International Conference on Whole Life Urban Sustainability and its Assessment
M. Bottero, G. Mondini, M. Valle (Eds)
Glasgow, 2007

The use of the Analytic Network Process for the sustainability assessment of an urban transformation project

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ABSTRACT

Environmental problems and the principles of sustainable development in projects and planning processes have become increasingly important over the last years. In this sense, the feasibility studies should involve not only the technical elements and the social-economic aspects but also the factors related to the interferences of the operation with the environmental components. This means that sustainability assessment can be considered as a complex decisions system with several elements that have to be taken into account.

Speaking about complex decisions, the multi-criteria techniques provide a useful support in the choice among several alternatives with different objectives and criteria and allow one to include in the evaluation all the factors, tangible and intangible, related to the specific problem. Particularly, the Analytic Network Process (ANP) is a multi-criteria theory of measurement used to derive relative priority scales of absolute numbers from individual judgments. The ANP offers a general framework to deal with complex decisions which provides a comparison of the different options.

The object of the work is the sustainability assessment of an urban transformation project in Italy. Through the use of the ANP, the analysis will put in evidence the most important elements for the evaluation of the process and their reciprocal influence, with particular reference to the environmental aspects.

Key words: Analytic Network Process, Multi-Criteria Analysis, Sustainability Assessment, Environmental Compatibility, Urban Transformation Project

1 INTRODUCTION

Sustainability has become a more and more interesting and complex subject whose analysis, due to the new possibilities it involves, requires a suitable “governance of knowledge”.
We are living in a transition age and the experiences that we are facing, particularly in the field of urban transformation, are characterized by evolution, diversification and instability. These elements lead to both deterministic and stochastic, both reversible and irreversible phenomena.
The environment is one of the main elements that cause the development of a certain territory. Natural components (air, water, soil, physical and natural agents) are the basic elements for the ecosystem and human life. Unfortunately, they do not have unlimited duration and they cannot be indefinitely exploited without the risk of depletion or deterioration. Thus, it is necessary to move from an economic efficiency based approach to a more wide-ranging vision, based on the concept of sustainable development. This principle, by this time quite common, presupposes the capability of going beyond sector approaches in assessment activities towards more generalized methods. Planning and programming do not depend only on economic efficiency, but they include it in a multidisciplinary perspective. Social and economic development does not depend on the possibility of reaching deterministic objectives but on the capacity of strengthening creative activities in a world where uncertainty, probability and risk are absolutely necessary conditions that create real choice opportunities (Prigogine, 1997). It is evident that this new way of operating has to take into account a great deal of variables, both qualitative and quantitative.
A very useful tool to deal with this kind of issue is given by multicriteria analyses (Nijkamp et al., 1990; Roy and Bouyssou, 1995), that mean to supply a rational basis to complex choice problems characterized by different criteria, such as the economic, social, physical, cultural criteria.
The objective of this paper is to present an application of a particular multicriteria analysis, the Analytic Network Process, for the sustainability assessment of three alternative scenarios of territorial transformation. The study case refers to a project located in the city of Nichelino in the Turin metropolitan area in Italy.

2 THE SUSTAINABILITY ASSESSMENT IN TERRITORIAL TRANSFORMATION

The concept of integrated planning has been nowadays increasingly taking into consideration environmental issues and sustainable development principles. This very new approach makes it necessary to integrate the objectives related to built environment with the policies for natural resources, paying careful attention to their interconnecting dynamics.
As far as planning process management is concerned, it is necessary to develop new specific tools to supply information on the state of the projects and plans from the point of view of their impact on the surrounding natural environment.

