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A mixed methods approach for the integration of urban design and economic evaluation: Industrial heritage and urban regeneration in China

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Abstract

This paper presents the early results of a study aimed at experimenting an innovative approach to the design and the evaluation of complex urban transformation processes, based on the combined use of different design strategies and tools. The purpose of the paper is to illustrate, by means of a case study, a multi-level decision aiding process, able to support strategic urban design, with specific reference to regeneration processes for abandoned industrial sites in urban areas. The case study presented in the paper concerns different alternative proposals for the requalification of the former Shougang/Er-Tong mechanical factory in Beijing, China. The choice of a Chinese case study as a field test for an experimentation about mixed methods research approaches in the domain of urban transformation is related to the peculiar emerging conditions of that context, in which huge economic potentials are speeding up the transformation but a substantial lack of cultural and methodological instruments to manage a so fast modification exists. During the design process, three methods in particular have been combined according to a multi-phase design: (i) Stakeholders Analysis, (ii) Multicriteria Analysis, and (iii) Discounted Cash Flow Analysis. Each one of them has been applied in parallel to the evolution of the different design scenarios. The results of the performed study show that mixed methods approaches are a promising line of research in the field of environmental evaluation and urban design. Insights and guidelines for the replication of the proposed methodological approach in other territorial contexts are also proposed.

Keywords

Multicriteria analysis, urban design, decision support, masterplanning, economic evaluation

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Introduction and overview

The evaluation of urban transformations has been introduced only recently in the Chinese practice and until now it has rarely enjoyed the favor of a large part of the establishment, the stakeholders and the planners/designers (Sun and Zhou, 2003). Despite its persistent condition of rapid economic growth, and – subsequently – of fast modification of its cities, the Chinese debate about urban transformations seems still lacking a comprehensive cultural approach on the integration between urban design and economic evaluation, supporting the decision-making process.

Contemporary China – since the reforms about the "Four Modernizations" (agriculture, industry, technology and defense) were introduced by Deng Xiaoping in the late 1970s – is facing a deep and quick metamorphose of its economic structures, of its production systems and of its society, having in the background a momentous transition process, from a mainly rural society to an essentially urban one. In only 30 years, between 1980 and 2010, the percentage of urban population in China increased from 19% to 49% and, in 2011, the amount of people living in the Chinese cities definitely exceeded the number of rural inhabitants (The World Bank).

This overall process has been almost everywhere materialized in a radical transformation of the urban space itself, affecting in particular the industrial settlements (Fulong et al., 2006; Jian et al., 2008; Yeh et al., 2011).

China is facing a wide transformation of its cities that could be compared – to a certain extent – to that "modification" (Secchi, 1984) which occurred in Europe starting from the 1980s, when the deindustrialization process became worldwide visible through the large abandoned industrial relics, survived within the fabrics of cities, which gave birth, in the European culture, to a long season of studies about the conservation, the refurbishment, the reuse and the requalification of industrial heritage. But, at the same time, it is important to avoid the trivializing temptation of reading China's recent "urban transition" (Friedmann, 2005) as a kind of an accelerated and over boosted new edition of the western urban dynamics that transformed the European cities in the late 20th century. The background is actually completely different, and somehow even opposite. Europe was experiencing, in the last part of the 20th century, a dawning crisis of its productive structures, as the industries were rapidly losing their primacy against service economy's and SME's rising importance; whereas China is now trying to match the new development of the service industry within the market economy, and the improvement of the domestic consumption, with a rationalization of the heavy industry, in the general framework of a still fast-growing economy, even in the framework of the "New normal" condition introduced by the 13th five year plan 2016–2020.

What is much interesting for our purposes is that the present condition of China is not only a potential term of comparison between two different models of economies and societies, like the European and Chinese ones, but most of all a promising testing ground to experiment new methodologies for the design and the evaluation of complex urban regeneration processes, which involve networks of actors and stakeholders bearing a variety of values and requirements often mutually contrasting or simply incommensurable, like for instance: financial returns, social improvement, environmental sustainability, etc. (Blackwood et al., 2014). The reason why we decided to use the Chinese reality – and specifically a brownfield regeneration process in a complex urban environment – as a field test for an experimentation about mixed methods applied to urban transformations is therefore related to the peculiar emerging conditions of that context, from the cultural, political and economic points of view. Many recent studies showed that Chinese cities – and most of all Beijing, which is rapidly reorganizing its traditional monocentric urban structure into a multipolar metropolitan

framework – are witnessing the combination of a huge economic potential, which is speeding up the transformations, and a substantial lack of cultural and methodological instruments to manage a so fast modification (Bonino and De Pieri, 2015). In this framework, a mixed methods research approach – allowing to take a large set of both qualitative and quantitative values into account, in the framework of a multi-level decision aiding process – seems to be a promising strategy to support strategic planning and design.

The mixed methods approach

Methodological background

In social sciences, three research approaches are normally employed: (a) qualitative, (b) quantitative, and (c) mixed methods (Creswell, 2003; Tashakkori and Teddlie, 1998).

Generally speaking, qualitative research is an approach for exploring and understanding the meaning that individuals or groups ascribe to social or human problems. Emerging questions and procedures are entailed in the research process, data are collected in the participant's settings and data analysis is inductively developed from particular to general themes.

The quantitative research approach aims to test objective theories by examining the relationship among variables and parameters. It is important to highlight that under this approach the theories are built deductively. In particular, variables and parameters can be measured and the data can be analyzed through mathematical and statistical procedures.

The combination of the aforementioned approaches refers to mixed methods research, that is an approach based on the collection of both qualitative and quantitative data, integrating the two forms of information and using distinct designs for the purposes of breadth and depth of understanding and corroboration (Johnson et al., 2007).

These three research approaches are based on different philosophical worldview assumptions. In particular, the main paradigms can be described as follows (Creswell, 2003).

- Post-positivist paradigm: these assumptions have represented the traditional form of research and they are based on quantitative research. This paradigm is also called the "scientific method" (Philips and Burbules, 2000).
- Constructivist paradigm: this paradigm is typically seen as an approach to qualitative research. According to this paradigm, individuals develop subjective visions of the world in which they live. Under these assumptions, researchers look for the complexity of these visions and they do not restrict meanings into specific classes of ideas (Crotty, 1998).
- Transformative paradigm: this approach arose in the 1980s and 1990s from individuals who felt that post-positivists assumptions imposed laws and theories that were not able to fully explain real-world problems; in fact, these theories did not fit marginalized people in the society, issues of power, social justice, discrimination and oppression. In studying these groups, the research focuses on inequities, linking political and social actions to these inequities.
- Pragmatisms: it is an approach where researchers focus more on the research problem rather than on methods and they use pluralistic approaches able to understand a problem. In particular, pragmatism applies mixed method research. Under this approach researchers have freedom of choice and they take inspiration from many approaches for collecting and analyzing data (Cherryholmes, 1992).

Table 1 summarizes the different research approaches available, highlighting the philosophical paradigm they refer to, the research design they apply and the research methods they use.

Table 1. Main research approaches.

