Decision making in urban development: The application of a hybrid evaluation method for a critical area in the city of Turin (Italy)

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Abstract

Smart cities and sustainable neighbourhoods are increasingly gaining more attention within policy decisions on urban transformations. In this context, Decision-Makers (DMs) need evaluation methodologies able to support the definition of policies and actions for the future of cities, that focus on a higher degree of life quality and new needs. In this paper, an integrated framework is proposed which combines the Stakeholder Analysis, the STEEP and SWOT analyses (STEEP+SWOT), the Scenario Building and the Multicriteria Decision analysis approach (MCDA) which can be used to envision sustainable future scenarios for an underdeveloped area in Northern Italy. The adoption of integrated methodologies facilitates the analysis of each phase of the decision problem, from its early stage to the selection of the most suitable scenario according to the context and the stakeholders engaged. With this perspective, the present research is a guiding tool for DMs for the design of transformation/regeneration scenarios with a long-term perspective of sustainable cities and neighbourhoods. From the results obtained, it is possible to build new and unexpected scenarios by combining the main opportunities and strengths of most suitable alternatives.

Keywords

Mixed-methods, urban design, MAVT, Scenario planning, urban regeneration, smart cities, sustainable neighbourhoods.

1 Introduction

The rapid urbanization and the increasing number of people living in urban contexts are negatively affecting cities and the life quality of their citizens (Al-Azzam & Alazzam, 2019; Kumar, Singh, Gupta, & Madaan, 2020). In 2010, 50% of the world population lived in urban areas and this figure

is forecast to rise to 68% by 2050 (United Nations, 2019). Due to the high density of people, capitals and job opportunities, cities become particularly attractive and are required to respond in a resilient and sustainable way to meet the new demands generated, but at the same time major environmental, social and economic challenges have arisen. Sustainable Development Goals (SDGs) adopted by all United Nations Member States recognised this urgency by delivering the 11th SDG which enhances inclusive and sustainable urbanization and promotes the participation in human settlement planning and management (United Nations, 2015). Given these premises, smart cities and sustainable neighbourhoods could be possible solutions for the common purpose of improving living standards of urban communities considering major environmental, social and economic benefits (Silva, Khan, & Han, 2018). Even if the concept of smart cities and sustainable neighbourhoods has quite a fuzzy nature, it generally suggests the proposal of clever solutions aimed at boosting productivity both qualitatively and quantitatively (Caragliu, del Bo, & Nijkamp, 2011). In order words, they are meant as a complex composition of multiple attributes (Silva et al., 2018) linked to the concept of sustainable regeneration (Bottero, Caprioli, Cotella, & Santangelo, 2019).

Sustainable regeneration, beyond the triple-bottom-line approach (Sala, Ciuffo, & Nijkamp, 2015), requires the consideration of the land take and the reuse of abandoned sites to preserve the scarce land resource and to reduce criticalities generated by the urbanization (Sdino, Rosasco, & Dell'Ovo, 2021). A crucial issue is represented by the presence of abandoned industrial sites, located in peripheral and not attractive locations (Dell'Ovo, Bassani, Stefanina, & Oppio, 2020). Their reuse implies remediation costs but their neglect may entail an ecosystem degradation and thus a loss of ecosystem services (Assumma et al. 2021; Caprioli et al. 2021). Here, positive and negative externalities have to be managed, as well as a trade-off among the multiple dimensions involved for selecting the most sustainable alternative of requalification.

In this context, the adoption of integrated methodologies is strategic for analysing each phase of the decision problem from its early stage to the selection of the most suitable scenario according to the context and the stakeholders engaged. The development of a multi-methodological framework allows

Decision-Makers (DMs) to guide the regeneration by considering different perspectives and satisfying the demands of society and the city (Shen, Peng, Zhang, & Wu, 2012). The identification of priority actions and transformational changes require a complete and structured understanding of the overall urban system and its subsystems (Webb et al., 2018).

The purpose of this contribution is to present a multi-level methodology where the regeneration of an abandoned and polluted site is carried out through analytical phases. The case study selected concerns the requalification of the area called Basse di Stura, a former industrial area located in the city of Turin (Italy). As in most regeneration processes, DMs are mainly the Public Administration, policy makers and public bodies, which work for city transformation with a comprehensive sustainable view, spanning environmental protection, social cooperation, technological advancement and cultural preservation.

Although the individual frameworks and methodologies adopted in this research are not new, their combination through a multi-level, multi-scalar and multi-stakeholders approach is novel. This combination of frameworks and methodologies makes possible to support integrated and informed decisions and explore strategic urban issues. Their implications can be explored using a rich knowledge framework developed from the analysis of the social, infrastructural and environmental layout of the case study (Webb et al., 2018). This integrated method can be used as a systematic scheme for supporting research and practice in scenario analysis to cope with the intrinsic complexity and uncertainty of urban strategy building (von Wirth et al., 2014a). Moreover, the method can ensure that knowledge development will be salient, credible, evident and legitimate (Cash et al., 2003).

2 A Multi-level methodology

Several evaluation models are available for supporting the assessment of policies, plans and projects in the context of urban transformations. Three main families of methods can be identified (Mondini, 2016). A first family records the economic analysis methods such as Cost-Benefit Analysis (CBA). These methods are based on the identification of the full range of costs and benefits generated by the projects and they provide synthetic performance indicators that allow to assess a preliminary

feasibility of the operations (Sartori et al., 2014). The limits of these methods have been highlighted by many authors considering that a reductionistic approach does not consider the overall complexity of the system and the participation of the different stakeholders (Munda, 2005). In the light of these limits, a second family of methods can be recalled, which refers to Multicriteria Analysis. These methods allow several criteria, both economic and extra-economic, to be taken into account and they are based on a strong interaction between DMs and stakeholders. A third category of methods can be lastly mentioned, related to Environmental Impact Assessment (EIA) and Strategic Environmental Assessment (SEA) which focus on the evaluation of impacts on the environmental systems. Each one of the three aforementioned families has positive aspects but also intrinsic limits, thus moving partial assessments; in this sense, for a more holistic vision, the paradigm of the integrated assessment has been proposed which combines different approaches. In facts, (von Wirth et al., 2014b)(Ighravwe, Babatunde, Denwigwe, & Aikhuele, 2020)(Ariza-Álvarez, Soria-Lara, Arce-Ruiz, López-Lambas, & Jimenez-Espada, 2021a)(Alessandra Oppio & Dell'Ovo, 2020) as it is well known, urban design is a process characterized by the presence of multiple actors and stakeholders, many conflicting values and perspectives which should be taken into account simultaneously, such as socio-economic, technical, political and environmental aspects. In that context, the adoption of only qualitative or quantitative approaches seems to give a partial view of the problem under analysis. For that reason, the interest in mixing methods has strongly increased to create purposeful knowledge and support DMs in urban contexts addressing future urban development policies (Colorni and Tsoukiàs 2013). Different ways of designing and combining methods are feasible. The multi-phase approach has been chosen in the present work (Meissner, Creswell, Klassen, Plano, & Smith, 2011), due to the characteristics of the case study, where the urban design is crucial. The multi-phase approach supports the development of a step-by-step process (Figure 1): firstly, qualitative analyses highlight the goal, objectives and values of the decision problem; then, quantitative analyses help to validate and evaluate the final project solutions (Berta, Bottero, & Ferretti, 2018). In particular, the proposed methodology combines three main working phases: the problem framing, the scenario building and

the problem-solving.

The first phase starts from a broad analysis of the case study to highlight the main elements, which characterize the decision problem. In parallel, a Stakeholder Analysis has been conducted, to understand the actors involved in the process and predict their potential support or rejection of a strategy. The second phase concerns the scenario building. Grounding on the results of Phase 1, this phase is related to the design of possible alternatives taking into consideration the role and expectations of stakeholders in the wider context of transformation of the area. To support the scenarios formation, the STEEP Analysis is combined with SWOT Analysis (STEEP+SWOT). Their combination helps both the definition of strategies for the design of alternatives, and the identification of a preliminary set of indicators. An additional tool, the Wilson Matrix, has been used during the scenario building to define plausible strategies for the regeneration (Amer, Daim, & Jetter, 2013). The third phase involves the evaluation of the alternatives through a Multicriteria Decision Analysis (MCDA) technique, in order to identify the best sustainable solution for the regeneration of the site. The final result of this process is a set of ranked alternatives where the winning scenario represents the most suitable alternative according to stakeholders' expectations.