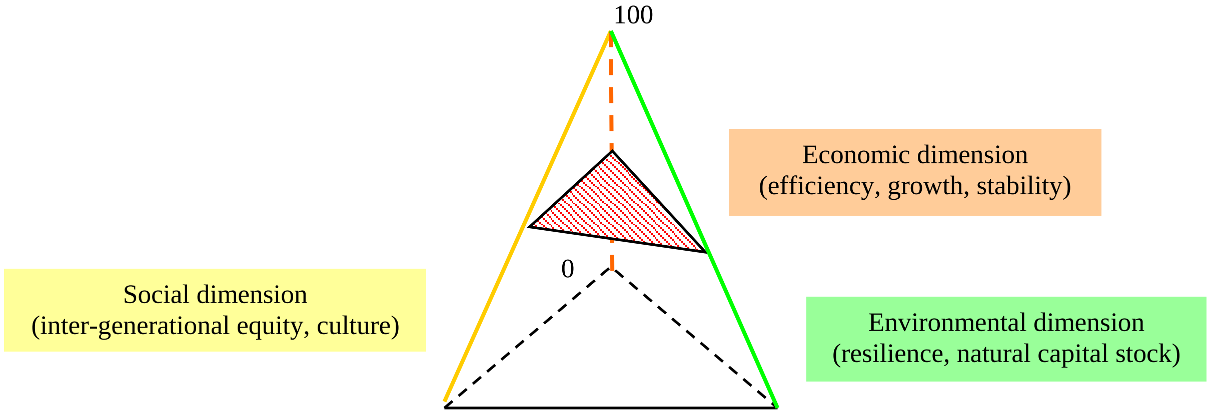

Figure 1: Sustainable development representation

Sustainable development based studies (Bruntland, 1987; Fusco Girard and Nijkamp, 1997) attempt to solve the relationships between environment, development and economic growth by superseding the specific approaches in assessment activities with more integrated methods. The concept of sustainable development, in fact, allows to consider both the quality and the efficiency of land transformations according to its three main dimensions: economic, social and environmental. A representation of the concept of sustainable development is shown in Figure 1. The pyramid in Figure 1 has a triangular base with vertices in the three main dimensions (economy, society and environment) and the apex in the ideal point of best sustainability. The percentage level of the corresponding sustainability reached can be identified along the three sides of the pyramid. Three points are determined, one for each side, by giving a score to each dimension. The connection of the points provides a triangular area that measures the sustainability that can be achieved: the smaller the area, the higher the sustainability level. Looking for a sustainable development means moving along the three pyramid sides in order to find a balance between ecosystem integrity, economic efficiency and social equity.
According to the equilibrium created among the different requirements, it is possible to talk about two levels of sustainability, weak and strong. Each of these levels can be developed in the ecological, economic and social dimension. Table 1 represents the different levels of sustainable development in accordance to its three dimensions

Table 1: Different levels of sustainability

	WEAK SUSTAINABILITY	STRONG SUSTAINABILITY
	Manufactured capital of equal value can replace natural capital.	The existing stock of natural capital must be maintained and enhanced because the functions it performs cannot be duplicated by the manufactured capital
ENVIRONMENTAL DIMENSION	The exploitation rate of non-renewable resources must not exceed the development rate of alternative renewable resources.	Non-renewable resources must be preserved. The exploitation rate of renewable resources must not exceed their development rate. The pollution rate must not reduce the carrying capacity of the environmental system.
ECONOMIC DIMENSION	Respect of the critical threshold value for any form of capital.	The different forms of capital must be conserved for all the time. The increase of economic capital is possible only if it does not affect natural and social capital.
SOCIAL DIMENSION	Social capital is taken into account.	Social capital must be conserved over the time. Cooperation, coordination and collaboration initiatives are promoted, according to bottom-up models.