	Qualitative research	Quantitative research	Mixed methods research
Philosophical paradigm	Constructivist/ transformative	Post-positivist	Pragmatics
Research design	Narrative research Phenomenology Grounded theory Case study	Experimental designs Surveys	Convergent Explanatory sequential Exploratory sequential Transformative, embedded, multiphase
Research methods	Emerging methods Open-ended questions interviews, observation data, audiovisual data text and image analysis interpretation	Pre-determined Methods Instruments based questions Performance data Statistical analysis Mathematical interpretation	Both pre-determined and emerging methods Both open-ended and closed-ended questions Multiple forms of data Statistical and text analyses Across databases interpretation

Source: Elaboration from Creswell (2003) and Tashakkori and Teddlie (1998).

From the analysis of Table 1, it is possible to stress that mixed methods research is based on the pragmatism paradigm, it makes use of both pre-determined and emerging methods, it concerns both closed-ended and open-ended questioning and it focuses on non-numeric and numeric data analysis. Moreover, considering the research design, four possible schemes are available in mixed methods research that can be described as follows (Creswell, 2003):

- convergent parallel mixed methods is a form of design in which the researcher converges or merges quantitative and qualitative data in order to provide a comprehensive analysis of the research problem;
- explanatory sequential mixed methods is one in which the researcher first conducts quantitative research, analyzes the results and then builds on the results to explain them in more detail with qualitative research;
- exploratory sequential mixed methods entails first a qualitative phase that can be useful for constructing evaluation instruments or for specifying variables that need to go into a follow-up quantitative study;
- more advanced mixed methods implies innovative design such as transformative, embedded and multi-phase mixed methods. In particular, transformative mixed methods is a design that uses the theoretical perspective of social justice and power as basis for the research. In embedded mixed methods design, quantitative or qualitative data are embedded within a larger experiment. Multiphase design is common in the field of evaluation and program interventions and concurrent or sequential strategies are used in tandem over time in order to understand long-term consequences.

From the point of view of the applications, it is possible to state that mixed methods research has been extensively used in health science and education research to develop new methodologies and to improve the quality and scientific power of data. In particular, in the aforementioned contexts, the diversity of mixed methods research approaches reflects the nature of problems faced by public health and education, such as disparity among population, age, cultures, behavioural factors, etc.

Mixed methods research applied to the evaluation of urban design

It is well known that urban design can be regarded as a multifaceted concept which includes socio-economic, ecological, technical, political and ethical perspectives. Moreover, urban design can be also understood as a process, referring to a method, procedure or series of actions or events that led to the accomplishment of some results (Boyko et al., 2006). Following these assumptions, decision problems in the domain of urban design represent "weak" or unstructured problems since they are characterized by multiple actors, many and often conflicting values and views, a wealth of possible outcomes and high uncertainty (Prigogine, 1997; Simon, 1960). Under these circumstances, the evaluation of alternative scenarios is therefore a complex decision problem where different aspects need to be considered simultaneously, taking into account both technical elements, which are based on empirical observations, and non-technical elements, which are based on social visions, preferences and feelings.

In this research, we tried to set up, and to experiment in the field, a mixed methods approach (Bazeley, 2004) to urban design and project evaluation, based on a multidisciplinary work. In particular, the present study aims at investigating the role of mixed-method approaches for supporting decision-making processes in the context of urban design.

Among the different possibilities for designing mixed methods research, the multi-phase one has been chosen (Creswell et al., 2011). This design seems to be particularly appropriate in the context of urban design, because it allows to follow the subsequent phases of project formulation and it allows to have a dataset built on the results of the previous one. As it will be presented in the rest of the paper, the multi-phase design permits to begin in clarifying the problem and in defining the goal and the objectives/values to be reached by a qualitative investigation that is followed by a quantitative analysis for better defining the project and for validating the final proposed solution.

As observed by Myllyviita et al. (2014), although there is a wide scholarly discussion on mixing methods, successful real examples in environmental decision and policy making are still scarce. Moreover, so far, the assumed benefits of using mixed methods have not been systematically tested. There is thus an evident need to pursue and to better communicate the benefits of mixing. Very few applications of mixed methods can be found in the domain of urban and territorial planning (e.g. Bottero, 2015; Cerreta et al., 2014; Ferretti, 2016). Most studies concern the combination between SWOT analysis and Multicriteria Analysis (MCA) for structuring the preliminary phases of the decision process (Ferretti et al., 2014a; Kajanus et al., 2012; Kurttila et al., 2000; Yavuz and Baycan, 2013; Zavadskas et al., 2011) and the integration of MCA and economic-financial evaluation models for addressing design projects (Azimi et al., 2013; Jimenez and Pascual, 2008; Mikucioniene et al., 2014). Mention should be made to the fact that the approach proposed in the present paper has an innovative character because it considers the integration of different methods for supporting the overall process and their early application starting from the very beginning of the design process, from the definition of objectives and values to be reached with the intervention to the final definition of the morphological form of the project. To the knowledge of the authors of the paper, this study represents the first experimentation of the combination of a specific technique of MCA (i.e. the Multi Attribute Value Theory) with stakeholders' analysis and Cash Flow Analysis.

The rationale for mixing three approaches in the study

Process scaffolding

A distinguishing feature of the methodology followed in the present study is the combined use of different tools for designing complex urban regeneration processes, in the framework

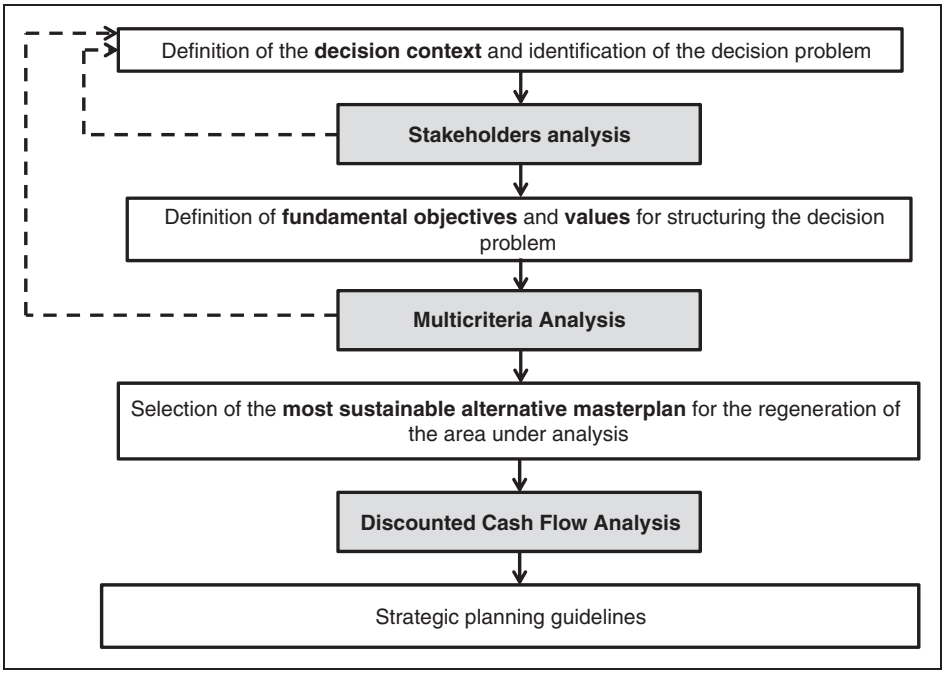

Figure 1. The mixed-methods decision process followed in the study.

of a multi-level decision aiding process able to support strategic planning and design, with specific reference to regeneration processes for abandoned industrial sites in urban areas.