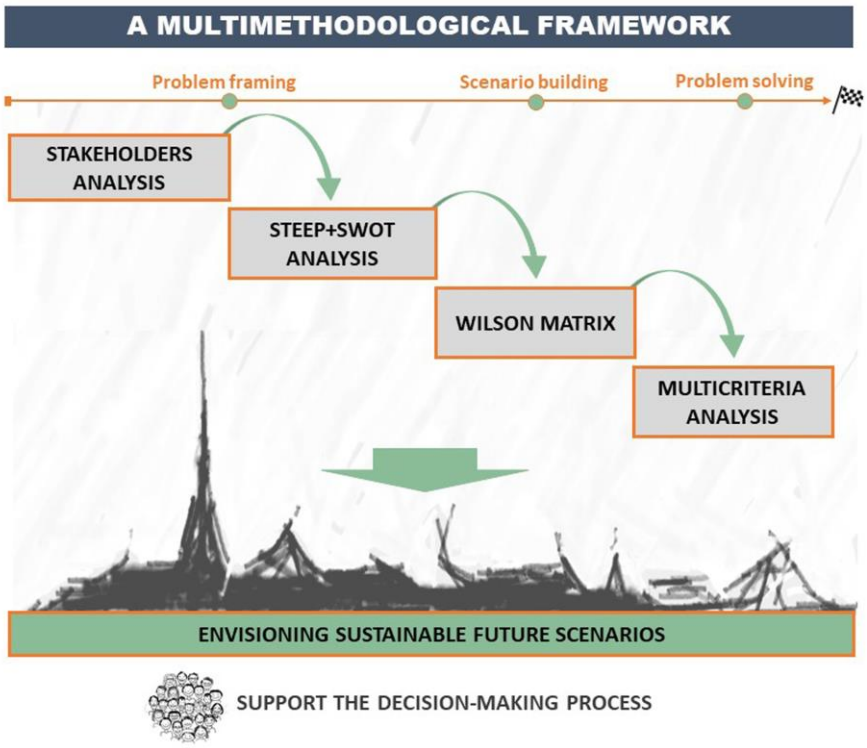

Figure 1. Process scaffolding

2.1 Stakeholders Analysis

In the multi-level methodology proposed, the Stakeholder Analysis is the first method applied to support the decision-making process. Its role in urban transformation and planning is particularly useful to identify all the actors involved and interested in the process under analysis and, consequently, to highlight their capacity to affect the diffusion or inhibition of strategies (Dente, 2014; Yang, 2014). A single or a group of actors can strongly influence the decisional outcomes, both for satisfying individual interests and objectives based on their values and preferences, and after their relations with other stakeholders (Dente, 2014). As far as the decision-making process is concerned in strategic planning and sustainability assessment procedures, the identification and classification of the stakeholders are fundamental to highlight the conflicting interests among them at an early stage of the process and to avoid negative effects in the next ones (Gill, Lange, Morgan, & Romano, 2013). From a practical point of view, the first step in the development of a Stakeholders' Analysis is related to the identification of some characteristics of each actor: their level of intervention (national, regional, local), the category of actors they belong (political, bureaucratic, special interest, general interest, experts) and the resources which they carry out (political, economic, legal, cognitive), as well as their roles and expectations (Dente, 2014).

Among the different approaches to develop a Stakeholder Analysis, the present research combines two different methodologies: the Power Interest Matrix (Johnson, Scholes, & Whittington, 2007; A. L. Mendelow, 1981) and the Social Network Analysis (Marin, B., Mayntz, 1994; Rhodes, 1997). Their combination comes from the need of integrating the potentialities of these two approaches: from one side, the Power Interest Matrix clearly shows the power and interest of each stakeholder in the specific decision-making process (A. Mendelow, 1991), on the other side, the Social Network Analysis (SNA) identifies the relationships among stakeholders. According to this approach, it is possible to visually understand the size and the form of the network, as well as the coalitions and key actors in the decision context. This information is particularly useful because the connections and

147 relations among stakeholders can affect the overall performance of the decision-making process
148 (Bottero, Caprioli, & Berta, 2020).

149 **2.2 STEEP+SWOT Analysis**

150 The SWOT Analysis is a well-known technique developed during the 60's (Humphrey, 2005) with
151 the aim at analysing the strengths (S), the weaknesses (W), the opportunities (O) and the threats (T)
152 of a complex problem. The SWOT Analysis is a 4 quadrants matrix, that allows DMs to divide a
153 given problem according to existing endogenous factors (i.e. strengths and weaknesses) and possible
154 exogenous factors that could occur in the future (i.e. opportunities and threats). The SWOT analysis
155 supports the interpretation of the state of the art and the identification of the drivers able to empower
156 strengths and opportunities, and to minimize weaknesses and threats. It can be used as a tool to
157 validate and ensure the efficacy of the selected strategies. The SWOT Analysis was used in the fields
158 of marketing and economy, and, since the 80's, it was employed in the public sector for evaluating
159 alternative scenarios and public policies. Today, the SWOT Analysis is applied to both public and
160 private sectors, such as in the evaluation of plans, programs and projects, or territorial analysis for
161 the localisation of new interventions.

162 Despite the general validity of the SWOT analysis, this tool has been recently combined with
163 complementary ones to provide better and more organized results. The STEEP analysis is often
164 integrated with the SWOT analysis (STEEP+SWOT), a more recent tool that is generally employed
165 in the decision-making process to better visualize the driven factors of possible objectives and actions
166 of transformation scenarios (Armstrong, 2014; Cadrien, Messaadia, Majumdar, & Eynard, 2011;
167 Ighravwe et al., 2020). The STEEP Analysis considers the 5 following components: 1) the Society
168 (S) considers the features related to the citizens that live in the context under investigation, such as
169 the people age, non-employment rate, people migration, or social capital, among others; 2)
170 Technology (T) refers to the presence or the lack of devices, infrastructures that contribute to the
171 economy of the context under investigation in terms of cooperation and/or competitiveness in the
172 market, or even in terms of security, e.g. presence of security devices, renewable energy or

accessibility to services; 3) the environmental component (E) provides an analysis of the environmental characteristics with the aim to monitor the health status of the context under investigation, e.g. CO2 emissions, air pollutants, water quality, or production of biological energy; 4) the economic component (E) refers to the state of the art of the sectors that contribute to the Gross Domestic Product (GDP) and thus to the attractiveness of a given territory; 5) Policy (P) refers to the presence or the lack of plans and programs, funds or projects that could contribute to the improvement of the life quality in the context under investigation.

In this study, the STEEP Analysis components are combined with the 4 SWOT quadrants to analyze the complex dynamics of a critical area.

2.3 Scenario building

Scenario is intended as "a set of hypothetical events set in the future constructed to clarify a possible chain of causal events as well as their decision points" (Kahn, 1989). Over the last decades, the traditional planning was not able anymore to satisfy the needs of contemporary cities and to plan efficacy long-term policies. Strategic planning has increased its role in planning processes thanks to the multidisciplinary approach, the long-term vision and a more place-based approach. Renovated thinking and practice through scenario building and planning are ever more required to govern the uncertainty (Chiffi & Chiodo, 2020).

The scenario building is a methodology that supports strategic planning (Albrechts, Healey, & Kunzmann, 2003; Godet, 2000; Pillkahn, 2008; Stojanovic, Mitkovic, & Mitkovic, 2014) in the design of possible city evolutions (Amer et al., 2013), taking into account the *desiderata* of actors and stakeholders engaged, thus increasing policy consensus (van de Kerkhof, 2006).

