (http://www.theguardian.com/cities/2015/feb/05/bike-paths-abandoned-tube-tunnels-london-underline?CMP=share_btn_tw).
UK (Edinburgh)	The Edinburgh Metro uses the city's disused railway heritage combined with modern light rail technology to provide a popular and sustainable transport system.
Italy	Recently, about 1700 train stations in Italy have been granted to municipalities and social associations to be used as small museum, theaters, recreational places, etc (http://www.labsus.org/2014/10/vecchie-stazioni-ferroviarie-cedute-comodato-duso-gratuito/).
Australia	The "East Gippsland Rail Trail" is a 96 km greenway mainly used for bicycle and excursions build on an abandoned railway line situated in Victoria.
Canada	The "Prince Edward Island Railway" consists of the requalification of the railway in a corridor that is used all year round, during summer as a pedestrian path and during winter as a snowmobile path managed by "PEI Snowmobile Association".
France (Paris)	The Museé D'Orsay is one of the most well-known museums of Paris and is located inside the old train station which has been used from 1900 to 1950.
France (Paris)	The "Promenade Planteé" is a suspended railway which has been abandoned in 1969 and has been recovered as a green park which extends for 4.7 km.
Germany	The "Karlsruhe model" is the first experimentation worldwide of the tram-train service.
Belgium	Since 1990s disused railways are being transformed into greenways, focusing primarily on tourism. The greenway network of the Programme RAVeL (Réseau Autonome de Voies Lentes) based on disused railways, pathways and canals is currently 900 Km long (European Greenway Association, 2000).
UK	The "Bristol and Bath Railway Path" is a 24 km bicycle path built on a railway abandoned in 1986.
USA (Missouri)	The "Katy Trail" in Missouri is the longest rail trail worldwide (386 km). It follows the

Country	Project
	Missouri River and crosses many small valley and villages.
USA (New York)	The “High Line” is a suspended park which extends for 1.6 km on an abandoned railway line in Manhattan.

2.1 Multicriteria Decision Aiding and abandoned railway lines

The selection of what to do with an abandoned railway line represents a complex decision making problem, as many heterogeneous and often conflicting impacts have to be taken into account, ranging from economic considerations, to environmental impacts and social issues.

Multiple Criteria Decision Aiding (Figueira et al., 2005) is a valuable and increasingly widely-used tool to aid decision-making where there is a choice to be made between competing options. It is particularly useful as a tool for sustainability assessment and urban and territorial planning, where a complex and inter-connected range of environmental, social and economic issues must be taken into consideration and where objectives are often competing, making trade-offs unavoidable. There are numerous approaches that all fall under the umbrella of MCDA, each involving different protocols for eliciting inputs, structures to represent them, algorithms to combine them, and processes to interpret and use formal results in actual advising or decision-making contexts (Huang et al., 2011). The selection of which method to use is thus an important one and different meta-choices are available (Ferretti and Montibeller, 2016). The rational underpinning our choice for this study will be explained in section 3.

In order to better understand how MCDA has been used for dealing with railways management, Table 2 summarizes the main scientific contributions available in the literature, highlighting for each of them the decision context, the objective of the evaluation, the methods that have been applied and the scientific journal in which the contribution has been published.

Table 2 Key references concerning MCDA applications for dealing with railway management problems

Authors	**Title**	**Context of the analysis**	**Objective**	**Methods**	**Journal**
Chang et al. (2009)	*Using ANP priorities with goal programming for revitalization strategies in historic transport: A case study of the Alishan Forest Railway*	Evaluation of revitalization strategies	Selection of the most suitable alternative for the revitalization of an historical railway line in the Alishan forest in Taiwan	**Analytic Network Process (ANP) and Delphi Method**	Expert Systems with Applications
Lee S-M. (1998)	*Analytic Hierarchy Process for Transport Project Appraisal – An application to Korea*	Strategic planning of railway lines	Identification of the best location for a railway line with associated stations in the historical city of Kyongju	**Analytic Hierarchy Process (AHP)**	Journal of Advanced Transportation

Authors	Title	Context of the analysis	Objective	Methods	Journal
Gercek et al. (2004)	*A multiple criteria approach for the evaluation of the rail transit networks in Istanbul*	Optimization of railway transportation	Ranking of alternatives for railway transit in Instanbul city	**AHP**	Transportation
Macura et al.(2011)	*A Model for Prioritization of Rail Infrastructure Projects Using ANP*	Priority ranking of railway investments	Ranking of investment for railway infrastructures	**ANP**	International Journal of Transport Economics
Longo et al. (2009)	*Considerations on the application of AHP/ANP methodologies to decisions concerning a railway infrastructure*	Location of railway lines	Land suitability analysis for a railway connection between the lines Turin-Milan and Turin-Lyon	**ANP**	Proceedings of the International Symposium on the Analytic Hierarchy Process 2009
Tudela et al. (2006)	*Comparing the output of cost-benefit and multi-criteria analysis – An application to urban transport investments*	Optimization of railway transportation	Selection of the most suitable alternative for the optimization of the railway traffic in Chiguayante in Concepcion (Cile)	**AHP**	Transportation Research Part A
Wey e Wu (2007)	*Using ANP priorities with goal programming in resource allocation in transportation*	Enhancement of railway lines	Ranking of improvement options for the railway infrastructures in Taichung City	**ANP + ZOGP**	Mathematical and Computer Modelling
Shang et al. (2004)	*A unified framework for multicriteria evaluation of transportation projects*	Decision support for the development of new lines	Strategic planning of railway projects for the city of Ningbo (China)	**ANP**	IEEE Transactions on Engineering Management

From the analysis of the references proposed in Table 2, it is possible to highlight the following important issues:

(i) to the knowledge of the authors, there are no studies dealing with the evaluation of competing alternatives for the requalification of an abandoned railway line; indeed, most of the applications deal with the selection of alternatives/locations for the optimization of the traffic. Studies dealing with the problem of abandoned railways do exist but they focus more on the ecological implications of the disused infrastructure (e.g. Mitchell and Cooke, 1991; Altherr et al., 2007) or on the discussion of a single solution or project without supporting the identification and comparison of alternative solutions (e.g. Ward and Ruff, 1986).

(ii) The most applied MCDA method is the Analytic Hierarchy Process (AHP; Saaty, 2013) and its evolution as Analytic Network Process (ANP; Saaty, 2013).

3. Methodological background: the Multi Attribute Value Theory approach

Within the family of MCDA methods, the specific technique named Multi Attribute Value Theory (Fishburn, 1967) has recently emerged as a promising tool in the field of sustainability assessments

and strategic planning for territorial transformation processes (e.g. Huang at al., 2011; Ferretti, 2016a; Ferretti and Comino, 2015).
Multi-Attribute Value Theory can be used to address problems involving a finite and discrete set of alternative options that have to be evaluated on the basis of conflicting objectives/impacts. The reasons for using an MAVT approach in the present study are as follows: (i) since it is founded on fundamental axioms of rational choice (e.g. Von Winterfeldt and Edwards, 1986), results are justifiable, which is vital for policy decisions that have to be defended in the policy arena; (ii) it can deal with a large number of alternatives without an increase of the elicitation effort compared to a study with a smaller number of alternatives (Schuwirth et al., 2012), thus ensuring replicability to the whole process; (iii) it allows for both qualitative and quantitative impacts to be evaluated, thus playing a crucial role in the field of environmental decision-making and policy design where many aspects are often intangible (e.g. Ferretti and Comino, 2015); and (iv) it is a well-researched and well-founded methodology, and a relatively simple MCDA method, thus complying with the need highlighted by recent research in Multi Attribute Decision Making (Ulengin et al., 2010) for the use of simple, understandable and usable approaches for solving decision-making problems.
From the methodological point of view, the process to be followed in order to develop an MAVT model can be described as shown in Figure 1. While the MAVT modelling steps (items 1 to 5 in Figure 1) have already been presented in the decision analytic literature (e.g. Keeney, 1992; Belton and Stewart, 2002), the proposed diagram relates them to the recommended inputs and required outputs of public policy decision processes in order to provide a comprehensive perspective.

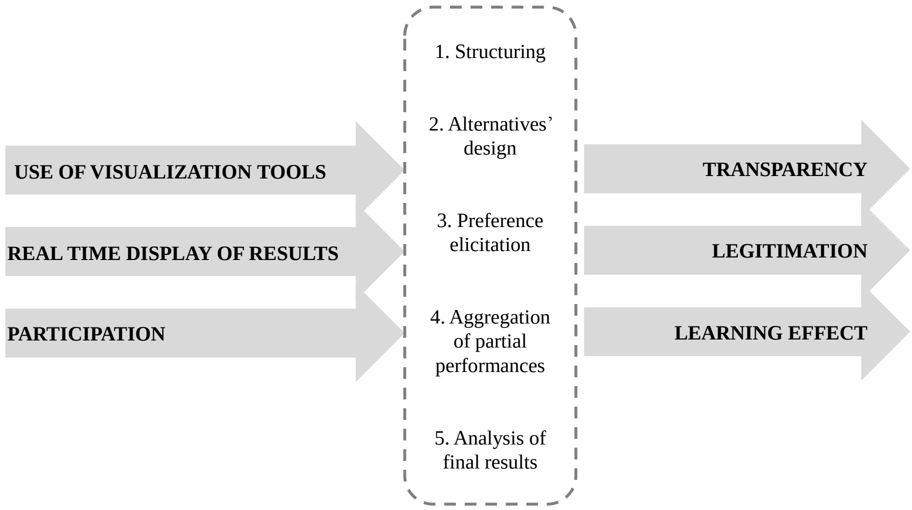


Figure 1 MAVT methodological steps

In particular, the first step concerns the definition of the problem, which implies identifying and structuring the fundamental objectives and related attributes (i.e. measurable characteristics used to quantify the objectives) by means of a value tree. Following a value focused thinking approach

(Keeney, 1992), the second step consists in the identification of alternative options, i.e. potential solutions to the decision problem. To be able to evaluate the identified alternatives, preferences and value trade-offs need to be properly elicited. In particular, the performances of the alternatives need to be translated into a value score representing the degree to which each objective is achieved (i.e. marginal value function). The interested reader can refer to Beinat (1997) for a detailed explanation of the different available approaches for preference elicitation in MAVT. In order to aggregate all evaluations and obtain a final ranking of alternatives, the simplest aggregation method that can be used in MAVT is the additive model (Belton and Stewart, 2002) as it is represented in equation (1):

$$V(a) = \sum w_i \times v_i(a_i) \qquad (1)$$

where $V(a)$ is the overall value of alternative a, $v_i(a_i)$ is the single attribute value function reflecting alternative a's performance on attribute i, and w_i is the weight assigned to reflect the importance of attribute i. The key condition for the additive form in (1) is mutual preference independence. Attributes i and j are preference independent if trade-offs (substitution rates) between i and j are independent from all other attributes. Mutual preference independence requires that preference independence holds for all pairs i and j. Since (1) aggregates the options' performance across all the attributes to form an overall assessment, MAVT is thus a compensatory aggregation rule.