In particular, phase I of the proposed process consists in the development of a stakeholder analysis (Dente, 2014) aiming at identifying the actors involved in the problem, as well as their values and objectives. Phase I informs phase II of the process as the system of identified objectives is used in the development of an MCA (Figueira et al., 2005) aiming at the selection of the best alternative project for the regeneration of the abandoned site under investigation (see section Context description for more details on the analyzed case study). Finally, phase III of the process develops a Discounted Cash Flow Analysis (DCFA, French and Gabrielli, 2004) in order to assess the economic feasibility of the project that has been selected through the MCA procedure (Figure 1).

The proposed approach has been tested on five different portions of the area under analysis, by applying the different combinations of approaches shown in Table 2.

As far as Stakeholders' analysis is concerned, three different methodologies have been considered in the study. The Stakeholder Circle methodology developed by Bourne and Walke (2008) provides a means for the project team to identify and prioritise a project's key stakeholders and is based on the development of the Stakeholder Circle diagram which allows to analyse and map the characteristics of each stakeholder. The stakeholders mapping approach is based on the construction of the power/interest matrix which is represented by a grid where the power and the interest are the relevant elements, allowing the comprehension of crucial issues, such as the level of interest of each stakeholder group to impress its expectations on the project decisions and the power of each group to affect the project decisions (Olander and Landin, 2005). Differently from the previous methods, Social Network Theory is an interdisciplinary endeavour and the information used in this method focuses on the relationships between pairs of stakeholders in a network (Dente, 2014).

Table 2. The mixed methods combinations experimented by the authors.

Methods	Masterplan A	Masterplan B	Masterplan C	Masterplan D	Masterplan E
Stakeholder Analysis					
Stakeholders circle		■		■	
Social network analysis			■		■
Power interest matrix	■				
Multicriteria Analysis					
Simple Analytic Network Process (ANP)	■				
ANP (Benefits and Costs networks)				■	
Complex ANP network			■		
Multi Attribute Value Theory (MAVT)		■			■
Cash Flow Analysis	■	■	■	■	■

With reference to MCA, among the available approaches and methods, the present research has focused on the methods of Analytic Network Process (ANP) and Multi-Attribute Value Theory (MAVT). In particular, the ANP (Saaty, 2005) represents a theory of relative measurement on absolute scales of both tangible and intangible criteria based on both the judgement of experts and on existing measurements and statistics needed to make a decision. By including dependences and feedback, the ANP is able to capture what happens in the real world, thus providing effective support for the kind of decisions needed to cope with the future. There are different possible ways for structuring the decision problem in ANP: in the present study we considered the simple network, the complex Benefits-Opportunities-Costs-Risks network and the Benefits-Costs network. On the other hand, MAVT can be used to address problems that involve a finite and discrete set of alternative options that have to be evaluated on the basis of conflicting objectives. For any given objective, one or more different attributes, which typically have different measurement scales, have to be identified in order to measure the performance in relation to that objective (Keeney and Raiffa, 1976). By being able to handle quantitative as well as qualitative data, MAVT plays a vital role in the field of environmental decision-making where many aspects are often intangible.

The remainder of the paper will develop more in detail the combination that, according to the authors, has more potential for urban and regional planning applications (i.e. the combination used under the column "Masterplan E"). The rationale for the selection of the combination Social Network Analysis (SNA)–Multi Attribute Value Theory and Cash Flow Analysis will be explained in sections 'Stakeholder analysis' and 'Multicriteria Analysis', respectively.

Stakeholder analysis

As shown in Figure 1 and in Table 2, the first method proposed in the process refers to Stakeholder analysis.

In public policy making, the stakeholders groups and their behaviors represent the core of any possible theoretical model (Boerboom and Ferretti, 2014; Dente, 2014). The stakeholders are those individuals or organizations that make the actions able to influence the decisional outcomes and that do it because they pursue goals regarding the problem and its possible solution, or regarding their relations with other stakeholders (Dente, 2014). 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 (Liu and Du, 2014).

Stakeholder analysis plays a very important role in strategic planning and sustainability assessment procedures since it allows to identify conflicting interests at an early stage of the process (Gill et al., 2013).

From a practical point of view, Stakeholder analysis is based on the identification and classification of stakeholder groups. Indeed, stakeholders have access to and can mobilize different types of resources (i.e. political, economic, legal and cognitive resources), they can be grouped into different categories (i.e. political actors, bureaucratic actors, special interests, general interests and experts) and they can have different roles (i.e. promoters, directors, opposers, allies, mediators, gatekeepers and filters) (Dente, 2014).

The final aim of the analysis is to develop a strategic view of the human and institutional landscape, the relationships between the different actors and the issues they care about most.

Different techniques are available to analyze stakeholders and actors but, in the field of urban development projects, it is of particular importance to highlight the solution dynamics of collective problems. This is the main focus of the so-called Social Network Analysis (Marin and Maintz, 1991; Rhodes, 1997) that became popular at the end of the past century and that generated sophisticated methodologies for the study of a decisional network. One of the most popular ways to represent the morphology or form of a network of actors is to represent actors as dots and their connections as arrows, as shown in Figure 2 (Dente, 2014).

SNA has the advantage of representing very interdisciplinary endeavours, based on sociology and anthropology, thus attracting attention towards the use of behavioural social analysis. In contrast with other stakeholders' analysis methodologies, SNA focuses on the relationships between pairs of stakeholders in a network. This approach seems particularly appropriate for studying urban and territorial decision processes, where the different stakeholders are associated in very dynamics contexts (Yang, 2014).

Multicriteria Analysis

The second method proposed in Figure 1 consists in the application of a specific MCA technique. MCA (Figueira et al., 2005; Roy and Bouyssou, 1993) is a valuable and increasingly widely used tool to aid decision-making where there is a choice to be made

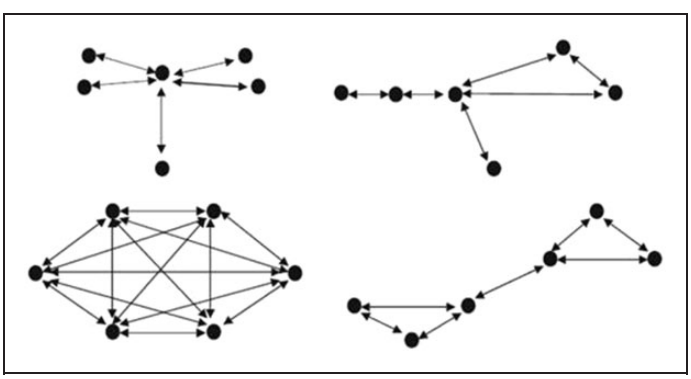

Figure 2. Possible forms of the network (source: Dente, 2014).

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 (Huang et al., 2011). MCA has been regarded as a suitable set of methods to perform sustainability evaluation as a result of its flexibility and the possibility of facilitating the dialogue between stakeholders, analysts and scientists (Cinelli et al., 2014; Munda, 2005; Rowley et al., 2012).

As shown in Table 2, different techniques have been tested in the present research but the following section will present in more detail the Multi Attribute Value Theory (Keeney and Raiffa, 1976) which seems a particularly promising line of research in the field of strategic planning and environmental decision-making (Ferretti and Comino, 2014; Ferretti et al., 2014b).