Increasing emphasis is being placed on the use of scenario planning techniques which are able to consider uncertainty and complexity of decision problems and urban systems. Scenario planning stimulates a strategic thinking and helps to overcome thinking limitations through the envisioning of alternative futures and to support policy-making processes under uncertainty conditions. Scenarios are defined as possible, often hypothetical, sequences of events constructed in an internally consistent

199 way considering casual processes and decision points. Scenario building is broad, diverse and
200 comprises a wide range of approaches and techniques. The integrated use of scenario analysis in the
201 context of urban planning and design leads to several benefits connected to the improvement of the
202 decision-making process and identification of new issues and challenges which arise in the future,
203 thus creating a learning process.
204 It is widely agreed in literature the consideration of a finite number of scenarios for future
205 transformations. In many applications, the average number of scenarios range between 3 and 5 with
206 a timeframe of development from the short to the medium-long term. Among the numerous tools
207 available in scenario planning, Wilson matrix can be used to evaluate and prioritize the degree of
208 influence/impact and uncertainty of each scenario driver, concept or factor on the future. It has been
209 recommended that ‘‘high’’, ‘‘medium’’ and ‘‘low’’ categories are sufficient to rank the drivers within
210 the matrix (Amer et al., 2013).

211 **2.4 Multicriteria Decision Analysis**

212 The MCDA method has been selected to evaluate the alternatives generated by the scenario building
213 approach previously detailed. In particular, MCDA is a specific field of Operational Research aimed
214 at supporting decision processes (Brans & Gallo, 2007; Ormerod & Ulrich, 2013). In detail, MCDA
215 techniques aid DMs in taking decisions among a set of alternatives by eliciting their preferences. It
216 is defined both as an approach and a set of techniques able to provide an overall rank of alternatives
217 (Dodgson, Spackman, Pearman, & Phillips, 2009) and to consider at the same time qualitative and
218 quantitative data (Dodgson et al., 2009).
219 Among the different MCDA methods (for a complete survey it is possible to refer to Figueira et al.,
220 2005), the Multiattribute Value Theory (MAVT) has been applied. MAVT supports DM in addressing
221 problems that involve a finite and discrete set of alternatives that can be evaluated based on
222 conflicting objectives (Keeney & Raiffa, 1976). It has to be noticed that, among the Multiattribute
223 Decision-Making (MCDM) field of research, several methodologies have been developed to aid the
224 DM in taking a consistent decision. The Multi-Attributive Border Approximation area Comparison

(MABAC) approach takes into consideration the conflicting attributes evaluating border approximation area generated by the context and the DM (Pamučar & Ćirović, 2015; Zhang et al., 2020); the Multi Attributive Ideal Real Comparative Analysis (MAIRCA) method is based on the gap between theoretical and real ratings within the alternatives evaluation (Gigović, Pamučar, Bajić, & Milićević, 2016); the complex proportional assessment (COPRAS) method is structured to evaluate the significance and utility degree of alternatives (Zavadskas et al., 1994). More generally, with respect to other MCDA methods such as VIKOR, ELECTRE, TOPSIS, PROMETHEE, or GRA approaches, MAVT has been selected because it has the strengths to orientate the discussion towards the values of the performance of the alternatives, forcing the stakeholders to reason about projects priorities and opening new perspectives for the discussion. For these reasons, MAVT has been applied to many real world decisions also in the context of urban territorial transformations and in particular, a compensatory method has been selected due to the different dimensions and values to be considered, the necessity to find a trade-off among them. The aggregation function is the following:

$$V(a) = \sum_{i=1}^{m} k_i v_i(x_i(a)) \quad [1]$$

Where *V(a)* is the overall value function of alternative a; $x_i(a)$ is the alternative as performance value for the attribute i, with $i = 1, \ldots, m$; v_i is the partial value reflecting the performance for attribute i; k_i is the scaling factor for attribute i (Belton & Stewart, 2002) with specific reference to this parameter, different assessment methods are available in MAVT, such as SWING weights, rating, pairwise comparison, trade off and qualitativr translation. The aggregation rule presented within the additive model selected (MAVT) supports the definition of a compromise between conflicting values which is of extreme importance in the field of urban development (A. Oppio, Bottero, & Arcidiacono, 2018).

3 Case study

The case study chosen for the experimentation of this innovative mixed-methods approach is a downgraded area called Basse di Stura, located in the Northern part of the city of Turin (Italy) (Figure 2). With its 150 hectares, it represents one of the wider free areas of the city, but, until now, underused due to the high level of contamination of the soil. In the last years, the Municipality of Turin has expressed its interest for this area for the natural potentialities of this site and its strategical location. The area is part of three relevant undergoing projects connected to the regeneration of blue-green infrastructures in the city of Turin and the surrounding municipalities. The river Stura, the rural past and the position at the edge of the city constitute fundamental elements in the definition of the natural potential of the area. For that reason, the local administration established, for a long time now, to transform the area in an urban and fluvial park. Until now, no operation has been started on the area and its original conditions were strongly compromised in the last fifty years. The development of industrial activities, around the 50s, but in particular after the 70s, has gradually led to a transition from a rural to an industrial vocation of the area. Even today, many factories and car dealerships occupy the area, but, due to the crisis of the industrial sector that has taken place in Turin, a lot of these activities are now closed. The main problem affecting the area is the worrying soil contamination caused by the presence in the past of heavy factories and the illegal disposal of industrial waste. For the transition to an urban and fluvial park, the Municipality of Turin has allowed the landowners to build a small surface on the area or another site of the city in exchange for soil remediation. However, the high costs connected to the remediation have prevented the transformation, which is not feasible for the small buildable surface expected (around 0.10 sqm/sqm). Other aspects characterize the area of Basse di Stura and its surrounding: a set of farmhouses dating back to the 17th and 18th century, legal and illegal urban allotments located in the residual spaces among infrastructures, the variety of flora and fauna along the river, two quarry lakes and the Roma camps. Figure 7 synthesizes the main characteristics which affect this site.

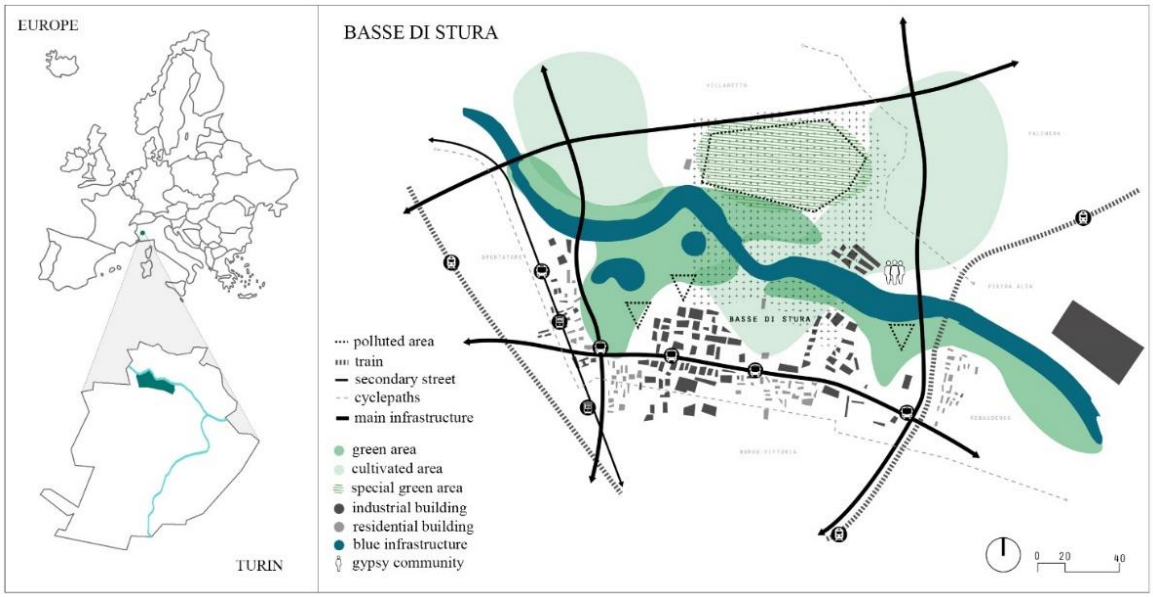

Figure 2. Localization and the main characteristics of Basse di Stura area.

The complex situation of the area, the variety of aspects to be considered and the multiple actors involved in the process require the adoption of structured evaluation methods. For these reasons, Basse di Stura area represents a useful example for testing such innovative mixed-methods approach.

4 Application

In this section, the methodological framework previously described has been applied to the Basse di Stura area. It should be noticed that the results obtained by the individual tools and as product of their integration are finalized to support the functioning of the methodological framework.