Finally, a sensitivity analysis is recommended in order to test the stability of the obtained results with regards to variations in the inputs. As a result, a final recommendation can be obtained and be further discussed with the Decision Makers and stakeholders.

4. Case study: what to do with disused railways?

4.1 Contextualization

This study deals with the problem of abandoned railway lines. In Italy there are more than 7,500 Km of abandoned railways, 50% of which has been evaluated as suitable to be recovered for touristic purposes and ecological valorisation (Italian Greenways Association, 2015). Due to cost-saving measures for transportation policies in Italy, this figure is increasing and in 2012, in the Piedmont Region (North West of Italy), twelve passenger railway lines, characterized by low patronage, have been replaced by bus services.

Among these lines, the Pinerolo - Torre Pellice, which stretches for 16.5 km between the city of Pinerolo and the Pellice Valley, crossing six municipalities, was selected as the most strategic one to be further studied for requalification purposes. The selection of this railway line among the 12 abandoned ones was guided by the following four criteria:

(i) Infrastructural problems: this criterion includes the presence of structural and infrastructural problems along the railway line, which in some cases have been the main reason for the suppression of the line due to the high costs of restoration works.
(ii) Potential users: municipalities with a distance between the city centre and the nearest station of at most six kilometres as the crow flies (criterion adopted based on studies previously carried out in the same region, e.g. Agenzia Mobilità Metropolitana Torino, 2011) are considered to be concerned by the railway. The number of potential users has been calculated with the use of Geographic Information Systems.
(iii) Presence of attractors: the railway lines have been analysed to detect the presence of particularly popular destinations. For each line, the number of attractors within a 500 meters' buffer has been determined with the use of Geographic Information Systems.
(iv) Average distance from urban centres to railway stations: the distance has been calculated as the average of the distances between all the towns crossed by the railway lines and the respective stations.
The logic followed for the selection of the most strategic railway line from which to start the requalification study is summarized in the following paragraph.
Since the requalification of the abandoned railway line would be strongly influenced by the high cost of repairing or rebuilding damaged items, the lines including sections with infrastructural problems were excluded from further consideration in the analysis. Then, the attention focused on the routes with the greater number of potential users, so that redevelopment would benefit the highest number of residents. Afterwards, a ranking of the lines was made based on the presence of attractors and the average distance from railway stations to urban centres.
As a result, the Pinerolo – Torre Pellice railway line was selected as the most strategic one for which to find an alternative use. Figure 2 illustrates the geographical location of the selected line while Figure 3 presents some historical photos of the same line.

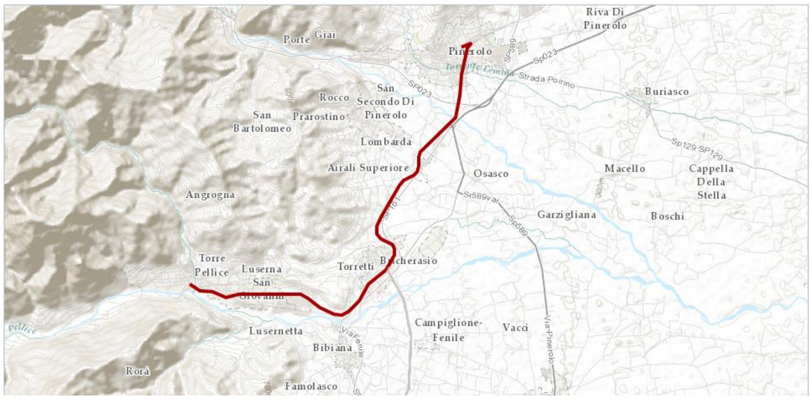


Figure 2 The Pinerolo- Torre Pellice railway line (source: Abandoned railway lines, 2016, http://www.ferrovieabbandonate.it/linea_dismessa.php?id=271)

Figure 3 Historical pictures of the Pinerolo- Torre Pellice railway line and of the old station of the Luserna San Giovanni Municipality (source: Abandoned railway lines, 2016, http://www.ferrovieabbandonate.it/linea_dismessa.php?id=271)

4.2 Methods

The methodological approach tested in this study followed the main steps of MAVT as explained in Section 3 but combining them with visualization analytics in order to facilitate understanding and participation of real stakeholders and decision makers who were involved in the process (Figure 4). In particular, as shown in Figure 4, the first phase of the study used stakeholders' analysis, value focused thinking and best practices analysis to design feasible alternatives/solutions to the decision making problem under consideration. The second phase of the process consisted in the development of the MAVT model and in the organisation of a first focus group with experts and stakeholders in order to elicit preference information by combining consolidated elicitation protocols with visualization tools. The final phase of the process consisted in the development of a second focus group with experts and stakeholders in order to show and discuss in real time the results of the evaluation by again using visualization tools.

Expert panels were thus used to expand the knowledge basis and avoid possible biases, which characterize the situation with a single expert. On the other side, the use of experts' panels has a range of problems associated with it, such as the panel composition, the interaction mode between panel members, the possible dilution of expertise and power among the group, which might make it difficult to reach an agreement and implement the chosen solution (Phillips, 2007) and, above all, the aggregation of panel responses into a form useful for the decision (Beinat, 1997).

A detailed description of each step's inputs and outputs for the present study will be provided in the following paragraphs.

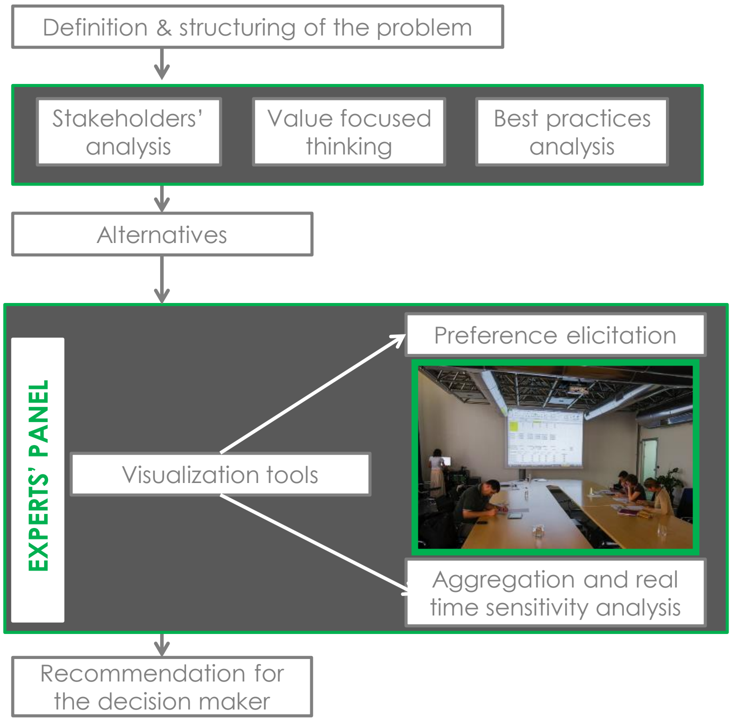


Figure 4 The methodological process followed in the study

4.2.1 Structuring

In public policy making the stakeholders and their behaviors represent the core of any possible theoretical model (Dente, 2014; Boerboom and Ferretti, 2014). In this paper stakeholders are defined as any actor having a vested interest in the decision process, either directly affecting or being affected by its resolution, including experts and the public. In the literature experts and citizens are however sometimes viewed as separate categories (see e.g. Keeney, 1988; Renn et al., 1993). The first, essential, step of a decision process to support public policies formulation thus consists in the identification of the stakeholders and of their objectives (Dente, 2014).

The present study links the analysis of the stakeholders involved in the process to the definition of the impacts to be achieved with the requalification process under analysis (i.e. some of the impacts refer to objectives to be maximized, while some other impacts refer to objectives to be minimized). As a matter of fact, scientific research has demonstrated that the identification of the fundamental objectives associated to a decision is not an easy task and that we often generate about half of the relevant objectives (Bond et al., 2008). Collaborative decision processes can thus help to tackle this challenge, as will be shown in section 4.4.

In this study, we used semi-structured interviews with both stakeholders and experts (Reed et al., 2009) in order to support the definition of a comprehensive set of both stakeholders to be involved in the collaborative process and objectives to be achieved with the proposed requalification strategy.

In particular, a bottom up approach based on value-focused thinking (Keeney, 1992) has been used to identify the relevant objectives for the analysis. In order to provide an example, one of the devices proposed by Keeney (1994) to support the identification of relevant objectives consists in asking key questions about a future best possible scenario for the project and a future worst possible scenario in 5 years' time. These questions prompt the participants for the identification of both positive features (i.e. impacts to be maximise) and negative features (i.e. impacts to be minimized). Focusing on the values that should be guiding the decision situation thus removes the anchor on narrowly defined alternatives and makes the search for new alternatives a creative and productive exercise. Further insights for the identification of the impacts came from the analysis of the scientific literature (see Section 2) as well as from the legislative requirements in the field of sustainability assessments of territorial transformation processes.

As a result, a set of measurable impacts has been identified for the evaluation of the alternatives and it has been organized according to the value tree approach (Figure 5). As it is possible to see, the main objective of our model is to determine which is the best alternative for the requalification of the abandoned railway "Pinerolo – Torre Pellice". Each mean objective identified in Figure 5 is characterized by a measurement unit (i.e. an attribute, see Table 4) which allows to measure the degree of the respective impact by different alternative options or projects.