MAVT presents several advantages for dealing with complex decision making problems in the territorial planning domain. Firstly, MAVT helps in structuring the decision by classifying the problem in various objectives, criteria to measure the objectives and alternative options to solve the problem. Secondly, MAVT allows both qualitative and quantitative information to be taken into account in the evaluation. Thirdly, MAVT enhances the understanding of the policy problem by forcing the Decision Makers to build a value function that represents their preferences. Fourthly, MAVT offers the possibility of reasoning about the problem by clarifying the strengths and weaknesses of the different alternative policies. Furthermore, MAVT strongly supports the decision-making process because it permits to clearly visualize and communicate the intermediate and final results (Ferretti et al., 2014b; Reichert et al., 2015). Finally, MAVT has demonstrated to be able to support a transparent decision-making procedure and to efficiently handle decisions with large sets of alternatives and attributes (Schuwirth et al., 2012). For these reasons, MAVT has been applied to many real-world decisions, in both the private and public sectors (Munda, 2005).

From the methodological point of view, the process to be followed to build an MAVT model can be described as follows:

(1) Defining and structuring the fundamental objectives and related attributes.
(2) Identifying and creating alternative options.
(3) Assessing the scores for each alternative in terms of each attribute.
(4) Modelling preferences and value trade-offs.
(5) Ranking of the alternatives.

More details about each step and its development will be provided in the case study account.

Discounted Cash Flow Analysis

At this point of the process, further analyses are worthy in order to verify the financial feasibility of the best performing option (Manganelli, 2015). To this end, DCFA has been proposed and applied for all the five areas considered in our study. The method is based on the identification of the full range of costs and incomes of the project in order to allow the investor to understand if minimum objectives will be achievable (European Commission, 2015).

In particular, this technique is used to derive economic and financial performance criteria for investment projects (French and Gabrielli, 2004) in the form of synthetic and easy-to-interpret indicators that allow the Decision Maker to understand if the project should be accepted or rejected. The most used project performance criteria are the net present value (NPV) and the internal rate of return (IRR) (Manganelli, 2015).

Case study

Context description

The area chosen for the experimentation is the former mechanical factory of Shougang/Er-Tong, located in the western outskirts of Beijing, in the Shijingshan district, at about 15 km from the city centre and at about 2 km from the huge former steel factory of Shougang, part of the same industrial group. The factory site is situated outward to the fourth ring road and about 2 km southward to Chang'an Avenue, the main east-west infrastructure of the city.

The Overall Urban Plan of the city (2004–2020) determines that the neighborhood of Shijingshan, which will be linked to the city centre with the underground in the next years, is meant to become in a near future a "Central Recreation District", with facilities for service industry and leisure. In this framework, Er-Tong site (whose factories occupy an area of about 84 ha) has been identified as the core of a pilot operation of urban regeneration.

Er-Tong plant was originally the second mechanical factory of Beijing, founded in 1958; after only 20 years, it was renamed as Beijing Heavy-Duty Mechanical Factory and, after a bankruptcy, it was taken over in 1992 by Shougang group, which maintained this plant working until the first decade of the 21st century.

The whole site is characterized by a sizeable number of productive relics (buildings, chimneys, machines and conveyor belts, etc.), whose dimensions are in some cases monumental, and by an abundant presence of infrastructures, representing a physical trace of the original functioning of the factory. These features make it suitable, therefore, for a design experimentation whose ambition is to reflect on the valorization of the historic memory and its relationship with the conservation of the physical objects, as well as on the processes of selection and reinterpretation of the industrial heritage. In the last years an overall project for the entire area has been proposed, with core functions related to the construction of a "China Animation and Gaming City", a huge district dedicated to ICT gaming business. This project is already defined in physical terms, with a matrix of scattered towers surrounding the central area, where the main industrial relics are included. This scenario has been compared with two other hypothesis of masterplan. The first one is focused on the creation of a business park; the second one is meant to develop a more mixed urban fabric, with Service Industry facilities, commercial parts and residential zones.

Results of the stakeholder analysis

In order to support the design process in the formulation of the strategies for the transformation of the Er-Tong area, the stakeholders' analysis has been applied. In particular, the aims of the stakeholders' analysis were:

(1) to identity and group the stakeholders with an interest and/or an influence on the system;
(2) to understand the stakeholders' capacity development for the management of the transformation;
(3) to establish a set of values representing the stakeholders objectives and points of views with respect to the project under investigation.

According to the methodological framework described in section The rationale for mixing three approaches in this study, groups of organized stakeholders have been identified that can have an interest in the transformation of the Shougang area under examination. Table 3 surveys the most relevant stakeholders of the problem, with specific reference to the level, the type of actions and the nature of the resources at stake.

Table 3. Most relevant stakeholders for the transformation of Er-Tong.

No.	Stakeholder	Level	Type of actor	Resources
1	National government	National	Political	Political
2	National Health and Family Planning (NHFP)	National	General interest	Legal
3	Bejing city	Local	Political/bureaucratic	Political/legal
4	Fengtai district	Local	Bureaucratic	Legal
5	Shougang company	National	Special interest	Economic
6	Environmental associations	Local	General interest	Cognitive
7	Bureau of Commerce	Local	General interest	Cognitive/economic
8	Bureau of Culture	Local	General interest	Cognitive/economic
9	Developers	International/national/local	Special interest	Economic
10	Citizens	Local	Special interest	Cognitive/economic
11	Economic activities	Local	Special interest	Economic
12	Tourists/visitors	Local	Special interest	Cognitive/economic
13	Architects and planners	International/national/local	Experts	Cognitive

Another crucial aspect in the analysis of the stakeholders of the process is to move from the examination of the single actor to the groups of actors involved in the problem, with particular attention to the interactions existing among them. This allows to understand whether any feature exists which can contribute to highlight solution dynamics of the decision process (Dente, 2014). In order to develop such an analysis, the methodology of the SNA has been applied in the present study. According to this methodology, it is necessary to examine the size and the form of the decision network under investigation and to calculate specific indexes that allow the comprehension of the dynamics that regulate the network. Figure 3 represents the decision network for the present application. As it is possible to see, the nodes represent the stakeholders previously identified (Table 3) while the arrows represent the connections among them, based on the resources they exchange.

A relevant characteristic of the network is the density, meaning the intensity of the relations between the actors of a decision-making process. The density can be measured through the calculation of a specific index as represented in equation (1)

$$D = \frac{\sum K_i}{(n^2 - n)} \tag{1}$$

where D is the density index varying between 0 and 1, n is the number of actors and K_i is the number of relations in each group. In the present study, the application of formula (1) provides a quite low density index, i.e. 0.19. It is possible to state that in this case the high complexity of the network is weakened by the low density of the system, contracting both the benefits and the obstacles of the process.