A useful support in the sustainability assessment of a territorial transformation is provided by indicators and systems of indicators (OECD, 1991; Bell and Morse, 1999; Bottero and Mondini, 2003). The indicator is a measure that reflects an issue for which some information, temporarily and spatially well defined, are available. The main function of an indicator is to give targeted information. Generally speaking, an indicator expresses one or more characteristics that can be empirically observed or calculated and aims at identifying those aspects of a phenomenon that are considered to be important as for the monitoring. Therefore, it is a piece of information that refers to an intrinsic attribute or to a set of attributes pertaining to the phenomenon itself or it can be associated to another phenomenon strictly correlated to the former. Indicators are usually described with reference to their principal dimension: there exist environmental indicators (CO_2 emissions, quantity of wastes, etc.), social indicators (unemployment rate, crime level, etc.) and economic indicators (GDP, inflation rate, etc). An indicator is scarcely significant if it is not included into a system of indicators able to provide systematic information (Jesinghaus, 1998). A system of indicators is made up by various indicators -inter-correlated from a logical and functional point of view- that can describe and give information about different inter-coordinated –or thought of being such- situations. If, on the one hand, an approach based on systems of indicators is perfectly suitable for supporting the quantitative evaluation of one sustainability dimension, on the other hand, this approach is not fit (or scarcely fit) to represent, in any numerically efficient way, the interactions among the three main dimensions and their cause-effect relations, that are the fundamental basis of the sustainability model. This kind of approach does not seem to be useful either to read or evaluate, in a quantitative way, the relations and influences existing between the various elements that contribute to the sustainability (for example, the relations between polluted emissions in the atmosphere and the birth-rate or the interaction between energy efficiency and GDP). These reflections lead us to reflect on the potential development of sustainability assessment and they suggest the need for more integrated evaluation tools in order to consider and, above all, to measure the interconnections and the influences between the different sustainability dimensions. The limits of the indicators system approach can be extended to the totality of the evaluation tools for sustainability analysis. These methods, in fact, are very helpful to quantify the sustainability level for each of the dimensions, but they seem less appropriate to make explicit the causal relations that link the different aspects.

This paper aims at proposing, through the Analytic Network Process, an integrated approach for the sustainability assessment, that is suitable for providing a quantitative measure of the interconnections between the different elements that grant the sustainability of a territorial transformation.

3 THE ANALYTIC NETWORK PROCESS

3.1 Background and state of the art

Within multicriteria analyses, a very remarkable role is played by the Analytic Hierarchy Process - or AHP (Saaty, 1980; Saaty and Vargas, 1990) – and by its more generalized evolution, i.e. the Analytic Network Process – or ANP (Saaty, 2006).

Many decision-making issues cannot be structured hierarchically, because they imply interactions and dependences between the highest elements with respect to the lowest. In fact, not only does the importance of the criteria cause the importance of the alternatives, as in a hierarchy, but also the importance of the alternatives does cause the importance of the criteria.

A hierarchy has a linear structure that goes from the top to the bottom, while a network can be distributed along a number of directions, involving interactions and cycles. The ANP enables to survey and measure such inter-dependences. In fact, it extends the applications of the AHP to cases of interdependent relations between the assessment elements and generalizes the approach of the super-matrixes introduced by the AHP.

The ANP model consists of control hierarchies, clusters and elements, as well as interrelations between elements. The ANP allows interactions and counter-interactions between clusters and supplies a network structure able to connect clusters and elements in any manner in order to obtain priority scales from the distribution of the influence between elements and clusters.
The ANP requires a network structure to represent the problem, as well as pairwise comparison to establish relations within the structure. It is possible to face up to the difficulties coming out in creating the network through different modelling approaches. In fact, there are two possible structures for ANP: the BOCR (Benefits, Costs, Opportunities, Risks) approach, which allows to simplify the problem structuring by classifying issues into traditional categories of positive and negative aspects; and a free-modelling approach, which is not supported by any guide or pre-determined structure. The first approach is often inadequate because it forces the analysts to reason in term of traditional characteristics of cost, benefit, opportunity and risk, while the second one is often difficult to be applied in complex decision making problems. The analytical tools provided from ANP are very useful for supporting the decision making process; nevertheless, it is always very important to feed a great deal of information or a lot of experts to the model in order to come to a better solution.
Comprehensive collection of literature involving AHP could be found in http://www.expertchoice.com. Particularly, in the field on sustainability assessment there are many works involving AHP and phisycal and environmental planning (Fusco Girard and Nijkamp, 2005; Roscelli, 2005), built environment (Brandon and Lombardi, 2005) , regional development (Nijkamp and Vreeker, 2000). From the point of view of the ANP, the literature is quite recent and some publications are found in strategic policy planning (Ulutas, 2005), market and logistic (Agarwal et al., 2006), economics and finances (Niemura and Saaty, 2004), civil engineering (Piantanakulchai, 2005; Neaupane and Piantanakulchai, 2006), while the research activity on the themes of environmental evaluation still less rich.