To proceed with the generation of the alternatives and their evaluation, a deep analysis of stakeholders involved and the territorial context have been performed.

4.1 Results of the Stakeholder Analysis

Once listed the main stakeholders (see, Table A.1 in the Appendix), these single actors are divided based on their level of power and interest and analysed with respect to the interactions existing among them. This simultaneous analysis is possible thanks to the combination of the two Stakeholder analysis methods described in the methodological section, i.e. the Power Interest Matrix and the Social Network Analysis. Figure 3 shows the results of the Stakeholder analysis developed through this combination of methods. The analysis highlights the centrality of the Municipality of Turin which

is the most central actor; other relevant stakeholders are the landowners of the area, the developers and investors and their position in the bottom right part of the graph shows their relevant power and interest.

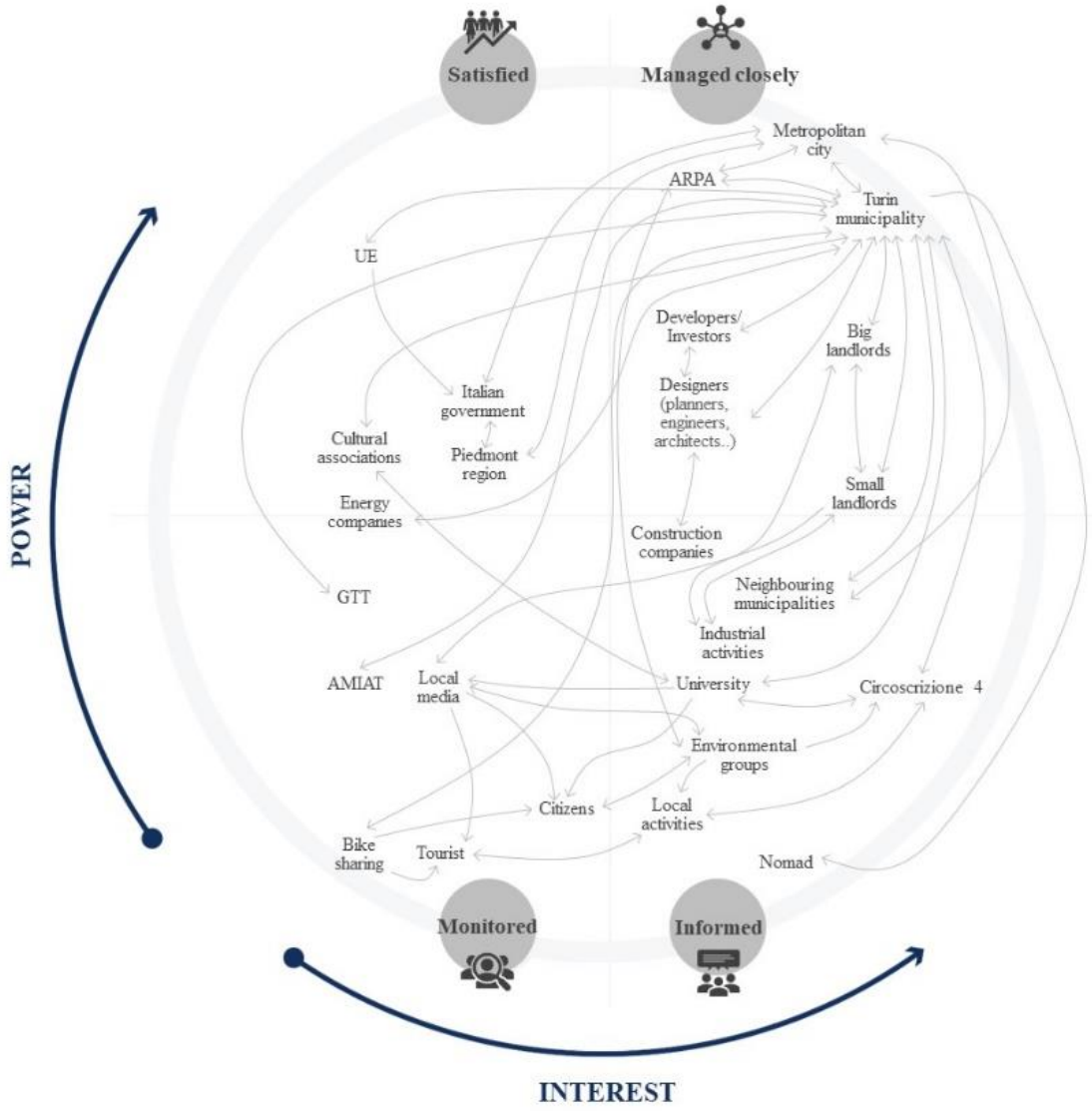

Figure 3. The decision network combined with the power interest matrix for the problem under investigation

4.2 Results of the STEEP+SWOT Analysis

The STEEP+SWOT Analysis portrayed the state of the art of Basse di Stura (Figure B.1), from which emerges a downgraded area with unexpressed potentialities to become in the future an attractive pole for the city. Soil contamination, air, and water pollutions caused health problems to Basse di Stura - workers and to the residents who live nearby. The informal allotments caused social marginality and abandonment of vulnerable people. The non-intervention could trigger irreversible impacts in the

area. Its location benefits from strategic accessibility, such as with highway, airport, future metro line, and technological opportunities (e.g. empowerment of intermodal transport, or energy production) can improve urban transportation. The vast green areas, the river Stura could connect this area with the green and blue infrastructures of the Metropolitan City. Possible inclusion of the area within environmental projects could facilitate the restoration and enhancement of its habitats. Education has the power of sensibilization and awareness of present and future generations about the area (e.g. social justice, or waste recycling). The river flooding is a threat that could further damage the area. The local economy is affected by a progressive abandonment of the farmhouses and industries. Some opportunities could be the adaptive reuse of the industrial buildings for green energy production (see EU project Together2020 of Turin), and for the creation of new job demand through the design of co-working spaces. Taxes and subsidies for green technology may attract investors in the area and facilitate the adoption of energy policies, even if the long-term transformations and the huge amount of economic resources could threaten their interest. The ongoing revision of the Municipal Plan is thus an opportunity to regenerate Basse di Stura .

4.3 Results of the Scenario Building

The key elements emerged from the STEEP+SWOT Analysis have been integrated within the scenario tool, i.e. Wilson matrix, able to evaluate impact and uncertainty of the strategies proposed for the regeneration of the Basse di Stura (see Figure 4). Those drivers evaluated in the Wilson matrix with a high impact and low uncertainty have been selected for defining potential strategic scenarios (Özkaynak, 2008). For example, the factors related to the remediation of the ground pollutants or the accessibility to the site are crucial for the definition of the transformation projects, whereas the elements related to the increase of the industrial activities or the valorization of cultural events can be devoted less attention as they are characterized by high uncertainty (industrial activities development) or low impact (cultural events promotion).