Finally, it is possible to take into consideration the centrality of the different actors, namely the fact that one or a few actors monopolize relations with participants. The centrality index of the network can be measured as in equation (2)

$$C = \frac{k_i}{\sum K_i} \tag{2}$$

where C is the centrality index that varies between 0 and 1 and k_i is the number of relations of each actor. According to the numerical results provided by the application of formula (2)

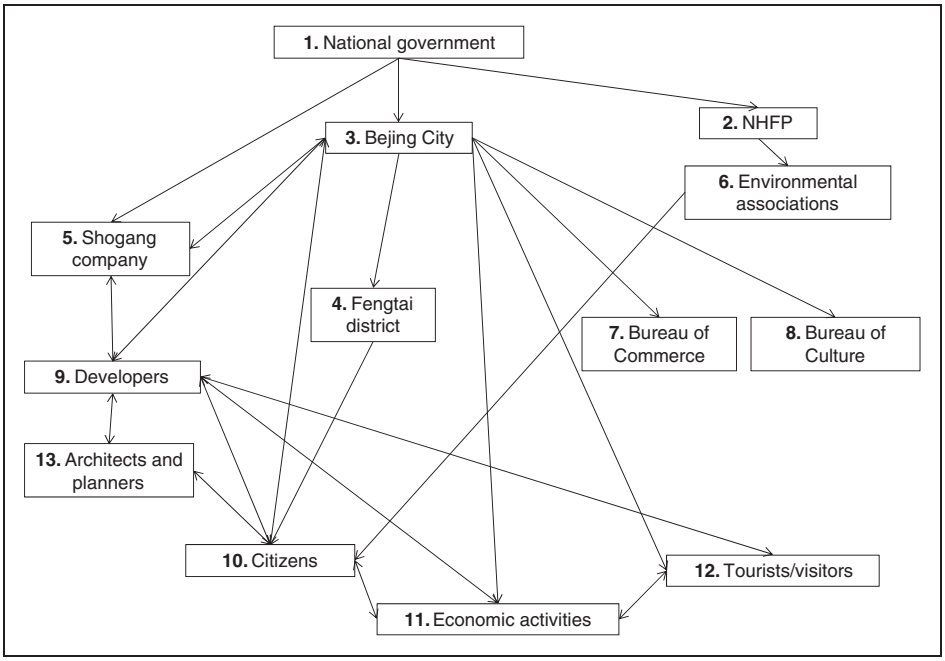

Figure 3. The decision network for the problem under investigation.

to the decision network under examination, it is possible to state that the most central actors of the process are the Beijing city (centrality index equals to 0.42) and the developers (centrality index equals to 0.39) meaning that they are the process directors; on the contrary, other actors such as the Bureau of Commerce and the Bureau of Culture show a low capacity of directing the process (centrality index equals to 0.03).

In conclusion, the analysis of the stakeholders of the decision-making process highlighted that the decision network under investigation is characterized by a high level of complexity, with several stakeholder groups acting at different levels and with conflicting objectives. In this sense, the use of a formal Decision Support System for assisting the decision-making processes seems to be very helpful.

Masterplan selection based on MAVT

As introduced in section The rationale for mixing three approaches in the study, the first step of the Multicriteria model consisted in structuring the decision problem as alternatives to be evaluated and objectives to be achieved. Figures 4 to 6 illustrate the alternatives that have been evaluated for the requalification of Er-Tong, while Figure 7 presents the set of measurable attributes that has then been identified for the evaluation of the options and that has been organized according to the value tree approach (Keeney, 1992).

Taking into account the full range of aspects relevant to the decision problem enhances the quality of the final decision, allowing the totality of the effects of the transformation project to be considered and the negative externalities and the intergenerational effects to be minimized.

It is necessary to highlight that the criteria considered in the present application arise from the Stakeholders Analysis that has been previously described. In particular, following Gamboa and Munda (2007) and Munda (2004), the evaluation criteria are the *technical*

translation operated by the research team of the actors' objectives and needs, resulting from the institutional analysis. In this sense, the evaluation criteria of Figure 7 are the representation of the interests and concerns of the stakeholders' groups identified in Table 3.

The model considers the full range of possible impacts related to the project under investigation. More precisely, the evaluation considers the following criteria: (1) environmental aspects, that concern the effects of the transformation in terms of pollution, natural resources consumption and green areas; (2) social aspects, that refer to the multi-faceted consequences of the intervention on the population, considering services for the inhabitants, public safety and social inclusion; (3) economic aspects, that represent the possible interconnection points of the operation with the economic system, such as job creation or synergies with local activities; considering also the feasibility of the investment in terms of development cost and profitability; (4) urban planning aspects, that take into account both cultural heritage and urban landscape valorisation, as well as, accessibility and mobility elements. The aforementioned criteria have been used for the evaluation of the alternative scenarios for the transformation of the site.

In particular, in the first scenario (Figure 4) the existing masterplan of the Gaming City has been assumed as the basic alternative. This project is mostly based on research and development activities, located in high-rise tower and mid-rise linear buildings, often

Figure 4. Representation of the masterplan related to the desing scenario 1.

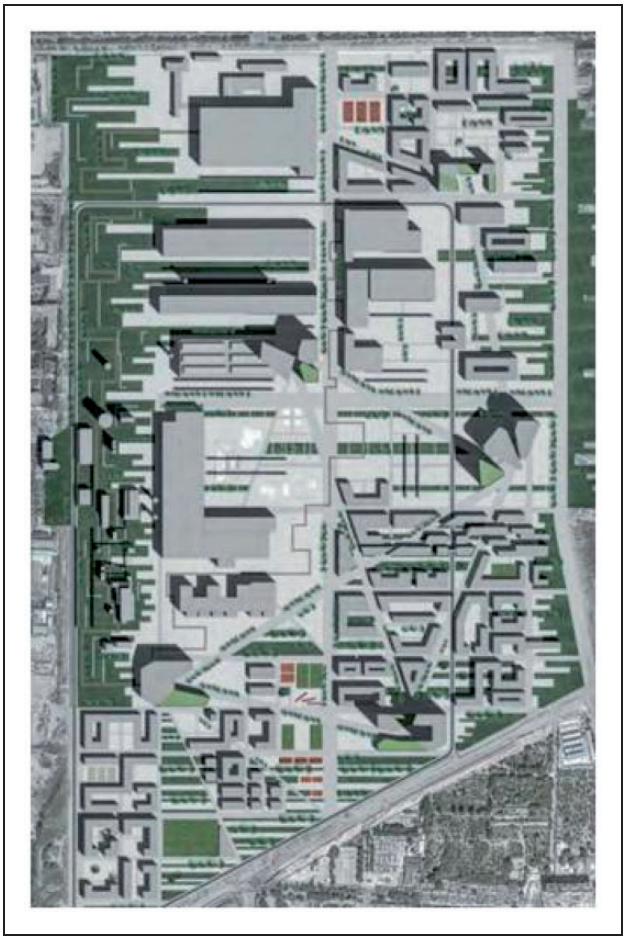

Figure 5. Representation of the masterplan related to the desing scenario 2.

grounded on horizontal slabs. The result is a homogeneous and mostly monofunctional urban fabric.

In the second proposal (Figure 5), the same functions have been maintained, but the road pattern has been radically changed, with the introduction of criss-cross local streets and pedestrian paths; the height of the building has been changed as well, although keeping an equivalent gross floor area, thanks to local variations in the density, which allow to create a more variable urban environment.

The third proposal (Figure 6), starting from the second scenario, increases the complexity, introducing new functions (different residential typologies, neighbourhood commercial activities, cultural spaces, etc.).