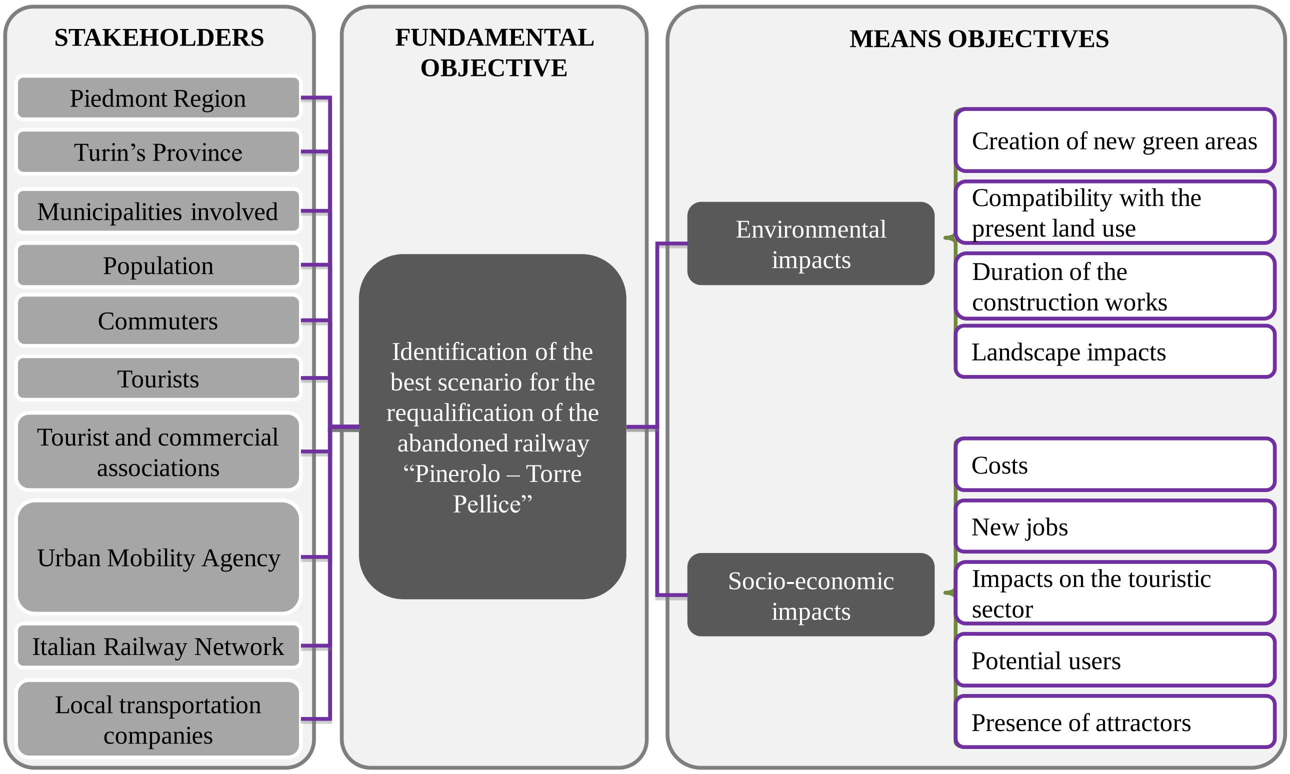


Figure 5 The value tree for the decision making problem under analysis

In the definition of the impacts (Figure 5), we paid particular attention to the key properties highlighted by Von Winterfeldt and Edwards (1986). In particular, we seek completeness by (i) involving different perspectives in defining the problem and the impacts (Bond et al., 2008), thus avoiding the framing bias and increasing understanding and by (ii) asking questions inspired by the list of the devises proposed by Keeney (1994) to identify fundamental objectives. We seek operability by using direct attributes as much as possible and by minimizing the use of qualitative attributes which can generate ambiguity in the model. We checked decomposability by verifying with the participants if the achievement of the overall goal of the analysis was fully explained by the achievement of its sub-objectives. Absence of redundancy has been checked by the analyst and facilitator at the end of the structuring phase and the minimum size of the value tree was verified by checking with the participants that only fundamental objectives were included (i.e. asking "is this a fundamental concern or a means concern?"). Moreover, in order to avoid the splitting bias, which refers to a phenomenon in which attributes or objectives receive higher weights if they are split into more detailed levels, the identified attributes have been grouped as environmental impacts (4 objectives) and socio-economic impacts (5 objectives). A detailed description of each considered objective together with the explanation of how its measurement has been performed in the present analysis can be found in Table 4.

4.2.2 Alternatives' design

One of the research challenges that have recently been highlighted for the practice of operational research and decision aiding consists in the design of alternative options for decision making problems (Tsoukiàs, 2014). Indeed, in real decision making problems the set of alternatives is rarely given, but has to be constructed as much as the rest of the evaluation model. Despite the literature provides interesting hints (Problem Structuring Methods, Value Trees, Decision Trees, e.g. Rosenhead and Mingers, 2001), a consistent methodological framework for the innovative design of alternative solution is still missing.

In this study we propose a design of alternative options for the decision problem under analysis (i.e. what to do with abandoned railway lines?) based on the combined used of value focused thinking approach (see Section 4.2), stakeholders' analysis and worldwide best practices analysis (see Section 2). Based on this analysis, the following 5 alternatives have been defined, as explained in Table 3.

Table 3 The identified alternatives for the requalification of the abandoned railway Pinerolo- Torre Pellice

Alternatives	Description
Greenway	This alternative consists in the conversion of the 16.5 Km of abandoned railway into a green corridor able to link the different municipalities. The corridor will be used for pedestrian pathways, bicycles, horseback riding and excursions and will promote the touristic revitalization of the Val Pellice area. The portion of land crossed by the railway is mainly used for agricultural purposes, therefore the width of the greenway has been estimated as 5 meters on each side of the track.
Rail-banking	This alternative consists in ordinary maintenance works on the railway tracks in order to ensure standards of quality, security and efficiency that are compatible with a possible reopening of the railway tracks in the future.
Extension of the urban railway service	This alternative consists in the extension of line 2 of the urban railway service (which has been created with the aim of improving the efficiency of the connections between Turin, i.e. the capital of the Region, and the more peripheral cities) in order to include the municipalities that were crossed by the railway which has been abandoned.
Old station recovery	This option consists in the recovery for touristic purposes of one of the old train stations situated across the railway which has been abandoned. Based on the analysis of the tourist numbers and on the state of conservation of the buildings, the old station situated in the Municipality of Luserna San Giovanni has been identified as the most suitable to be recovered for touristic and recreational purposes. Figure 6 shows the graphical simulation which has been created for the presentation of this alternative to the stakeholders that have participated in the decision making process.
No action (status quo)[1]	This option consists in not taking any action for the alternative use of the abandoned railway and leaving the territorial system under analysis to naturally evolve. Consequently, the railway will be exposed to natural degradation, structural failures and to the risk of being used as illegal landfill.

Figure 6 Example project for the recovery of the Luserna San Giovanni old station

[1] The comparison of new development projects with the "no action" option is a frequent requirement within Environmental Impact Assessment procedures. Indeed, this comparison allows to effectively evaluate and justify the need for a new project to benefit the territorial system under consideration.

Table 4 Description of the considered attributes

	Means objectives	Description	Measurement unit/attribute	Direction of preference
Environmental Impacts	Creation of new green areas	The attribute considers the m^2 of new green areas that are going to be created for the requalification of the railway track. For the “greenway” alternative the measure has been obtained by multiplying the length of the railway times 10 m width while for the “old station recovery” alternative the measure considers the available land surrounding the station which will be transformed into a public green area.	m^2	Maximize
	Compatibility with the present land use	The attribute has a qualitative nature and takes into account the compatibility of the alternative with the present land use of the area. In particular, the values for the attributes are low, good, and high, depending on the agricultural value of the land, which has been identified using Geographic Information Systems.	Class	Maximize
	Duration of the construction works	The attribute considers the time needed for the realization of each alternative project. This attribute serves also as a proxy for the interferences with the natural ecosystems in the surrounding areas which could be affected by the construction works. The measure for the different alternatives has been estimated based on similar projects in the same and in other regions.	Months	Minimize
	Landscape impacts	The attribute has a qualitative nature and considers the aesthetic interference caused by the projects on the surrounding environment. In particular, the values for the attribute are negative, not relevant, positive, and very positive, depending on the nature of the impact. Moreover, the values have been estimated by experts in the field of landscape ecology and environmental engineering who have been involved in the decision making process.	Class	Minimize
Socio-economic impacts	Costs	The attribute considers a preliminary estimation of the costs associated to the realization of each alternative project. The measure for the different alternatives has been estimated based on similar projects in the same and in other regions. Mention has to be made to the fact that very detailed estimations have been obtained for this attribute thanks to the public databases of costs for very similar projects.	Euros	Minimize
	New jobs	The attribute considers the number of new jobs that will be generated by the realization and maintenance of each alternative. The measure for the different alternatives has been estimated based on similar projects in the same and in other regions.	Number	Maximize
	Impacts on the touristic sector	The attribute has a qualitative nature and considers the level of impact generated by each alternative option on the touristic sector. In particular, the values for this attribute are none, medium, and high and have been estimated by the experts participating in the decision making process.	Class	Maximize
	Potential	The attribute estimates the number of potential users	Number	Maximize

Means objectives	Description	Measurement unit/attribute	Direction of preference
users	for each alternative option. In particular, for the “greenway” alternative the measure has been obtained based on similar projects in other regions, for the “extension of the urban railway service” the measure corresponds to the actual number of users before the abandonment of the tracks, and for the “old station recovery” alternative the measure considers the tourist numbers observed in the municipality where the station is located.		
Presence of attractors	The attribute considers the number of attractors such as churches, architectural monuments, shopping centers, schools, hospitals, archeological sites and panoramic viewpoints within a buffer around each alternative project. For the “greenway” alternative the buffer is 5 km from the track, for the “extension of the urban railway service” alternative the considered buffer is 500m from each station, and for the “old station recovery” alternative the buffer includes the municipality of the station as well as the neighboring ones. The measures for each alternative have been obtained through GIS elaborations.	Number	Maximize

Table 5 provides the raw values of each alternative for all the considered impacts.