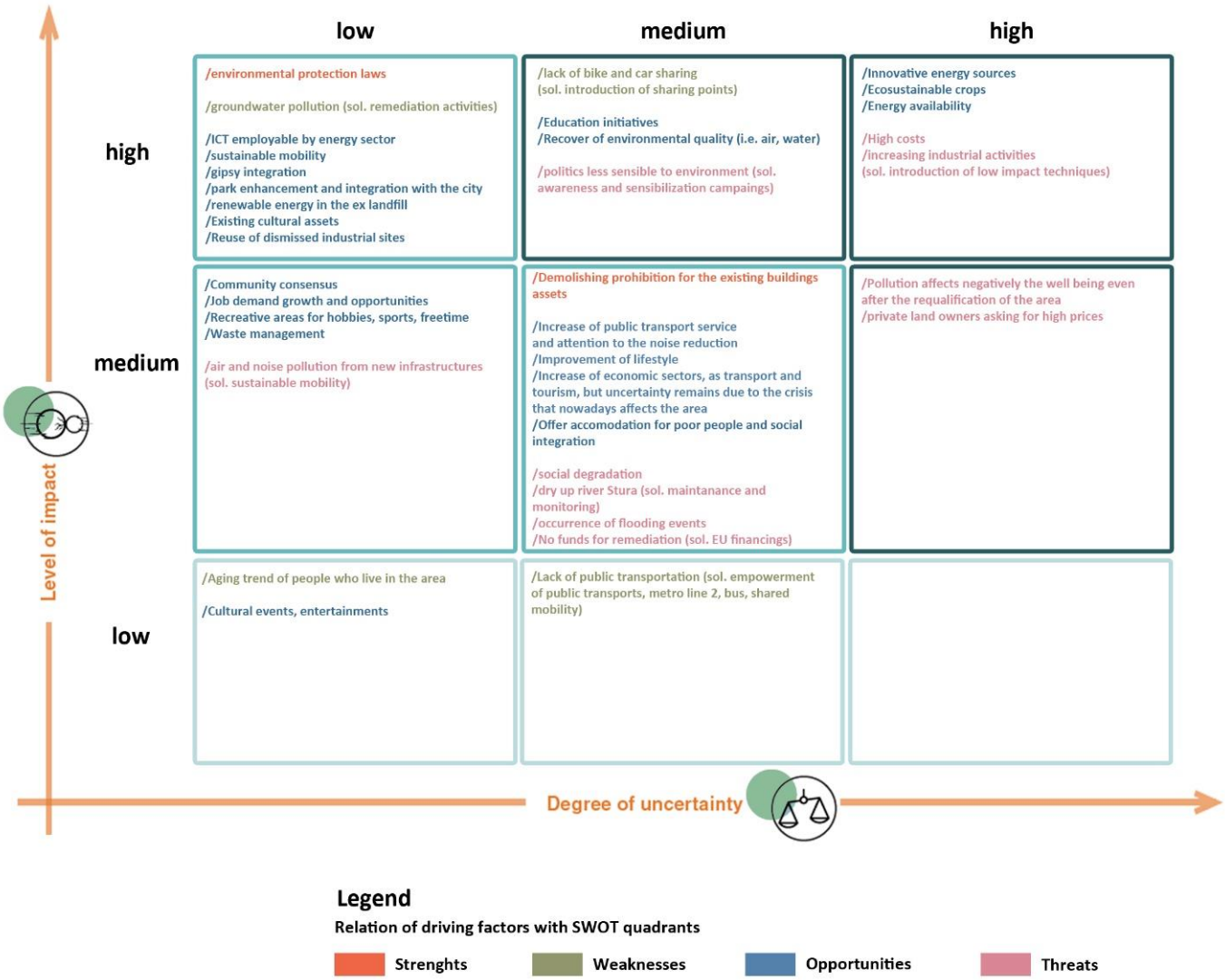

Figure 4. Integration of the STEEP+SWOT key elements as drivers into the Wilson matrix.

Observing the results of the Wilson matrix, three different scenarios have been proposed (i.e. inertial, tendential, strategic). In detail:

- The inertial scenario is only based on maintenance of the state of the art of the Basse di Stura area, according to the normative and regulatory tools in force;
- The tendential scenario envisions the achievement of the Municipality aims, given the Basse di Stura area to citizens through the creation of an environmental-energy park. This proposal is based on the remediation of the green areas from metals pollutants with the subsequent creation of social aggregation spaces.

- The strategic scenario is finalized to regenerate the Basse di Stura area into a positive environmental footprint area that is opened to the nearby areas. This scenario is enforced by the adaptive reuse of the industrial heritage to create data centres and start-ups aimed at triggering a clean and innovative business. The core building will be a research centre connected with other buildings opened to companies that could be interested in potential synergies. More in details, a photovoltaic (PV) park will be designed to produce electric energy, as well as an innovative system will be experimented to transform the energy produced by servers in a profitable opportunity of the district to heat and cool the surrounding areas. In this way, the Basse di Stura area will be transformed, in the short and medium-term, into an innovative industrial district that will carry out highly specialized workplaces according to a low-environmental-impact business.

Attention must be devoted to the presentation of the scenarios through storytelling, for facilitating actors and stakeholders in envisioning the potential transformations in the area (Figure 5). Storyline means a narrative which highlights the main features and the relationships between the scenarios driving forces. Finally, a set of objectives and strategies have been defined for each scenario and, then, organized into short, medium and long-term (see Figure B.2).

Figure 5. Storytelling to support the scenario building (Elaboration from the contents of the XIV ASP Summer School students, 2018).

4.4 Results of the MCDA evaluation

4.4.1 Ranking of alternative scenarios

Once having defined the scenarios, it is possible to evaluate them for obtaining the best sustainable one by employing the system of performance indicators, according to the Multiattribute Value Theory (MAVT).

In detail, starting from the study developed with the STEEP+SWOT Analysis, a consistent decision tree (Table 1) has been framed by taking into account main important characteristics of the area and needs of the stakeholders engaged in the decision problem. Table 1 shows the decision tree, reporting the objective of the evaluation, the criteria and sub-criteria considered. For each sub-criteria, the table describes the indicators selected to measure the performances of different alternatives, specified if qualitative or quantitative, the direction of preference, and the unit of measurement or the scale used.

Table 1. Decision tree

Objective	Criteria	Sub-Criteria	Indicators	Nature	C/B	Scale of measurement
Regeneration of Basse di Stura	Society	Employment	Estimation of the number of job places created	quantitative	B	n°
		Company image	Educative function and green-house emission reduction	qualitative	B	-: fair level of educational activities and greenhouse emissions reduction 0: good level of educational activities and greenhouse emissions reduction; +: Very good level of educational activities and greenhouse emissions reduction
	Technology	R&D Activities	Papers and patents increment for the company	qualitative	B	-: no change in the # of papers and patents published compared to previous year; 0: slight increase in the # of papers and patents published compared to previous year; +: very significant increase in the # of papers and patents published compared to previous year
		Acquired Know-How	Probability of the development of new products	qualitative	B	-: fair probability of developing new products; 0: good probability of developing new products; +: very high probability of developing new products
		Sinergy with pre-existing technologies	Degree of interactions between new and old facilities	qualitative	B	-: fair degree of interaction between new and old facilities; 0: good degree of interaction between new and old facilities; +: very good degree of interaction between new and old facilities
		Renewable energy technology	Estimation of the quote of renewable energy production	quantitative	B	%
	Environment	Air pollution	Estimation of NOx emission	quantitative	C	ton/y
		Soil pollution	Reduction of heavy metals contamination	qualitative	B	-: no reduction of pollutants in the soil; 0: slight reduction of pollutants in the soil;

					+: significant reduction of pollutants in the soil
	Natural landscape	Biodiversity (Red List Indicator)	qualitative	B	-: No changes in the current biodiversity level; 0: Increase in the number of different plant and animal species; +: High increase in the number of different plant and animal species
Economics	Attractiveness of further investment	Likelihood of further private investment in the area	qualitative	B	-: fair attractiveness for the future investments; 0: good attractiveness for the future investments; +: High attractiveness for the future investments
	Convenience of the investment	ROI (profit [€] / Investment [€])	quantitative	B	%
	Payback time	Payback time (Investment [€] / Yearly cash flows [€/y])	quantitative	C	y
	Public incentives (green certificate)	Revenues from green certificates (Saved CO2 [ton/y] * GC price [€/ton])	quantitative	B	M€/y

Once the decision tree has been framed, it is possible to measure the performances of the alternatives according to the indicators defined. Results are presented in Table C.1 in the Appendix. From the performance matrix, it is evident how the inertial scenario is not able to improve the overall quality of the area considering the set of criteria selected, but this scenario does not require costs, unlike the tendential and strategic scenarios. However, these two last scenarios, albeit in different ways, take into consideration the general objective of requalification with a particular focus on the natural environment.

The MAVT analysis has been carried out with the support of the Definite Software (Janssen, Van Herwijnen, & Beinat, 2000) which makes possible to standardize the performances, weight the set of criteria, aggregate scores, visualize partial and final rankings and perform the sensitivity analysis. Concerning the standardization phase, the software makes all the scores homogeneous by the transformation into dimensionless values [0-1] through linear functions (Figure 6). These functions have been carefully discussed with the client, the experts and the stakeholders involved and decided by considering the nature of the set of criteria defined.