In order to be able to combine the attributes identified in Figure 7 and obtain an overall ranking of alternatives, the next step of the MAVT approach requires to build a value function (Beinat, 1997) for each attribute in order to translate the original performances of the alternatives on each attribute into dimensionless values usually ranging between 0 (worst performance and low objective achievement) and 1 (best performance and high objective achievement). In order to provide an example, Figure 8 shows the value

Figure 6. Representation of the masterplan related to the desing scenario 3.

function that has been built for the attribute "green areas" by interviewing specific experts in the field of urban planning.

As it is possible to see from Figure 8, green areas' extensions smaller than 20% of the whole area covered by the project are not fulfilling the objective of regenerating the site (0 value on the y axis) while green areas' extensions bigger than 50% of the whole area covered by the project are totally fulfilling the objective (value 1 on the y axis). For the intermediate percentages of green areas, the linear function signifies that the bigger the extension, the better it is.

Once the alternatives have been evaluated, it is necessary to define the importance of the different attributes of the decision problem. In this case, the Swing method has been used 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 interviewee to assign points (e.g. in the range 0–100) to states in which one attribute at a time moves to the best state. The weights are then proportional to these values.

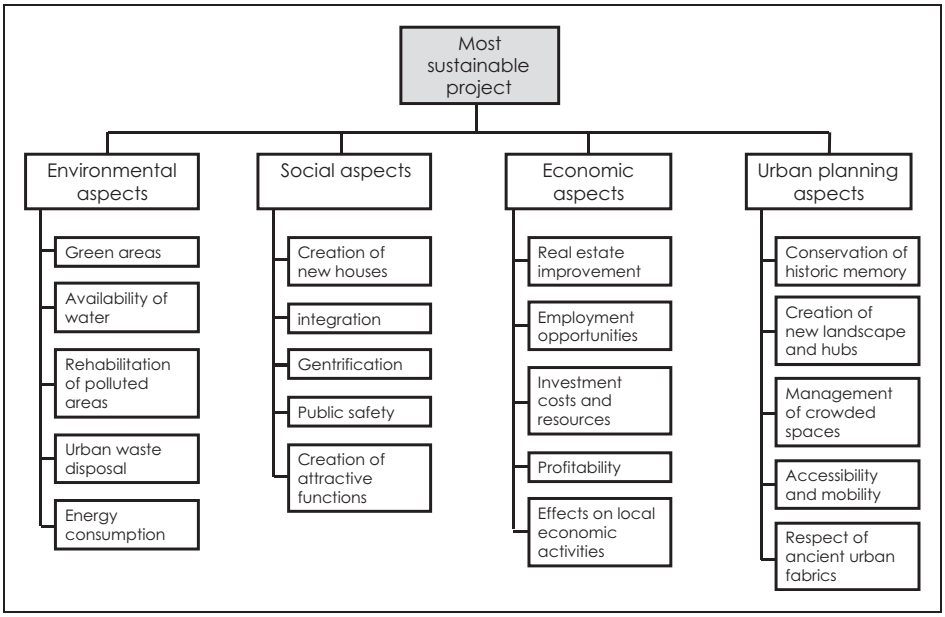

Figure 7. The value tree for the decision problem under analysis.

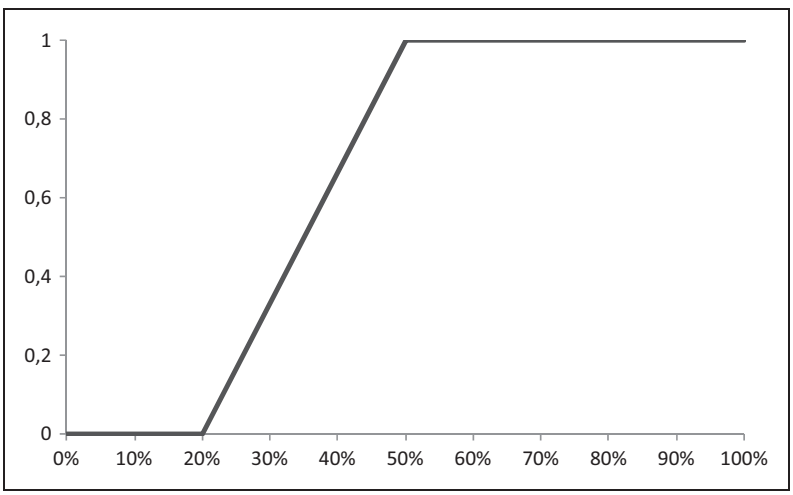

Figure 8. Value function for the attribute "green areas".

In this study, the evaluation has been performed by a multi-disciplinary panel of experts with expertise in the field of environmental engineering, sociology, urban planning and economic evaluation. In particular, the disciplinary experts were chosen in the light of their specific knowledge in the domain of Chinese architecture and urban planning. For the evaluation of the attributes, each expert had to answer a detailed questionnaire related to her/his own specific field of expertise while for the evaluation of the criteria, the questionnaire was solved by all the experts together.

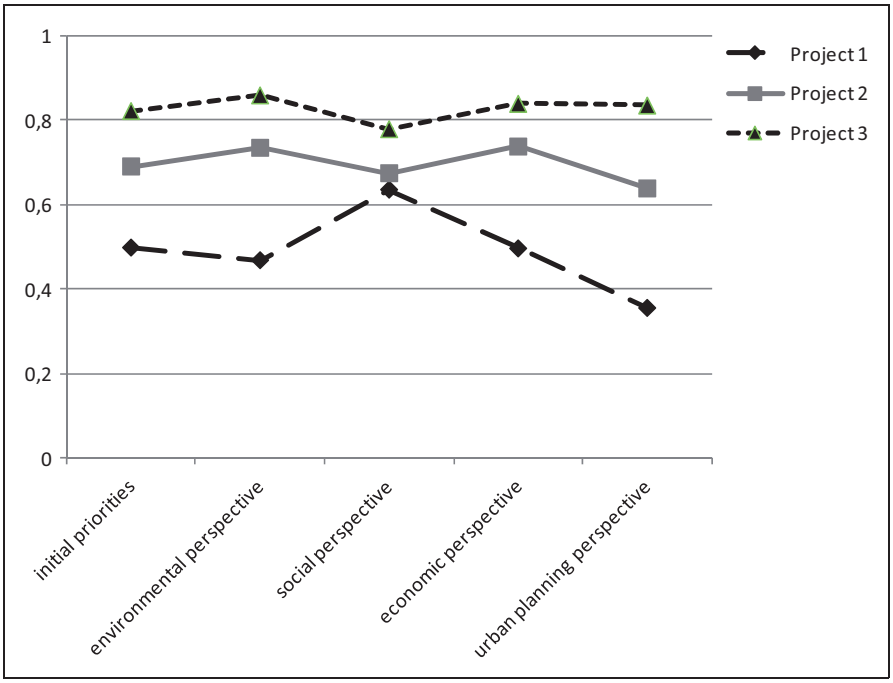

Figure 9. Sensitivity analysis results.

Table 4. Critical variables for the estimation.