Table 5 Performance table

ALTERNATIVES	GREEN AREAS	LAND USE	CONSTRUCTION WORKS	IMPACT ON THE LANDSCAPE	COSTS	NEW JOBS	TURISTIC IMPACTS	POTENTIAL USERS	PRESENCE OF ATTRACTORS
GREENWAY	165,000	Good	12	Very positive	830,000	4	High	75,000	78
RAIL-BANKING	0	Very good	1	Irrelevant	170,000	0	None	0	0
TRANSPORT	0	Very good	1	Irrelevant	170,000	3	Medium	249,200	33
OLD STATION	4,000	Low	5	Very positive	240,000	5	High	19,400	32
NO ACTION	0	Very good	0	negative	0	0	none	0	0

4.2.3 Preference elicitation

As anticipated in section 3, different approaches are available for preference elicitation in MAVT. In this study, in order to keep the cognitive burden on the participants as limited as possible, we used the decomposed scaling approach (Beinat, 1997), meaning that the multi-attribute value model was broken down into simpler sub-tasks (i.e. the marginal value functions and the weights) which were assessed separately. The crucial steps thus consisted in:

(i) the construction of value functions, to make the attributes comparable (as they are measured according to different units of measure), and

(ii) the determination of the level of trade-offs among them, to understand which are the most important impacts for the system under analysis and weight them accordingly in the model.

Indeed, these steps are the most cognitive demanding in the whole process, as well as the most inherently subjective.

Due to the above mentioned reasons, in this study the preference elicitation phase took place within a focus group setting. This allowed to bring together experts and stakeholders with different backgrounds and thus ensure an inclusive perspective on the problem under analysis. In particular, 6 actors participated to the focus group: an expert in the field of transportation engineering and consultant for the Regional Authority, an expert in the field of public transportation policies, an expert in the field of mathematical modelling and operational research, an expert in the field of environmental engineering and collaborative decision support systems, an expert in the field of landscape ecology and consultant for the Regional Authority on many projects related to the river basin management in the area under analysis and, finally, an expert in the field of transportation planning and consultant for different local authorities involved in transportation related projects. The two authors of the paper worked as facilitators for the whole decision support process.

As anticipated, the first task consisted in value functions elicitation. Eliciting value functions means translating the performances of the alternatives into a value score, which represents the degree to which an objective is achieved. The value is a dimensionless score: 1 refers to a very good performance (i.e. full achievement of the objective), while 0 refers to a poor performance (i.e. low objective achievement). What characterizes the use of value functions is the measure of “differences of preferences” using interval scales (Bouyssou et al., 2006). Since people do not naturally express preferences and values in this way, value functions have to be estimated through a specially designed interviewing process in which the relevant judgments for the decision are organized and represented analytically. In this sense value functions are at best an approximate representation of human judgments and are constructed or produced (Beinat, 1997).

Single-attribute value functions can be elicited with different methods (e.g. Von Winterfeldt and Edwards, 1986). In this study, we used the Mid-value Splitting Method (Bisection) because we wanted to explore opportunities and limits of this elicitation protocol, which seems to lead to more reliable results than direct rating (Schuwirth et al., 2012) in a transportation policy making context. To this end, one of the actors listed above (i.e. the expert in the field of transportation planning and consultant for different local authorities involved in transportation related projects) has been interviewed in order to interactively build the value functions and test the mid-value splitting protocol. Mention should be made to the fact that for value functions elicitation only few experts should be involved in order to obtain, as a result, a consensus solution of the worthiness of each value and avoid the complexity of having to aggregate different and maybe conflicting value functions. Nevertheless, there are cases in which a large participation of both experts and the public could be interviewed in order to collectively build the value functions for those attributes for which the literature or similar projects do not provide any reference (e.g. Jelokhani-Niaraki and Malczewski, 2015). The actor interviewed for this project is a knowledgeable expert in the field of transportation planning and modeling and was thus able to easily state the worthiness of the values associated to the different attributes. On the other hand, the second elicitation task, i.e. weighing, requires a group perspective in order to ensure comprehensive and less biased results. Consequently, all the experts mentioned above have been involved for this second task, as will be better explained later.

The interviewing process for the value functions elicitation was organized as a series of two half day meetings with the expert in the field of transportation planning and consultant for different local authorities involved in transportation related projects. During these meetings, the first author of this paper worked as the analysts and facilitator of the elicitation process.

Contrary to the traditional way of employing operational research in organizational interventions (i.e. the expert mode, according to which the problem situation faced by the client is given to the operational research consultant, who then builds a model of the situation, solves the model to arrive at an optimal (or quasi-optimal) solution, and then provides a recommendation to the client based on the obtained solution), the present study has used an alternative mode of engagement, named facilitated modeling, which means conducting the whole intervention together with the client: from structuring and defining the nature of the problem situation of interest, to supporting the evaluation of priorities and development of plans for subsequent implementation (Franco and Montibeller, 2010; Phillips and Phillips, 1993). In this latter mode, the operational researcher works throughout the intervention not only as an analyst, but also as a facilitator to the client.

In this study two meetings have been necessary for the value functions elicitation task because during the elicitation of the value function for the attribute “new green areas” in the first meeting, the expert being interviewed highlighted some drawbacks of the elicitation protocol, which will be explained in the following paragraphs. The elicitation protocol consists in interactively asking the interviewee to compare two intervals (e.g. from a to b and from b to c, where a is the worst performance value in the range and c is the best performance value in the range) in order to find out the indifference point, i.e. the performance value for which the interviewee is indifferent between an improvement from a to b or from b to c.

In order to efficiently cope with time constraints inherently associated to real actors’ participation, we elicited value functions by asking the expert for the mid-value of the intervals [v=0, v=1], [v=0, v=0.5], and [v=0.5, v=1]. The mid-value of the interval [v=0.25, v=0.75] was used as consistency check (see Ferretti, 2016 for a detailed explanation of the protocol). To provide an example, Figure 4 shows the first question asked to the expert with reference to the attribute “new green areas”, i.e. “Imagine two possible scenarios for this project: in the first scenario the m^2 of new green areas increases from 0 to 80,000, while in the second scenario the m^2 of new green areas increases from 80,000 to 160,000. Would you be equally satisfied?” During the first meeting the involved expert stated that the mid-value splitting protocol was generating too abstract questions, making thus uneasy for him to provide a reliable answer.

We thus tried to improve the operability of the protocol by enhancing it with visualization analytics. In particular, we used each time a coordinate plane labeled with the attribute range and we interactively modified the extension of the two intervals considered in each question (Ferretti, 2016). Moreover, with reference to the attribute “new green areas”, in order to make the questions more concrete and realistic, we associated to each value of the subsequent intervals physical pictures of urban parks that are well known to the inhabitants of the city of Torino. This helped the two experts to clearly associate a meaning to the different extensions that were compared in each question and thus to better complete the elicitation task.

Figure 7 shows an example of the graphical representation of the subsequent questions that we experimented for the elicitation of the value function for the attribute “new green areas”. The same procedure has been repeated for all the other attributes. The elicited midpoints were marked on the coordinate plane and were finally interpolated to a value function which was further discussed with the interviewee to stimulate the learning effect arising from graphical awareness and real time visualization of results (Ferretti, 2016).

After the improvement of the elicitation protocol with graphical representations of the values, disagreement between the intervals [v=0, v=1], [v=0, v=0.5], [v=0.5, v=1], and [v=0.25, v=0.75] did not occur.

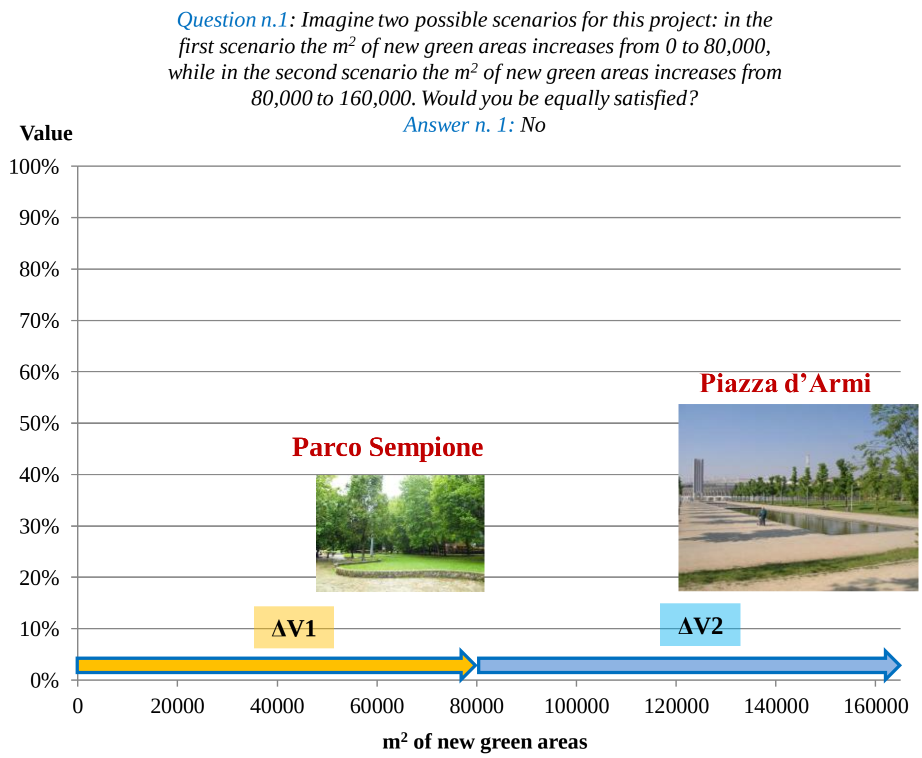


Figure 7 Graphical representation of the first question used to elicit the mid-value splitting point for the attribute "new green areas". In this case the answer to the question was no. During the second iteration of the protocol we thus had to shorten the interval that satisfied most the expert being interviewed, i.e. the 0 – 80000 one. The second question that we asked was then ""Imagine two possible scenarios for this project: in the first scenario the m^2 of new green areas increases from 0 to 70,000, while in the second scenario the m^2 of new green areas increases from 70,000 to 160,000. Would you be equally satisfied?" The reader can refer to Figure 8 for the elicited final value function.