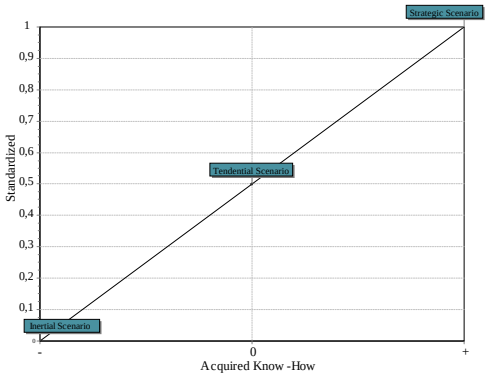

Figure 6a. Value function – benefit.

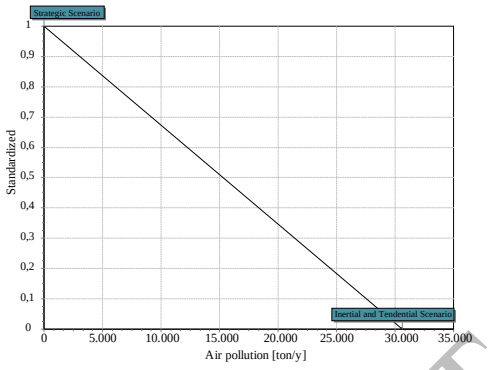

Figure 6b. Value function – cost.

Once the performances have been standardized, it is possible to proceed with the aggregation considering the formula [1] presented in section 2.4. As it has been already explained, a compensative aggregation procedure has been selected, which means that a weak performance obtained in one criterion can be compensated by a good one obtained in another criterion (Dodgson et al., 2009), with the final aim to provide an efficient solution which is a balance among the criteria defined. Given the importance of all the four components in achieving the final objective and always in agreement with the objectives elicited by the DM, it has been decided to visualize a neutral scenario where the same influence has been assigned to the dimensions considered in the decision problem (i.e. 25% of importance to the four considered criteria of Technology, Society, Environment and Economic). From the calculations, the strategic scenario ranks at first place with an overall score of 0.80, followed by the tendential scenario (0.53) and the inertial scenario (0.06).

4.4.2 Sensitivity analysis and final recommendations

Despite the global coherence of the obtained results, it is always necessary to perform a sensitivity analysis in order to test the internal robustness of the ranking and to validate the results. In particular, the sensitivity analysis was performed based on "what if" questions to see if the final answer is stable when the inputs were changed. Moreover, it is of special interest to see whether these changes modify the order of the alternatives. In the present paper, the stability of the results has been studied with reference to the variation of the weights of the criteria using the One-at-a-Time (OAT) approach. The

OAT approach assigns to one criterion at a time the highest weight (50%) and the others an equal weight (16,7%) in order to observe the effects on the final results (Figure 7). As it is possible to see in Figure 6, the result is constant and robust and the strategic scenario achieves always the first place, also by changing the set of weights.

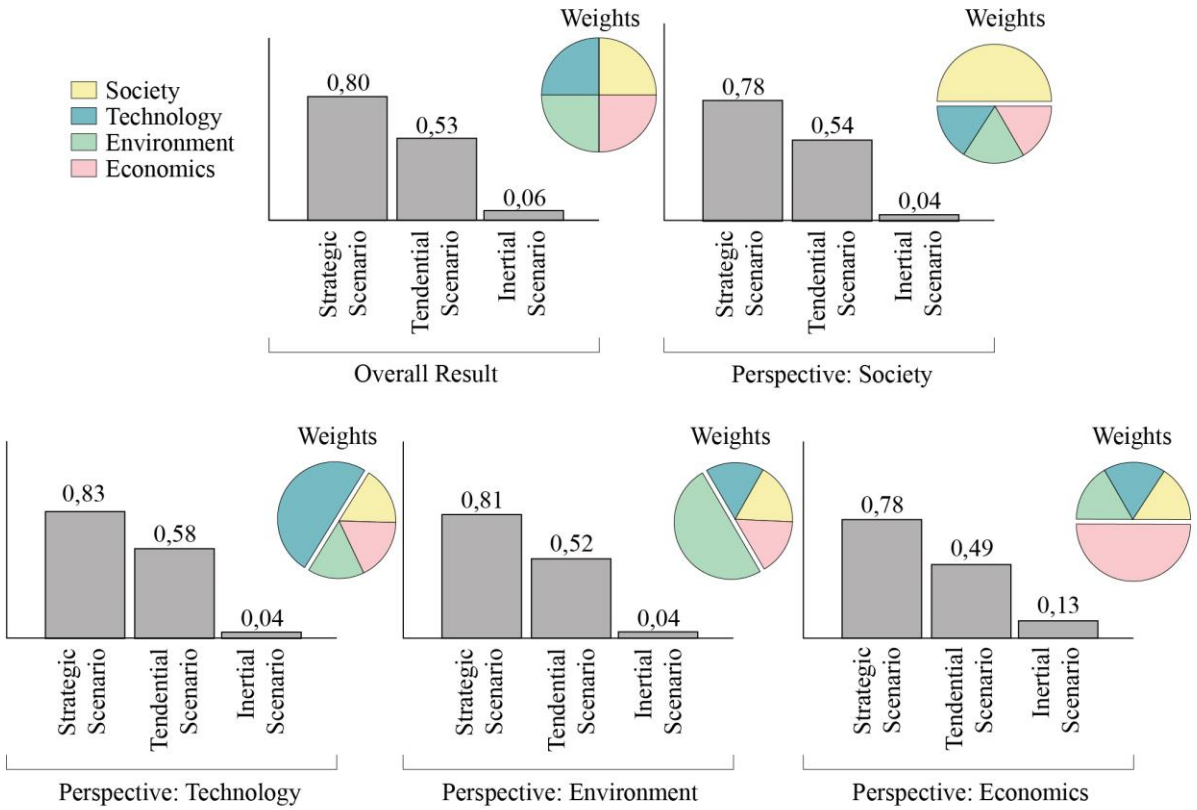

Figure 6. What if scenario.

The ranking visualized is not only important for the selection of the most suitable alternatives but also to discard those not good enough. In this case, it is evident how the inertial one does not reach the needs required for the requalification of the area, whereas both the strategic scenario and tendential one present different positive features. For this reason, they have been thus envisioned according to meaningful values that are represented by the economic value, energy services, future generations heritage and environmental protection. An effective way could be the generation of a new hybrid scenario that comes from the combination of the tendential and strategic scenarios and maximises the positive aspects of the two projects (Figure 8).