Value/cost	
Costs	
Land	690 €/m^2
Cleaning up	85 €/m^2
New residential building	475 €/m^2
New offices and retail buildings	537 €/m^2
Refurbishment of industrial buildings for retail	370 €/m^2
Green areas	25 €/m^2
Streets	34 €/m^2
Incomes	
New residential buildings	2390 €/m^2
New offices and retail buildings	1890 €/m^2
Refurbishment retail	1500 €/m^2
Other costs	
On costs	2% on Total construction cost
Technical costs	8% on Total construction cost
Marketing cost	2% on Incomes
Interest	5% (Passive rate) and 2% (active rate)
Discount rate	6%

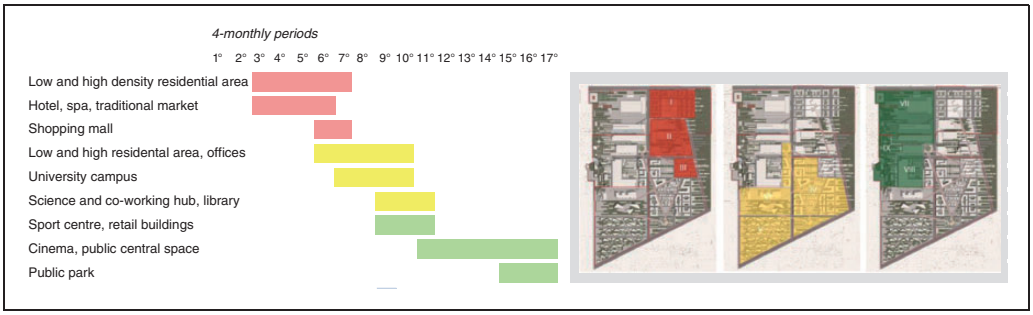

Figure 10. Time schedule for the project under investigation.

As an example, Appendix 1 shows the questionnaire that the expert in sociology had to answer with reference to the "social aspects" attributes while Appendix 2 shows the overall results of the MAVT application.

From the obtained priority list it is possible to notice that the preferred alternative is Project 3 (Figure 6), followed by Project 2 (Figure 5) and then by the Gaming City project (Figure 4). These results have been further investigated by developing a sensitivity analysis on the weights of the general criteria (Figure 9) that confirm the stability of the model.

Application of DCFA

According to the methodology described in section Discounted Cash Flow Analysis, a cash-flow analysis has been developed for the best alternative, i.e. Project 3.

Table 4 summarizes the main input for the analysis with reference to the foreseen costs and incomes.

A fundamental step of the analysis is represented by the timing of the project. In the case under investigation, the project will be developed over 5 years and 8 months that have been subdivided into 17 periods of 4 months each. Figure 10 details the time line chart for the project.

The final step of the evaluation consists in the creation of the table for the cash-flow feasibility study. Appendix 3 reports the Cash-Flow Analysis that has been developed for the evaluation of project 3. From the calculation done, it is possible to evaluate the overall economic performance of the masterplan: the final NPV of the transformation is 667 millions of Euros and the IRR is 18%; according to these indicators, the project can be considered as feasible.

Conclusions and future developments

This paper offered a creative way of combining, in the design activity, decision making support and participatory procedures through an approach that integrates stakeholders' analysis, multicriteria decision aiding and DCFA for the definition and evaluation of urban regeneration strategies in a complex territorial system.

In particular, with reference to the different combinations of methods experimented in the work (Table 1), it has been noticed that combining MAVT with actors' analysis seems to provide enhanced support in the structuring phase of the whole process, since it allows to link the actors to their system of objectives and therefore to identify the criteria needed for the analysis based on a formal study of the values at stake.

Further research could explore more complex research designs for the application of the mixed methods approach (Creswell et al., 2011). In the context under investigation, the embedded design seems to be particularly promising, as it allows to consider both qualitative and quantitative methods, that are used in tandem in order to provide new insights or more refined thinking.

The proposed methodology, in conclusion, shows a promising effectiveness in supporting complex urban transformations, where a sizeable amount of claims and constraints – coming from a wide and diversified community of actors and stakeholders – is influencing the design process. The early introduction of their values and objectives, starting from the very beginning of the design activity, and the continuous feedback between morphological choices and actors' evaluations are key points of this approach, whose aim is not to define the 'best' solution (supposing that it could exist), but instead to identify the most shared one.

The Chinese reality is an interesting testing ground and mostly a promising field of application of this methodology. First of all because, as it has been discussed, a new consciousness about the transformations of the existing city is emerging in that context, involving a huge part of the industrial estate (Leys, 1991; Zhang, 2003). Secondly, the broad transformation of a large part of the former industrial settelements grown within the Chinese urban fabrics, entails a wider problem concering the relationship with the physical dimension of history and memory, whose interpretations in eastern and western cultures are radically divergent. Thus, we do believe that the application of a multi-level decision aiding process jointly with the traditional instruments of urban design could be an interesting innovation for urban regeneration policies that face the arduous task of defining what the supposed values of the existing urban environment are and how they can be preserved and improved.

Finally, this methodology seems to fit very well with the peculiar condition of public and private interaction in the Chinese real estate market, and with the short times of the urban transformations, which nowadays show clearly the need for new flexible and comprehensive instruments, supporting the decision-making process during the design phases.

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Appendix

Appendix 1. Questionnaire for the elicitation of the Swing weights for the "social aspects" attributes.

☺	**Creation of new houses** 60%				Score 75
☹		**Integration with the context** Very low	**Possible gentrification** Low	**Public safety** low	**Creation of attractive functions** 0%

Alternative: 5

☺		**Integration with the context** high			Score 60
☹	**Creation of new houses** 0%		**Possible gentrification** Low	**Public safety** low	**Creation of attractive functions** 0%

Alternative:4

☺			**Possible gentrification** medium		Score 70
☹	**Creation of new houses** 0%	**Integration with the context** Very low		**Public safety** low	**Creation of attractive functions** 0%

Alternative: 2

☺				**Public safety** high	Score 80
☹	**Creation of new houses** 0%	**Integration with the context** Very low	**Possible gentrification** Low		**Creation of attractive functions** 0%

Alternative: 1

☺					**Creation of attractive functions** 70% Score 90
☹	**Creation of new houses** 0%	**Integration with the context** Very low	**Possible gentrification** Low	**Public safety** low	

Worst hypothetical alternative

☺					Score 0
☹	**Creation of new houses** 0%	**Integration with the context** Very low	**Possible gentrification** Low	**Public safety** low	**Creation of attractive functions** 0%

Table A2. Appendix 2. Development of the MAVT model for the overall evaluation of the alternatives.