Figure 8 shows the results of the procedure for all the considered attributes. Since the bisection technique can be applied only for quantitative attributes, direct rating was used for the qualitative ones.

A specific comment deserves the "costs" value function elicitation since the experts felt more confident in simply defining the monotonicity of the function, without specifying scores for specific levels of cost which they believe are subject to high levels of uncertainties.

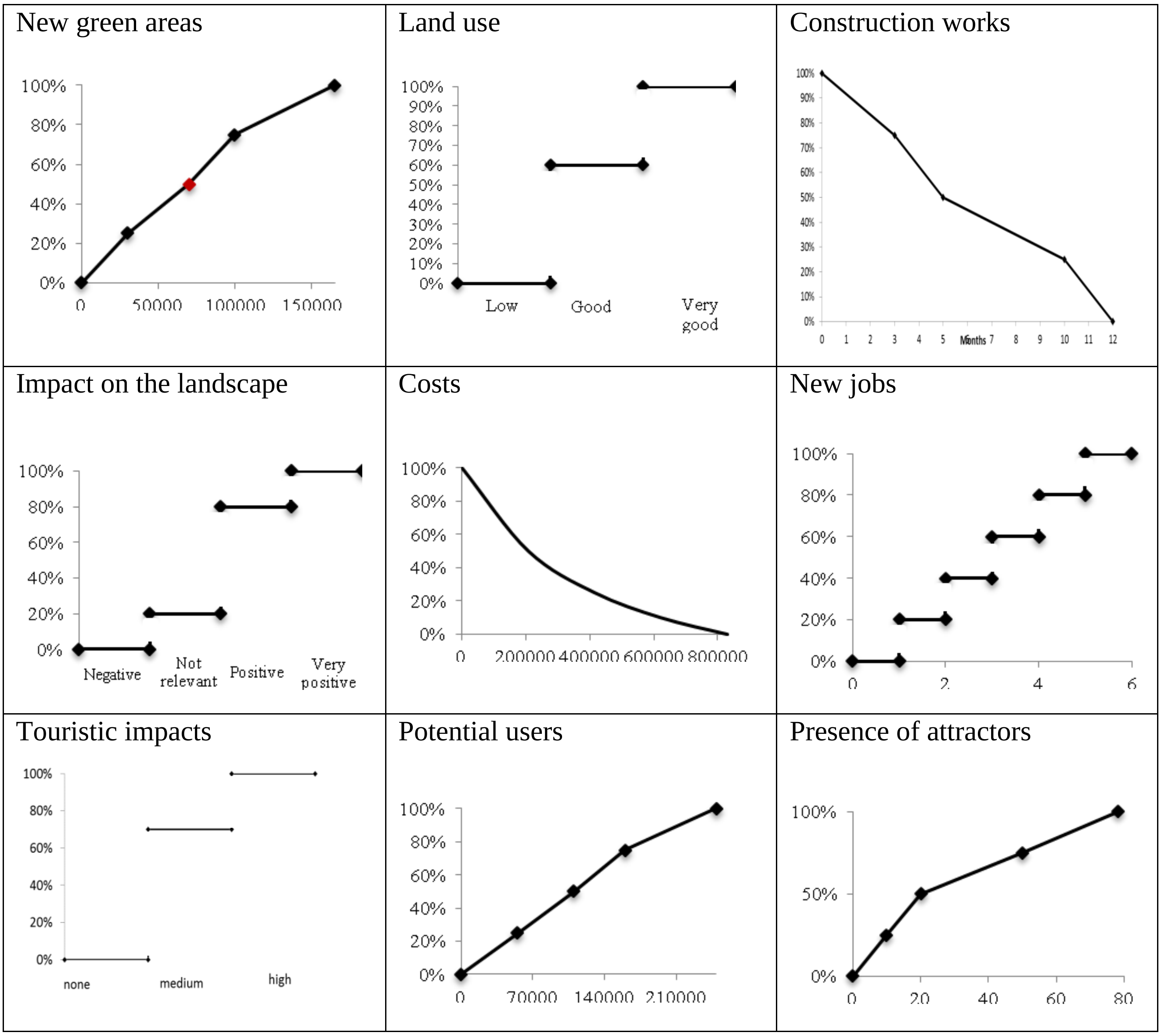


Figure 8 Final value functions for all the impacts (the red mark on the first value function is the result of the first question illustrated in Figure 7)

As a result of the value function elicitation procedure, the performance matrix of the alternatives under consideration has been built (Table 6).

Table 6 Standardized performance table

ALTERNATIVES	GREEN AREAS	LAND USE	CONSTRUCTION WORKS	IMPACT ON THE LANDSCAPE	COSTS	NEW JOBS	TURISTIC IMPACTS	POTENTIAL USERS	PRESENCE OF ATTRACTORS
GREENWAY	1.00	0.60	1.00	1.00	0.00	0.80	1.00	0.34	1.00
RAIL-BANKING	0.00	1.00	0.08	0.20	0.59	0.00	0.00	0.00	0.00
TRANSPORT	0.00	1.00	0.08	0.20	0.59	0.60	0.70	1.00	0.61
OLD STATION	0.31	0.00	0.50	1.00	0.48	1.00	1.00	0.09	0.60
NO ACTION	0.00	1.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00

As it is possible to see in Table 6, there is not an alternative that performs as the best one on all the considered attributes. Moreover, given that the attributes are not all equally relevant in this decision making context, we proceeded with the determination of their levels of trade-offs.

This second task was also accomplished by means of a half day workshop with the experts led by the first two authors of the paper. Particular attention was dedicated to the panel composition in order to have it balanced. Therefore, the 6 experts with expertizes ranging from environmental engineering, to landscape ecology, to transportation planning and policy making have been interviewed.

According to the MAVT approach, weights reflect trade-offs over the ranges of values under consideration for each impact. This implies that weights for use in an additive model are scaling constants and need to reflect the importance of the “swing” from the worst to the best outcomes under consideration (Beinat, 1997).

As for the elicitation of value functions, different techniques are available for the assessment of weights (e.g. swing weights, rating, pairwise comparison, trade-off, qualitative translation) which are then used explicitly to aggregate attributes’ specific scores.

Among the aforementioned approaches, one of the most used methods for eliciting weights in MAVT is the swing-weights procedure, which explicitly incorporates the attribute ranges in the elicitation question. In particular, the method asks to value each improvement from the lowest to the highest level of each attribute (Montibeller and Franco, 2007) by using a reference state in which all attributes are at their worst level and asking the interviewees to assign points to states in which one attribute at a time moves to the best state. The weights are then proportional to these points.

Since in a collaborative decision process is more difficult for the experts to agree on which attribute they would like to swing first and on which score to give to that specific swing (Ferretti and Comino, 2015), in this work each expert has been questioned separately by means of a specific questionnaire. In order to provide an example, Figure 9 illustrates the questionnaire filled in by the expert in the transportation planning field while Figure 10 summarizes the overall set of weights elicited from the whole panel of experts.

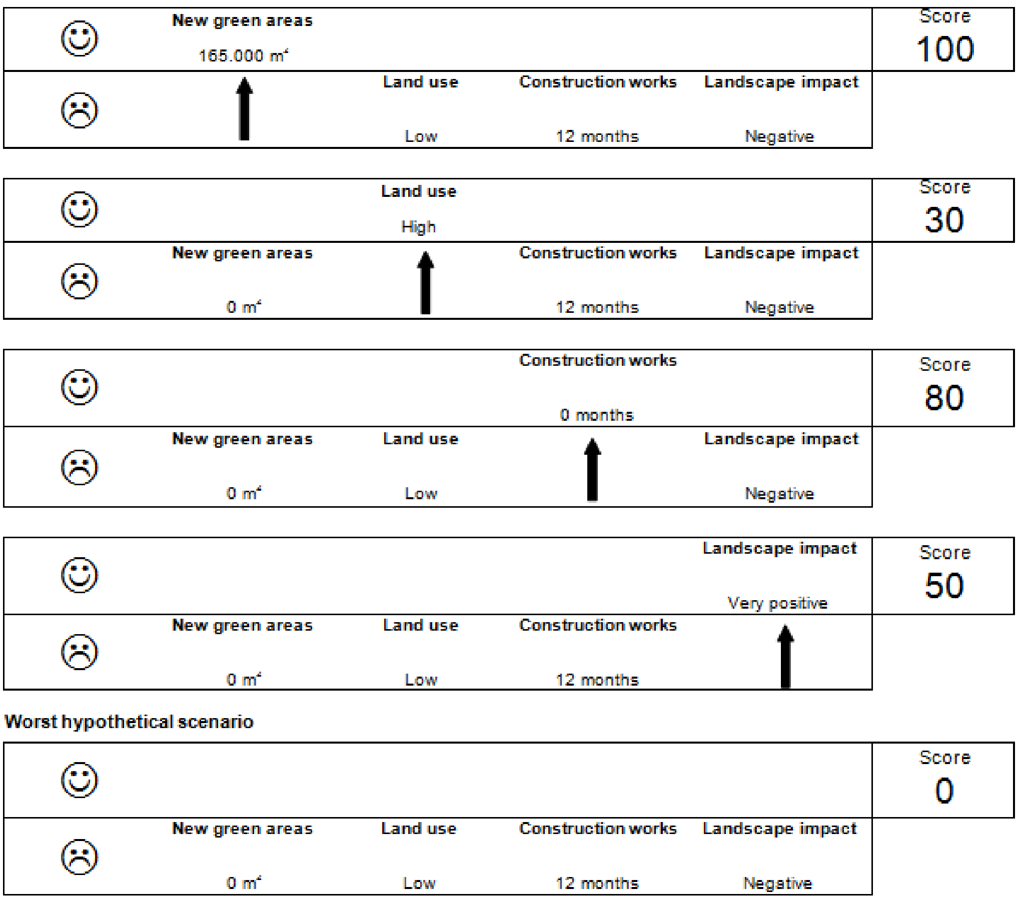


Figure 9 The questionnaire filled in by the expert in the field of “transportation planning”