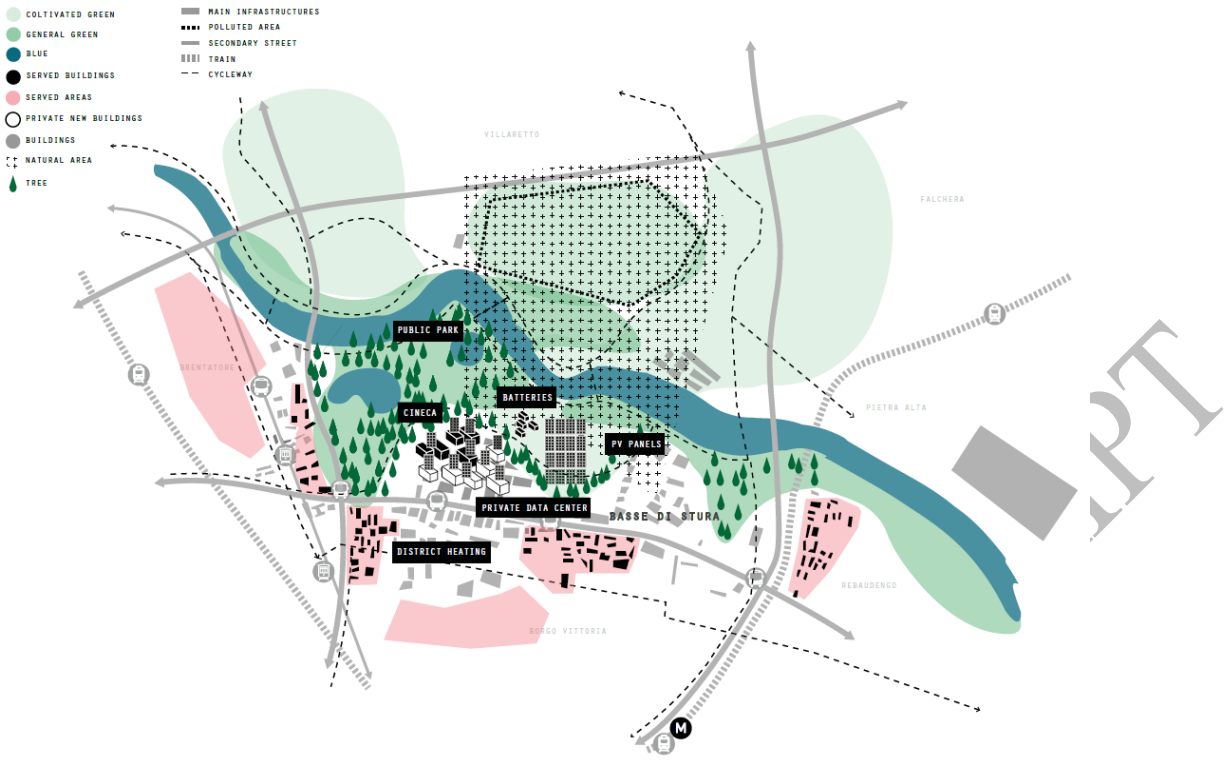

Figure 7. Spatial visualization of the winner scenario: the strategic scenario (Elaboration from the contents by the students of the XIV ASP Summer School).

5 Discussion and conclusions

This research presents a multi-level methodology for supporting the design and evaluation of alternatives in the context of complex problems, applied to the case study of Basse di Stura area in Turin. The integration of different tools into an overall evaluation methodology makes it possible to envision alternative transformations of the site. The combination of Stakeholder Analysis, STEEP+SWOT Analysis, Wilson matrix and MAVT shows its potentiality in supporting the definition of scenarios that take into account health and well-being aspects, socio-economic development and environmental valorization. Furthermore, it provides a strong structure to the design process. The adoption of scenario building is limited in practise, as emerged from the literature and as pointed by Ariza-Álvarez, Soria-Lara, Arce-Ruiz, López-Lambas, & Jimenez-Espada (2021). The practical application of this research ~~bridges the gap between theory and practice~~, is useful for highlighting scenario building potential . Moreover, the real-world case study application presented in this paper shows how the mixed method approach is able to build and compare different alternative scenarios related to a single action plan. More specifically, it can help to justify the decisions through

434 a clear, transparent and rational framework and supports DMs in establishing shared solutions and
435 intervention priorities. These last aspects are strongly relevant since scarce public resources and
436 consensus are the two main obstacles and constraints in urban project development.
437 The Stakeholder Analysis proved to be useful for understanding the multiple perspectives and views
438 to be taken into account for effective regeneration of the area. Thanks to the combination of the
439 Power/Interest matrix and the Social Network Analysis it was possible to identify the key players that
440 triggered the transformation of Basse di Stura.STEEP+SWOT Analysis allowed DMs to analyse the
441 current state of the art. The matching of the STEEP and SWOT analyses improve the organization of
442 strengths, weaknesses, opportunities and threats according to the meaningful dimension of "different
443 environments that coexist in a city" (Camagni, Capello, & Nijkamp, 1998).This tool also supports
444 the identification of the main driving forces relevant to the scenarios generator and their transfer
445 (Schwab, Cerutti, & Hélène von Reibnitz, 2003). The Wilson matrix and the storytelling facilitated
446 the envisioning of the potential scenarios to be evaluated, leading the identification of the driving
447 forces with the highest impact and low uncertainty, the definition of a set of performance criteria for
448 the evaluation and the construction of a protocol of objectives and strategies. The storytelling was a
449 suitable tool for describing the goal and the perspectives of each scenario, thus facilitating actors and
450 stakeholders in better understanding the defined objectives and strategies (Ariza-Álvarez et al.,
451 2021b; Carbonell, Sánchez-Esguevillas, & Carro, 2017). The efficacy of scenario tools in building
452 alternative scenarios depends on a comprehensive knowledge on the values, pressures, opportunities
453 and risks. If these are not properly detected by the evaluator, they could lead the key players to
454 prioritize certain issues rather others. MCDA was useful to compare different alternatives and select
455 the one able to find a balance among the dimensions considered. Moreover, given the level of detail
456 of the scenarios proposed, it allowed the analyst to use the different type of indicators and to select
457 those able to catch the peculiarity of each sub-criterion. The aggregation phase resulted in a final and
458 partial ranking and the sensitivity analysis is useful to validate and justify the final choice to be taken
459 by the DM and to communicate the results transparently. The results obtained by performing the

MCDA should be read considering the aggregated score and also the partial scores, which can give information about the main criticalities detected in each scenario. This consideration sheds light on the proactive role of the evaluation aimed at generating new and unexpected scenarios by combining the strengths of the most suitable alternatives or by improving the main weaknesses resulted (Caprioli & Bottero, 2020; Dell'Ovo & Oppio, 2019). The DM, according to the final ranking, can generate a new alternative aimed at maximizing the objectives considered as most important. MCDA provides DMs with the suitable process to solve a complex problem, even if political decisions have the final word on future transformations.

From this application, some future work can be outlined. Firstly, the proposed evaluation methodology will be replicated in other critical areas, to increase its reliability. Secondly, the STEEP+SWOT Analysis will be improved by integrating the dynamic SWOT Analysis (Carmelina Bevilacqua, Anversa, Cantafio, & Pizzimenti, 2019; Bezzi, 2005) to explore the degree of dependence between the driving forces, aiding the structuring of decision problem and more efficiently supporting strategic guidelines and recommendations. Thirdly, the main actors identified in the Stakeholder Analysis could be further involved in the criteria weight elicitation phase also to visualise different scenarios by performing a sensitivity analysis and test the internal robustness of the final rank. Fourthly, concerning MCDA, other methods could be tested such as the Analytic Network Process (ANP) to further explore the interdependency of the performance criteria deriving from the interrelations of driving forces and thus evaluating a group of alternative scenarios defined through scenario tools. To this end, it is possible to conclude that the combination of the evaluation tools seems to be very promising in the generation of useful framework able to support real strategic assessment procedures and to aid the DMs to renovate the vision of urban plans, programs and projects.

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Appendix A

Table A.1. Survey of the relevant stakehodelrs for the Basse di Stura area

STAKEHOLDERS	*LEVELS*	*RESOURCES*	*CATEGORIES*	*EXPECTATIONS*
EU (European Union)	international	economic	political, bureaucrats	supporting projects for solving environmental and social issues
Italian government	national	legal, political, economic	political, bureaucrats	supporting projects for solving environmental and social issues
Piedmont Region	regional	legal, political, economic	political, bureaucrats	- supporting projects for solving environmental and social issues; - developing projects for the regeneration of blue-green infrastructures in the city of Turin and in the surrounding municipalities
ARPA (environmental agency)	regional	legal	bureaucrats, expert	- bringing the environment to a safe and clean condition; - preventing environmental degradation
Designers (architects, planners…)	national, regional, local	cognitive	expert	developing effective projects;
Big landlords (Poste, Italgas) - Private land owners	national	legal, political, cognitive, economic	special interest	- creating value from land - profiting from developing, building, leasing or selling land of buildings
Investors	national, regional, local	economic	special interest	profiting from developing, building, leasing or selling land of buildings
Metropolitan city of Turin	local	legal, cognitive, political, economic	political, bureaucrats	- developing projects with the municipality of Turin and the neighbourhoods
Municipality of Turin	local	legal, cognitive, political, economic	political, bureaucrats	- developing the urban park - safety and security; - quality services; - efficient and organized public transports; - involving local communities; - supporting projects for solving environmental and social issues - preventing environmental degradation; - supporting urban regeneration and social inclusion;
Neighbouring municipalities	local	legal, cognitive, political, economic	political, bureaucrats	- new services (e.g: bike sharing, green spaces,…); - developing projects with the municipality of Turin
AMIAT (Municipal waste management company)	local	cognitive	special interest	- safety and security; - bringing the environment to a safe and clean condition
GTT (transport agency)	local	cognitive, political	special interest	- increasing the number of clients of their service; - collaborating with public and private sector
Environmental associations	local	cognitive, political	general interest	- raising awareness about topics related to protection of environment, wildlife; - supporting projects for solving environmental issues; - preventing environmental degradation