	Attributes	Standardized scores of the alternatives			Weights of the attributes (individual evaluation of disciplinary experts)	Weights of criteria (common evaluation of the experts' panel)	Global weights of attributes (weight of the attribute × weight of criterion)	Priorities of the alternatives (standardized score × global weight)		
		Project 1	Project 2	Project 3				Project 1	Project 2	Project 3
Environmental aspects	Green areas	0	1	1	0.24	0.2	0.048	0.000	0.048	0.048
	Availability of water	0	0.4	0.6	0.13	0.2	0.026	0.000	0.010	0.016
	Rehabilitation of polluted areas	0.8	0.6	0.8	0.25	0.2	0.050	0.040	0.030	0.040
	Urban waste disposal	1	1	1	0.15	0.2	0.030	0.030	0.030	0.030
	Energy consumption	0.5	0.8	1	0.21	0.2	0.042	0.021	0.034	0.042
Social aspects	Creation of new houses	0.8	1	1	0.2	0.29	0.058	0.046	0.058	0.058
	Integration	0.5	0.6	0.8	0.16	0.29	0.046	0.023	0.028	0.037
	Gentrification	1	0.6	0.75	0.18	0.29	0.052	0.052	0.031	0.039
	Public safety	0.8	0.3	0.2	0.21	0.29	0.061	0.049	0.018	0.012
	Creation of attractive functions	0.6	0.8	1	0.24	0.29	0.070	0.042	0.056	0.070
Economic aspects	Real estate improvement	0.5	1	1	0.21	0.25	0.053	0.026	0.053	0.053
	Employment opportunities	0.4	0.6	0.8	0.19	0.25	0.048	0.019	0.029	0.038
	Investment costs and resources	1	0.6	0.8	0.2	0.25	0.050	0.050	0.030	0.040
	Profitability	0.5	0.6	0.8	0.24	0.25	0.060	0.030	0.036	0.048
	Effects on local economic activities	0	0.8	0.6	0.22	0.25	0.055	0.000	0.044	0.033
Urban planning aspects	Conservation of hystoric memory	0.6	0.8	0.8	0.2	0.26	0.052	0.031	0.042	0.042
	Creation of new landscape and hubs	0	0.5	1	0.22	0.26	0.057	0.000	0.029	0.057
	Management of crowded spaces	0.3	0.6	0.8	0.16	0.26	0.042	0.012	0.025	0.033
	Accessibility and mobility	0.3	0.6	0.8	0.2	0.26	0.052	0.016	0.031	0.042
	Respect of ancient urban fabrics	0.2	0.6	0.9	0.19	0.26	0.049	0.010	0.030	0.044
	Final priorities							**0.498**	**0.690**	**0.821**

Appendix 3. Discounted Cash Flow Analysis for the masterplan.

						4-monthly periods																
Parametric value						1°	2°	3°	4°	5°	6°	7°	8°	9°	10°	11°	12°	13°	14°	15°	16°	17°
of land		€/m²		Instantaneous costs-benefits				Beginning of the works												End of the works		
		690.0		€	%																	
COSTS																						
Land	m²	295,707		**204,037,830**	46.2%	102,018,915	102,018,915	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Land reclamation				25,135,095	5.7%	12,567,548	12,567,548	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Technical costs		8.0%		14,263,337	3.2%	7,131,669	7,131,669	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Totale				243,436,262	55.1%	121,718,131	121,718,131	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		quantity	unitary cost € /m²																			
CONSTRUCTION COSTS																						
Green and public space	m²	122,891	25	3,072,278	0.7%	0	0	0	0	0	0	0	1,024,093	1,024,093	1,024,093	0	0	0	0	0	0	0
Streets	m²	44,950	34	1,528,300	0.3%	0	0	0	0	0	0	0	509,433	509,433	509,433	0	0	0	0	0	0	0
Residential buildings	m²	266,630	475	126,649,250	28.7%	0	0	0	0	21,108,208	21,108,208	21,108,208	21,108,208	21,108,208	21,108,208	0	0	0	0	0	0	0
Underground parking	m²	34,710	290	10,065,900	2.3%	0	0	0	0	10,065,900	0	0	0	0	0	0	0	0	0	0	0	0
Offices and retail buildings	m²	69,114	535	36,975,990	8.4%	0	0	0	0	6,162,665	6,162,665	6,162,665	6,162,665	6,162,665	6,162,665	0	0	0	0	0	0	0
Total				178,291,718	40.3%	0	0	0	0	37,336,773	27,270,873	27,270,873	28,804,399	28,804,399	28,804,399	0	0	0	0	0	0	0
TOTAL CONSTRUCTION COSTS				**421,727,980**	95.4%																	
MANAGEMENT COSTS		2.0%	on costr. costs	3,565,834	0.8%	237,722	237,722	237,722	237,722	237,722	237,722	237,722	237,722	237,722	237,722	237,722	237,722	237,722	237,722	237,722	0	0
SELLING COSTS		2.0%	on sales	16,605,407	3.8%	0	0	0	0	0	87,932	87,932	107,212	107,212	107,212	2,301,130	2,301,130	2,301,130	2,301,130	2,301,130	0	0
TOTAL COSTS				441,899,221	100.0%	121,955,853	121,955,853	237,722	237,722	37,574,496	27,596,528	27,596,528	29,149,333	29,149,333	29,149,333	2,538,852	2,538,852	2,538,852	2,538,852	2,538,852	0	0
		quantity	selling price € /m²																			
BENEFITS (sales)																						
Residential buildings	m²	266,630	2,390	637,245,700	76.8%	0	0	0	0	0	0	0	0	0	0	91,035,100	91,035,100	91,035,100	91,035,100	91,035,100	91,035,100	91,035,100
Underground parking	m²	34,710	1,520	52,759,200	6.4%	0	0	0	0	0	4,396,600	4,396,600	4,396,600	4,396,600	4,396,600	4,396,600	4,396,600	4,396,600	4,396,600	4,396,600	4,396,600	4,396,600
Offices and retail buildings	m²	69,114	1,890	130,625,460	15.7%	0	0	0	0	0	0	0	0	0	0	18,660,780	18,660,780	18,660,780	18,660,780	18,660,780	18,660,780	18,660,780
Cultural functions	m²	9,640	1,000	9,640,000	1.2%	0	0	0	0	0	0	0	964,000	964,000	964,000	964,000	964,000	964,000	964,000	964,000	964,000	964,000
TOTAL BENEFITS				830,270,360	100.0%	0	0	0	0	0	4,396,600	4,396,600	5,360,600	5,360,600	5,360,600	115,056,480	115,056,480	115,056,480	115,056,480	115,056,480	115,056,480	115,056,480
ECONOMIC CASH-FLOW				388,371,139		-121,955,853	-121,955,853	-237,722	-237,722	-37,574,496	-23,199,928	-23,199,928	-23,788,733	-23,788,733	-23,788,733	112,517,628	112,517,628	112,517,628	112,517,628	112,517,628	115,056,480	115,056,480
FINANCIAL CHARGES																						
Exposure		*year*	*4-monthly period*			-121,955,853	-245,911,339	-250,181,111	-254,520,892	-296,268,603	-324,326,256	-352,843,953	-382,418,042	-412,477,038	-443,028,892	-337,775,324	-230,795,980	-122,062,566	-11,986,189	100,291,716	217,354,030	336,757,590
Negative interests		5.0%	1.6%	-59,887,747			-1,999,632	-4,032,050	-4,102,059	-4,173,215	-4,857,726	-5,317,769	-5,785,355	-6,270,263	-6,763,121	-7,264,060	-5,538,285	-3,784,213	0	0	0	0
Positive interests		2.0%	0.7%	3,671,940		0	0	0	0	0	0	0	0	0	0	0	0	0	2,441,251	239,724	2,005,834	4,347,081
ANTE-TAXES CASH-FLOW						-121,955,853	-123,955,485	-4,269,772	-4,339,781	-41,747,711	-28,057,853	-28,517,697	-29,574,089	-30,058,996	-30,551,854	105,253,568	106,979,343	108,733,415	114,958,679	117,777,604	117,062,314	119,403,581
		year	*4-monthly period*																			
Discount rate		6.00%	1.96%																			
ANTE-TAXES NPV		186,973,669																				
ANTE -TAXES IRR		18.31%	5.77%																			