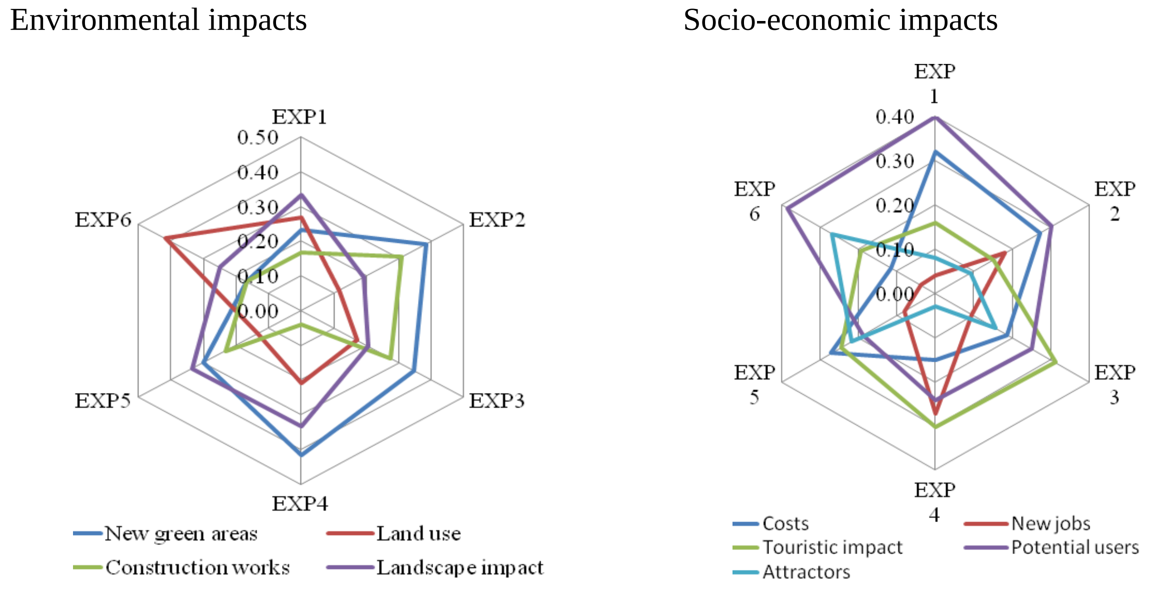


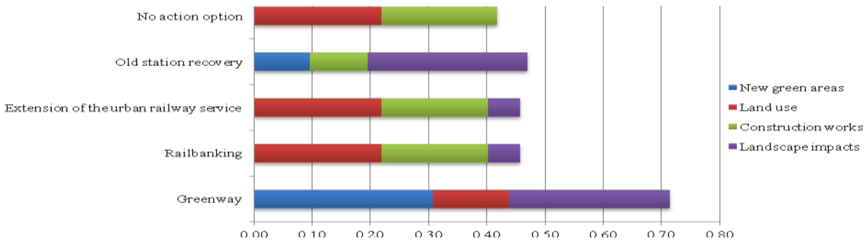
Figure 10 Schematic representation of the different perspectives of the experts on the relative importance of the impacts (the numerical values correspond to the weights)

As it is possible to see from the radar diagrams in Figure 10, the weights set by the different experts varied considerably, thus reflecting the participants' specific expertise. This was expected, since the weights reflect each person's individual values and attitudes, personal and professional history, education, cultural background, knowledge level, the stakeholder group he/she represents, etc. Nevertheless, it is possible to notice that, as far as the environmental impacts are concerned, the attribute "new green areas" was considered the most important one for 3 experts out of 6 while the "construction works" were considered less important by most of the experts. As far as the socio-economic aspect are instead considered, most of the experts agreed in considering the "potential users" and the "touristic impact" as the most important impacts, while the "number of new jobs" was considered less important.

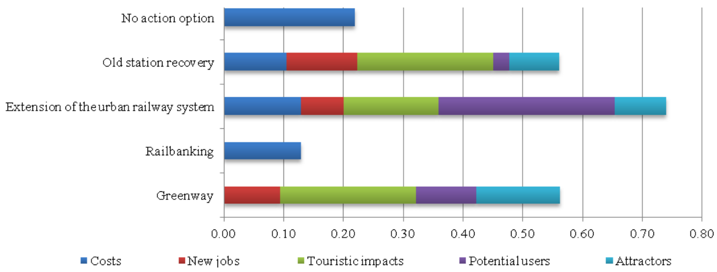
4.2.4 Results

The use of visualization analytics combined with preference elicitation protocols allowed to improve the operability of the decision support tool and evaluate the alternatives under consideration in the study. In particular, the scores obtained for each alternative from the marginal value functions (Table 6) have been aggregated using the obtained set of weights (Figure 10) and additive assumptions to calculate the total value of each alternative. Additive aggregation implies that a low value on one attribute can be compensated by large values on other attributes. Therefore, this aggregation technique must fulfill relatively strong independence conditions (Keeney and Raiffa. 1993) which must be verified in each case. In this case, the validity of the assumption was tested by asking the participants if they could think of preferences for several levels of attributes independently from the levels of other attributes (as in Sorvari and Seppälä, 2010). All participants stated they could.

Once the independence conditions were validated, the application of formula (1) provided the results shown in Figures 11 and 12. In particular, Figure 11 shows the results for the alternatives with reference to both the environmental and socio-economic impacts by using the average of the weights elicited from the participants in the focus group, while Figure 12 shows the final results according to both the average scenario and the individual perspectives of the experts involved in the process.

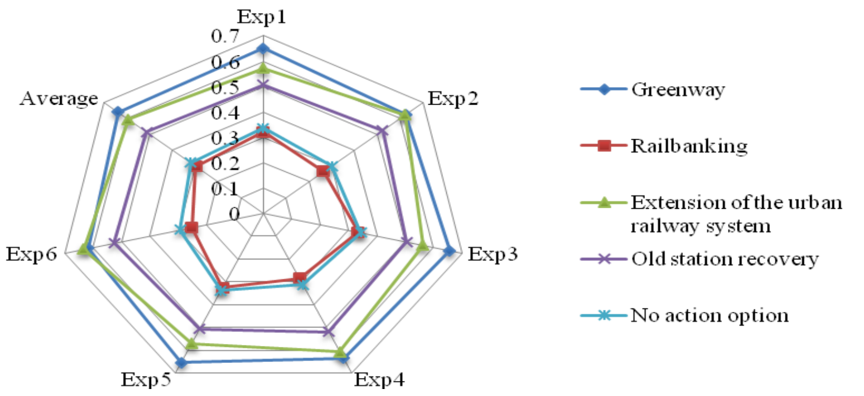


(a)

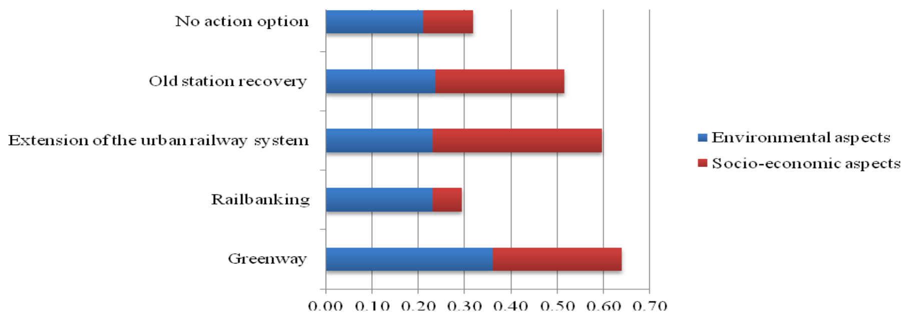


(b)

Figure 11 Partial results for the considered alternatives according to the average of the weights expressed by the involved experts. Figure 11a shows the priorities of the alternatives for the environmental impacts while Figure 11b shows the priorities of the alternatives for the socio-economic impacts.



(a)



(b)

Figure 12 Final results for the considered alternatives. Figure 12a shows the ranking of the alternatives according to the different experts involved in the focus group. Figure 12b shows instead the final priorities of the alternatives according to the average of the weights expressed by the involved experts.

As it is possible to see from Figure 11, the greenway option dominates all the others as far as the environmental impacts are concerned but the extension of the urban railway system performs better when the socio-economic impacts are taken into account. By considering both the environmental impacts and the socio-economic ones, Figure 12 shows that the greenway option, closely followed by the extension of the urban railway system, is the best solution for the requalification of the Pinerolo- Torre Pellice abandoned railway line. Moreover, the results show that the rail-banking and the no action options are clearly dominated by all the other alternatives and therefore are not worth further consideration. Surprisingly, the no action option is not the least preferred alternative. This is due to the fact that this option performs very well from the economic point of view because there are no costs associated with it and cost is always a very important concern in the field of public goods transformations.

4.2.5 Sensitivity analysis

The final step of the study consisted in a sensitivity analysis to test the stability of the results. The One-at-a-Time (OAT) approach (Daniel, 1973) has been used meaning that the weight of one attribute at a time has been increased while keeping all the others very small and homogeneous in order to observe the effects on the final results. It is worth highlighting that in this study the sensitivity analysis took place in the interactive environment of the focus group, i.e. the results of the changes in the inputs (weights of the attributes) have been showed and discussed in real time together with the experts participating in process. This allowed to gain a better understanding of the results of the whole process since the reasons for the changes in the final ranking have been explored interactively. In particular, the facilitator changed one at a time the weight of the attributes and showed in real time the resulting final ranking of the alternatives. For example, as far as the environmental aspects are concerned, the weights of the attributes in the first sensitivity scenario were 0.70 for “new green areas” and 0.10 for the remaining attributes, then 0.70 for “land use” and 0.10 for the remaining ones, and so on. Mention has to be made to the fact that in the interactive sensitivity analysis a balanced scenario has been discussed as well, both for the environmental impacts and for the socio-economic impacts, meaning that all the attributes related to that category have been equally weighted. The results of this process developed together with the participants are shown in Figure 13. The main advantage that we observed is linked to the fact that the participants clearly understood which are the attributes that, if weighted more, have the power to change the ranking of alternatives and thus the final recommendation.