Small landlords	local	cognitive	special interest	- profiting from developing, building, leasing or selling lands - avoiding remediation
Local commercial activities	local	cognitive	special interest	- safety and security - increasing profit - new transport connections and better quality of the existing ones - supporting urban regeneration and social inclusion
Citizens associations	local	cognitive	general interest	- safety and security; - new and quality services; - efficient and organized public transports; - collaborating with public and private sector
Nomad community	local	cognitive	general interest	- avoiding relocation - need for long-term housing solution - access to education and employment - safety and security
Owners of industrial activities	local	economic, cognitive	special interest	- avoiding relocation - profiting from developing, building, leasing or selling buildings
Cultural and heritage associations	regional	legal, cognitive	bureaucrats, expert, general interest	- raising awareness about topics related to protection of environment, wildlife, cultural heritage sights, endangered social groups etc.; - protecting historical sites (farmhouses…)
Tourists	regional, local	economic, cognitive	general interest	- safety and security; - quality services; - efficient and organized public transports
Circoscrizione 4	local	legal, cognitive	political, bureaucrats, special interest	- safety and security; - quality services; - efficient and organized public transports; - involving local communities; - supporting projects for solving environmental and social issues - preventing environmental degradation; - supporting urban regeneration and social inclusion;
Construction Companies	national, regional, local	cognitive	special interest	- profiting from developing, building, leasing or selling
Real estate developers	national, regional, local	economic, cognitive	special interest	- profiting from developing, building, leasing or selling
Local media	local	cognitive	general interest	informing about the entire process of the project (ex-ante, in-itinere, ex-post)
Energy companies	national	economic resources	special interest	- integration of energy facilities/grids in the area - exploitation of local energy sources - energy hub centre
Bike sharing	local	economic	general interest	increasing the number of clients of their service
University	regional	cognitive	expert	- collaborating with public and private sector; - supporting projects for solving environmental and social issues

Appendix B

STEEP components	STRENGHTS	WEAKNESSES	OPPORTUNITIES	THREATS
Society	Presence of historical rural heritage Proximity to high density residential areas	Health issues due in part to the site contamination Informal urban allotments (e.g. gipsy camps) Degradation of the architectures Neglected rural buildings (e.g. farm-houses)	Take advantage to historical and artistic assets. Open spaces can be used by different activities and education initiatives, in synergies with nearby places. Enhancing the landscape viewpoints	Obstruction of the landscape views Increase of social margination and marginality Abusive allotments in neighborhood Abandonment of the area
Tecnology	Waste of ex landfill is used to produce energy Area easily accessible from the highway Direct connection of the area with the airport Closeness to the metro line	Unused industrial structures Noise pollution from traffic Old industrial buildings Lack of bike lanes Lack of bike sharing Separation from nearby residential area Few public transports	Enhancement of the environmental management of the ex landfill area Adaptive reuse of the industrial buildings Development of new technologies for energy monitoring Regenerate the site for research R&D and renewable energy Connection of the area through cycle mobility to the city Improvement of public transport connection Enhancement of bike and electric car sharing points	Worse abandonement of the industrial buildings Increase of traffic and noise, air pollution High costs may limit the research of sustainable solutions. Creation of invasive structures and land take
Environment	Presence of extended green areas Presence of habitat and microhabitat annexed to the river Stura	High contamination by heavy metals and hydrocarbons, caused by the ex landfills Ecosystem degradation Industrial waste Air and water contamination Difficulty treatment of the groundwater flow	Inclusion of the area within a system of fluvial parks Increase of ecological quality Educational initiatives on waste recycling and reuse Potential use of the area to produce renewable energy. Inclusion into environmental projects, in network with other waterbodies that flow in the city.	Dry up of the river Stura and progressive groundwater pollution Occurrence of flooding events by river Stura Air contamination and pollution caused by abusive allotments Long time and huge funds to regenerate the area could limit the investors offers.
Economics	Rural and industrial vocation of the area Self-sufficiency of the farmhouses system (e.g. cultivation and cattle)	Lack of general services Progressive decommission of farmhouses Production of non-renewable energy by the industries Scarsity of funds for remediation of the area	Attraction of local activities thanks to the increase number of turists and citizens Refurbishment of dismissed industrial sites Reopening of indutries to increase the job demand in the area Producing renewable energy on site to reduce the high costs Promotion of tourism, workplaces, infrastructures initiatives in the area.	Private land owners that want to make profits No remediation funds Abadonment of the industries may decrease the job demand in the area Worsening situation in terms of quality of life in the area.
Policy	Strategic position in the city recognized by local policies Presence of regulations for protecting the existing cultural heritage Taxes and subsidies for green technology Periodic environmental monitoring of the area	Complexity of the bureaucratic problem Few flexibility of the current municipality plan of the city.	Take advantage to the strategic position can gain more important role inthe city. Subsidies and tax reduction guaranteed by the law can incentive to invest in the area. Participation of local community into a transparent negotiation process with the potential investors.	Potential adoption of too sectorial policies.

Figure B.1. STEEP+SWOT Analysis developed for investigating the Basse di Stura area

Scenarios	Objectives	Strategies	Vision
			SHORT / MEDIUM / LONG
Inertial scenario	i.1 Improve urban livability and attractiveness of the area	i.1.1 Creation of green areas by regenerating the area	LONG
		i.1.2 Creation of pedestrian and cycle paths	MEDIUM
		i.1.3 Remediation of agriculture areas	MEDIUM
		i.1.4. Improve nearby architectures and historic assets	SHORT
	i.2 Encourage socio-economic development	i.2.1 Obtaining energy from the ex-landfill remediation	LONG
		i.2.2 Improving intermodal transport network	LONG
Tendential scenario	t.1 Environmental regeneration	t.1.1 Remediation and decontamination of the area	SHORT
		t.1.2 Creation of a green wetland	MEDIUM
		t.1.3 Implementation of renewable energy solutions	LONG
	t.2 Improve the life quality of citizens	t.2.1 Creation of open public spaces	SHORT
		t.2.2 Sensibilization on environment and energy	LONG
		t.2.3 Educational initiatives on innovative solutions	MEDIUM
		t.2.4 Increase the economic attractiveness in the area	LONG
	t.3 Energy innovation	t.3.1 Localization of an energy research center	SHORT
		t.3.2 Active involvement of university and partners	MEDIUM
		t.3.3 Create a thematic park and energy-based	SHORT
Strategic scenario	s.1 Promoting socio-economic development with regard to industries	s.1.1 Adaptive reuse of the industrial buildings	SHORT
		s.1.2 Job opportunities in the new industries	MEDIUM
		s.1.3 Improve electrical transportation	LONG
	s.2 Minimizing the impacts on the environment	s.2.1 Produce energy through autonomous systems	SHORT
		s.2.2 Reduce pollution through sustainable solutions	SHORT
		s.2.3 Remediation of the whole area	MEDIUM
		s.2.4 Waste management for energy production	SHORT
	s.3 Create new energy indipendence	s.3.1 Renewable electric energy generators on site	SHORT
		s.3.2 Thermal energy generators on site	SHORT
		s.3.3 Creation of a smart micro-grid	MEDIUM

Figure B.2. Scenarios, objectives and strategies for the requalification of the Basse di Stura area

Appendix C

Table C.1. Performance matrix

Objective	Criteria	Sub-Criteria	U.M.	Inertial Scenario	Tendential Scenario	Strategic scenario
Regeneration of Basse di Stura	Society	Employment	n°	0	100	1200
		Company image	-/+	-	+	0
	Technology	R&D Activities	-/+	-	+	0
		Acquired Know-How	-/+	-	0	+
		Sinergy with pre-existing technologies	-/+	-	0	+
		Renewable energy technology	%	0	75	100
	Environment	Air pollution	ton/y	30600	30600	0
		Soil pollution	-/+	-	+	0
		Natural landscape	-/+	0	+	-
	Economics	Attractiveness of further investment	-/+	-	0	+
		Convenience of the investment	%	0	5	10
		Payback time	y	0	10	25
		Public incentives (green certificate)	M€/y	0 0		2