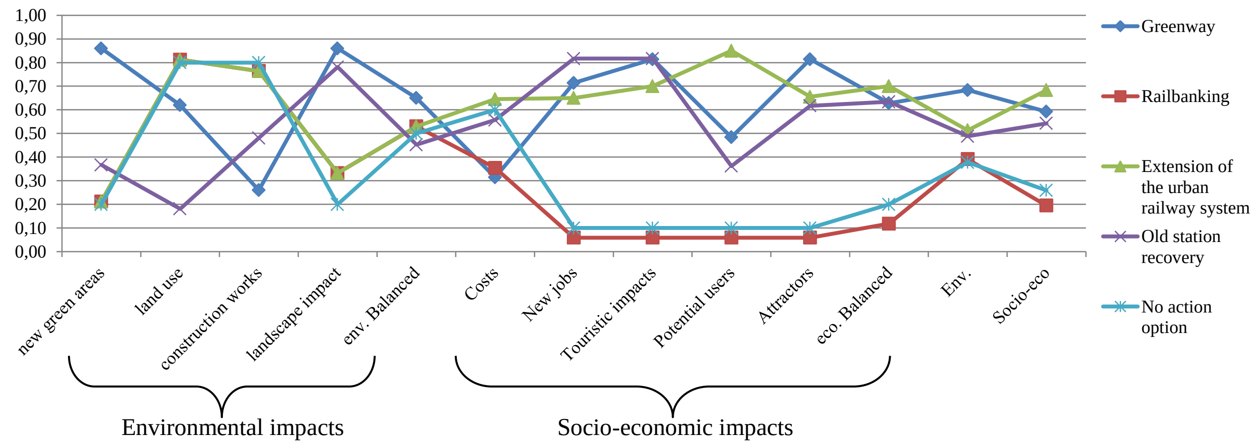


Figure 13 Sensitivity analysis results

As it is possible to see from Figure 13, if we look at the ranking of the alternatives only considering the sensitivity to environmental impacts (first 5 categories on the x axis), we notice quite a lot of instability in the ranking. At the same time the greenway option is the winning alternative in 3 cases out of 5. If we maximize the importance of land use and construction works then the “no action option” becomes the preferred one. If, instead, we look at the ranking of the alternatives only considering the sensitivity to the socio-economic impacts (categories 6th to 11th on the x axis in Figure 13), we notice a more stable ranking where the “rail-banking” and “no action” options are always the last ones in the ranking (except when the cost is the attribute being maximized in the simulation) and the “greenway” and the “extension of the urban railway system” are always the preferred alternatives (except when the cost is the attribute being maximized). When “new jobs” and “touristic impacts” are the attributes being maximized, then the “old station recovery” becomes the most preferred alternative requalification scenario for the abandoned railway.

5. Discussion and conclusions

The present paper proposes a transparent and transferable methodological framework able to support collaborative decision-making and planning processes related to complex public policies. The framework has been tested on a real world problem concerning the study of different requalification options for abandoned railway lines with respect to heterogeneous environmental and socio-economic impacts. The context of the application refers to a topical problem worldwide. Besides producing a quantitative ranking of the alternative options under consideration, this study allowed to shed light on the reasons why the conversion into a green corridor for walking and cycling, connecting different municipalities, is the best recommendation for the requalification of the abandoned railway line under analysis. Moreover, the proposed method showed relevant advantages compared to other similar decision support tools, i.e. (i) the possibility to be easily integrated with a real time sensitivity analysis, which showed to be a crucial feature for the development of a final consensus solution, (ii) the ability to support the construction of more justifiable and robust arguments to underpin the final recommendation (Tsoukiàs et al., 2013) and, finally, (iii) the use of more reliable preference elicitation protocols which make it difficult for stakeholders to influence the final results with an hidden agenda.

The objective of the study was to highlight the contribution that the development of an MAVT model according to a facilitated modeling approach can have in supporting transportation planning and management, where there is a strong need for transparency, replicability and learning mechanisms.

The aim of this section is to shed some light on the overall evaluation process through the analysis of the feedback received during the focus group sessions in order to provide guidelines for policy design and further developments. Overall, the analysis revealed an overwhelming agreement among local actors regarding the need for a new use of the abandoned railway.

The key considerations that emerged from the actors participating in the focus groups concerned the following issues:

(i) the facilitated modeling approach that has been used throughout the decision process has been perceived as a very positive feature by all the actors involved in the process. In particular, a vital role was played by the facilitators/analysts in order to ensure that all the experts had the same understanding of the attributes under consideration and that they were able to cope with the cognitive burden associated with the elicitation protocol.

(ii) One of the involved actors acknowledged that the transparency of the procedure made it more difficult to influence results with a hidden agenda than with unstructured negotiation processes. This we believe is a very important advantage of the MAVT approach and a particularly important feature for decision processes that have to be justified to the public.

(iii) The actors involved in the process appreciated the bottom up approach involving different expertise and stakeholders for structuring and modeling the complex decision making problem under analysis. They acknowledged that by discussing in real time the sensitivity of the results with respect to changes in the input weights and by listening to the arguments proposed by the other actors they changed some of their own initial ideas and learned from the collective process. The focus groups with different experts and actors thus improved the knowledge of the team on the different dimensions of the problem at hand. Indeed, in collaborative decision making, we do not strive for an optimum, a compromise, or a satisficing solution. Rather, collaborative decision making results in a significantly more valuable choice than the alternatives envisioned by any of the decision makers (Owen, 2015). At the end of the process, each participant felt ownership of the collaborative choice and agreed to further develop it. Nevertheless, it should be noted that since focus groups of experts do not involve a representative sample of population, they cannot be used for deriving consistent conclusions on social preferences (Munda, 2004).

Notwithstanding the above positive impacts associated to the use of the proposed framework, the application of classical models and techniques for cardinal measurement of values usually requires a person to answer quite difficult questions. For this reason, other methodologies have been proposed in the literature such as MACBETH (Bana e Costa and Vansnick, 1994) and aggregation-disaggregation methods (Jacquet-Lagrèze and Siskos, 1982). In particular, MACBETH is a technique that enables the construction of value functions derived from qualitative (i.e. non numerical) judgments about the difference of attractiveness between every two performance levels of the scale, thus avoiding the difficulty or cognitive uneasiness experienced by some evaluators when expressing their preference judgments numerically.

The weights elicitation protocol too presents some limitations. The technique is indeed based on direct rating, it does not include consistency checks, and the extreme outcomes to be compared may not correspond to a realistic alternative, which makes the questions difficult to answer (Schuwirth et al., 2012). On the other hand, one of the most important advantages of the Swing method is that it only requires to know the attribute ranges and is thus independent from the shape of the value functions.

Based on the above considerations, we can answer our research question concerning the role that the developed MAVT framework can play in transportation policy processes. As highlighted in section 2, the present study represents one of the first applications of MCDA for dealing with a current complex problem, i.e. what to do with abandoned railway lines. The proposed framework has shown to be able to properly represent the complexity of the decision problem and to efficiently support the collaborative decision making process. It thus represents a promising line of research for the future of Operational Research in transportation policy making.

The following paragraphs reviews the overall developed process by discussing its operability according to three specific dimensions, i.e. transparency, consensus building and applicability.

Transparency. Besides clarity and openness, the participants acknowledged that they were able to understand the purpose and the reasoning behind the process, that they became aware of both the positive and the negative aspects associated to the decision problem and that they learned from the justifications provided by the other participants.

Consensus building. Different perceptions were acknowledged throughout the process thanks to the involvement of multiple stakeholders and experts. Moreover, stakeholders were engaged since the very beginning of the process and this helped to reach a consensus and to develop a sense of ownership of the problem as well as of the solution.

Applicability. The process was judged successful by the involved stakeholders because it leaded to an action plan for implementing the recommendation. The availability of quantitative criteria and the development of the sensitivity analysis were also interpreted to enhance operability.

A specific consideration has to be made with reference to the “greenway” and “old station recovery” alternatives. Indeed, the results of the process highlight that the old station recovery is the third best performing alternative with an overall performance pretty close to that of the first two alternatives. As a consequence, an action plan for the development of both the “greenway” and the “old station recovery” alternatives was envisaged by the actors involved in the process. This demonstrates that considering disused railways and stations as integrated parts of a system can improve the accessibility of environmental, cultural and historical resources’ networks.

In conclusion, the contribution brought by the study can be summarized by the following two important aspects:

(i) enhanced operability of MAVT thanks to the combined use of visualization analytics and consolidated preference elicitation protocols. Such integrated approach is expected to increase the use of MAVT in policy decisions.

(ii) Replicability of the process. The developed framework is based on a transparent process that is simple in application, does not require sophisticated software, allows for a versatile and case specific use and deals with both qualitative and quantitative data. It thus represents a powerful working tool for public administrations and authorities dealing with choice problems among competing alternatives. In particular, the proposed framework could be easily re-used for analyzing not only the remaining 12 abandoned railway lines in the Piedmont Region, but also other similar context at the international level. New alternative options might be added at any time but the methodological framework is replicable and versatile.

Finally, future developments of the present study will follow four directions. The first direction of research concerns the testing of the other preference elicitation methods mentioned in this discussion section in order to improve the operability of MAVT in policy making contexts. The second one refers to the use of actors' analysis (i.e. power interest matrices; Dente, 2014) in order to weight the different experts participating in the process and thus aggregate their preferences according to their respective weights. The third direction refers to the study of the institutionalization of the proposed methodological framework using the Actor Network Theory methodological lens (e.g. Boerboom and Ferretti, 2014). The fourth direction of research refers to the investigation of different valuation approaches of social welfare changes (in terms of ecosystem services, cultural services as well as monetary price-determination of the "released" land areas) related to the redevelopment of disused railways (e.g. Asabere and Huffman, 2009; Besanko and Cui, 2016; West and Shores, 2011).

Acknowledgments

The authors of the paper wish to thank the 6 experts who participated in the workshops, Dr. Andrea Isabello and Dr. Maurizio Arnone for the support provided during the development of the project, and the two anonymous referees for their helpful comments. This paper is the result of the joint work of Dr. Valentina Ferretti and Alessandro Degioanni. Despite the overall responsibility being equally shared, Dr. Valentina Ferretti is responsible for paragraphs 1, 2, 3, and 4. The conclusions are the result of the joint work of the two authors.

Bibliographic References

Agenzia Mobilità Metropolitana Torino. 2011. Nuovo orario cadenzato Torino-Susa-
Bana e Costa C.A., Vansnick, J-C. 1994. MACBETH - An interactive path towards the construction of cardinal value functions. *International Transactions in Operational Research*, 1 (4): 489-500.

Bardonecchia (New timetable for the Torino-Susa-Bardonecchia line). Torino (accessed online from www.mtm.torino.it on February 26. 2016).

Altherr W., Blumer D., Oldörp H., Nagel P. 2007. How do Stakeholders and Legislation Influence the Allocation of Green Space on Brownfield redevelopment Projects? Five Case Studies from Switzerland, Germany and the UK. Business Strategy and the Environment. 16: 512–522

Asabere P.K., Huffman F.E. 2009. The relative impacts of trails and greenbelts on home price. *Journal of Real Estate Finance and Economics*. 38(4): 408-419.

Beinat E. 1997. Value functions for environmental management. Kluwer Academic Publishers: Dordrecht.

Belton V., Stewart T.J. 2002. Multiple criteria decision analysis: an integrated approach. Kluwer Academic Publishers: Boston.

Bertolini L, Spit T. 1998. Cities on Rails – the Redevelopment of Station Areas. Spon: London.

Besanko D, Cui S. 2016. Railway restructuring and organizational choice: Network quality and welfare impacts. *Journal of Regulatory Economics*. 50(2): 164-206.

Boerboom L., Ferretti V. 2014. Actor Network Theory Perspective on a Forestry Decision Support System Design. *Scandinavian Journal of Forest Research*. 29: 84-95.

Bond S., Carlson K., Keeney R. 2008. Generating Objectives: Can Decision Makers Articulate What They Want? *Management Science.* 56-70.

Bouyssou D., Marchant Th., Pirlot M., Tsoukiàs A., Vincke Ph. 2006. Evaluation and decision models with multiple criteria: Stepping stones for the analyst. Springer Verlag: Boston.

Chang Y.H., Wey W.M., Tseng H.Y. 2009. Using ANP priorities with goal programming for revitalization strategies in historic transport: A case study of the Alishan Forest Railway. *Expert Systems with Applications*. 36 (4): 8682–8690.

Colorni A., Laniado E., Muratori S. 1999. Decision support systems for environmental impact assessment of transport infrastructures. *Transportation Research Part D: Transport and Environment*. 4 (1): 1-11.

Daniel C. 1973. One-at-a-time-plans. *Journal of the American Statistical Association* 68: 353–360.

Dente B. 2014. Understanding Policy Decisions. PoliMI SpringerBriefs.

European Greenway Association 2000. http://www.aevv-egwa.org/#

Ferretti V. 2013. Spatial multicriteria evaluation to support planning and evaluation procedures: A survey and classification of the literature. *Geoingegneria Ambientale e Mineraria*. 139 (2): 53-66.

Ferretti V. 2016a. Exploring multi-methodology approaches for policy support: Case studies and lessons learned. OR58: The OR Society Annual Conference: 78-89.

Ferretti V. 2016b. From stakeholders analysis to cognitive mapping and Multi-Attribute Value Theory: An integrated approach for policy support. *European Journal of Operational Research*. 252(2): 524-541.

Ferretti V., Comino E. 2015. An integrated framework to assess complex cultural and natural heritage systems with Multi-Attribute Value Theory. *Journal of Cultural Heritage*. 16(5): 688- 697. http://dx.doi.org/10.1016/j.culher.2015.01.007

Ferretti V., Montibeller G. 2016. Key challenges and meta-choices in spatial multicriteria evaluation for environmental decision-making. *Decision Support Systems*. 84: 41-52, 10.1016/j.dss.2016.01.005

Figueira J.R., Greco S., Ehrgott M. 2005. Multiple Criteria Decision Analysis: State of the Art Surveys. Springer. Berlin.

Filippo S., Cezar Martins Ribeiro P., Ribeiro S.K. 2007. A Fuzzy Multi-Criteria Model applied to the management of the environmental restoration of paved highways. *Transportation Research Part D: Transport and Environment*. 12 (6): 423-436.

Fishburn P.C. 1967. Methods of Estimating Additive Utilities. *Management Science*. 13 (7) : 435-453.

Franco A., Montibeller G. 2010. Facilitated modelling in operational research. *European Journal of Operational Research*. 205: 489- 500.

Gerçek H., Karpak B., Kılınçaslan T. 2004. A multiple criteria approach for the evaluation of the rail transit networks in Istanbul. *Transportation*. 31 (2): 203-228.

Guerrieri, M. and Ticali, D. (2012) Design Standards for Converting Unused Railway Lines into Greenways. ICSDC 2011: pp. 654-660. doi: 10.1061/41204(426)80

Huang H.I., Keisled J., Linkov I. 2011. Multi-criteria decision analysis in environmental sciences: ten years of applications and trends. *Science of the Total Environment*. 409 (19): 578–3594.

Italian Greenways Association. http://www.greenways.it/ (accessed online on the 26th of February, 2016).

Jacquet-Lagrèze, E. and Siskos, Y. 1982. Assessing a set of additive utility functions for multicriteria decision making: The UTA method. *European Journal of Operational Research*. 10 (2): 151-164.

Jelokhani-Niaraki M., Malczewski J. 2015. A group multicriteria spatial decision support system for parking site selection problem: a case study. *Land Use Policy*. 42: 492-508.

Karlson M., Karlsson C.S.J., Mörtberg U., Olofsson B., Balfors B. 2016. Design and evaluation of railway corridors based on spatial ecological and geological criteria. *Transportation Research Part D: Transport and Environment*. 46: 207-228.

Keeney R.L. 1988. Structuring objectives for problems of public interest. *Operations Research*. 36: 396–405.

Keeney R.L. 1992. Value focused thinking. Harvard university press: Cambridge.

Keeney, R.L. 1994. Creativity in decision making with value-focused thinking. Sloan Management Review. 35, 33–33.

Keeney R., Raiffa H. 1993. Decisions with Multiple Objectives. Preferences and Value Tradeoffs. Cambridge University Press: New York.

Lee S.M. 1998 Analytic Hierarchy approach for transport project appraisal an application to Korea. PhD thesis. University of Leeds.

Longo G.,Padoano E., Rosato P., Strami S. 2009. Considerations on the application of AHP/ANP methodologies to decisions concerning a railway infrastructure. *Proceedings of the International Symposium on the Analytic Hierarchy Process* 2009

Macura D., Boskovic B., Bojovic N. 2011. A Model for Prioritization of Rail Infrastructure Projects Using ANP. *International Journal of Transport Economics*. 38 (3): 285-310.

Mitchell D.N., Cooke J.A., 1991. The current status and plant ecology of disused railway lines in north tyneside. Transactions Of The Natural History Society Of Northumbria. 55(4): 273-282

Montibeller G., Franco A. 2007. Decision and Risk Analysis for the Evaluation of Strategic Options. In F.A O'brien and R.G. Dyson (eds.) Supporting Strategy: Frameworks. Methods and Models. Chichester: John Wiley & Sons.

Munda G. 2004. Social multi-criteria evaluation: Methodological foundations and operational consequences. *European Journal of Operational Research*. 158: 662–677.

Owen D. 2015. Collaborative Decision Making. Decision Analysis. http://dx.doi.org/10.1287/deca.2014.0307

Phillips L.D. 2007. Decision conferencing, in: Ward Edwards, Ralph F. Miles, Detlof von Winterfeldt (Eds.), Advances in Decision Analysis: From Foundations to Applications, Cambridge University Press, New York: 375–399.

Phillips L. D., Phillips M. C. 1993. Faciliated work groups: theory and practice. *Journal of the Operational Research Society*. 44 (6): 533-549.

Reed, M.S., Graves, A., Dandy, N., Posthumus, H., Hubacek, K., Morris, J., Prell, C., Quinn, C.H., Stringer, L.C. (2009). Who's in and why? A typology of stakeholder analysis methods for natural resource management. Journal of Environmental Management. 90 (5), 1933-1949.

Renn O., Webler T., Rakel H., Dienel P., Johnson B. 1993. Public participation in decision making: a three step procedure. *Policy Sciences*. 26: 189–214.

Rosenhead J., Mingers J. 2001. Rational analysis for a problematic world revisited: problem structuring methods for complexity, uncertainty and conflict. Chichester: Wiley.

Saaty T. L. 2013. The modern science of multicriteria decision making and its practical applications: The AHP/ANP approach. *Operations Research*. 61(5): 1101-1118.

Schuwirth N., Reichert P., Lienert J. 2012. Methodological aspects of multi-criteria decision analysis for policy support: A case study on pharmaceutical removal from hospital wastewater. *European Journal of Operational Research*. 220: 472-483.

Shang J.S., Tjader Y., Ding Y. 2004. A Unified Framework for Multicriteria Evaluation of Transportation Projects. *IEEE Transactions on Engineering Management*. 51(3)

Sorvari J., Seppälä J. 2010. A decision support tool to prioritize risk man-agement options for contaminated sites. *Science of the Total Environment*. 408: 1786–1799.

Tsoukiàs A. 2014. Aiding to Decide and evaluation: challenges for the future. *Valori e Valutazioni*. 13: 33-36.

Tsoukiàs A., Montibeller G., Lucertini G., Belton V. 2013. Policy analytics: an agenda for research and practice. *EURO Journal of Decision Processes*. 1: 115-134.

Ulengin F., Kabak O., Onsel S., Ulengin B., Aktas E. 2010. A problem-structuring model for analyzing transportation-environment relationships. *European Journal of Operational Research*. 200: 844-859.

Von Winterfeldt D., Edwards W. 1986. Decision Analysis and Behavioral Research. Cambridge University Press: Cambridge. England.

Vreeker R., Nijkamp P., Ter Welle C. 2002. A multicriteria decision support methodology for evaluating airport expansion plans. *Transportation Research Part D: Transport and Environment*. 7(1): 27-47.

Ward J., Ruff A. 1986. Linear Landscape: Design for disused railways. Department of town and country planning, University of Manchester.

West S.T., Shores K.A. 2011. The impacts of building a greenway on proximate residents' physical activity. *Journal of Physical Activity and Health*. 8(8): 1092-1097.

Wey W.M., Wu K.Y. 2006. Using ANP priorities with goal programming in resource allocation in transportation. *Mathematical and Computer Modelling*. 46 (7–8): 985–1000.