3.2 Methodology

The model can be divided into four main stages, described below:

Step I: Development of the structure of the decision-making process.
First of all, the structure of the decision-making issue must be defined through the recognition of its main objective. Such objective must be later divided into groups (“clusters”), constituted by various elements (“nodes”), and alternatives or options where to chose.
Secondly, the relationships between the different parts of the network must be identified. Each element can be a “source”, that is an origin of path influence, or a “sink”, that is a destination of paths influences. Figure 2 gives a schematic representation of a network structure with influence and inter-dependence relations.

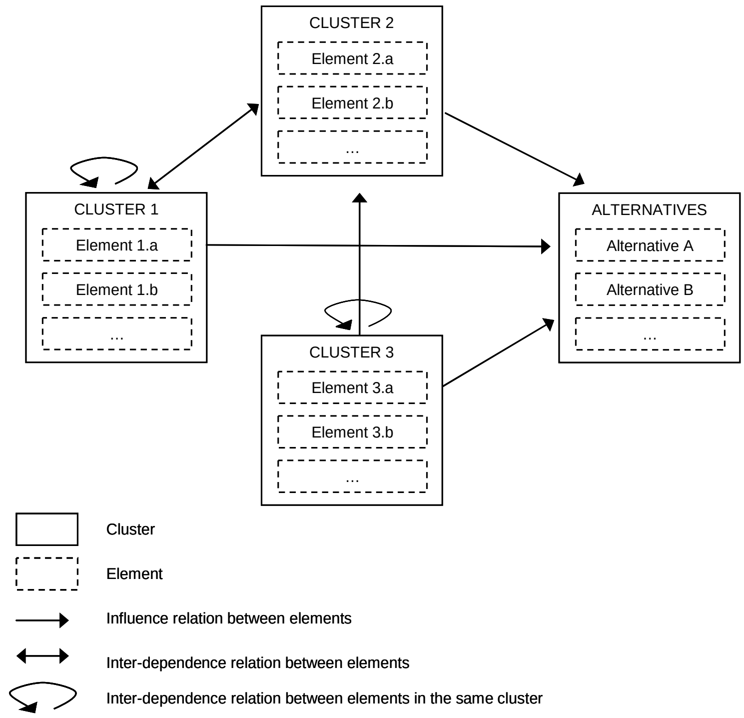

Figure 2: Example of network structure with clusters and elements

Step II: Pairwise comparison.

In this step, a series of pairwise comparisons are made to establish the relative importance of the different elements with respect to a certain component of the network. In the case of interdependencies, components with the same level are viewed as controlling components for each other. In pairwise comparisons, a ratio scale of 1-9 is used to compare any two elements (Table 2).

Table 2 Fundamental scale of Saaty

Value	Definition	Explanation
1	Equally important	Two decision elements equally influence the parent decision element.
3	Moderately more important	One decision element is moderately more influential than the other.
5	Much more important	One decision element has more influence than the other.
7	Very much more important	One decision element has significantly more influence over the other.
9	Extremely more important	The difference between influences of the two decision elements is extremely significant.
2, 4, 6, 8	Intermediate judgment values	Judgment values between equally, moderately, much, very much and extremely.

The numerical judgments established at each level of the network make up pair matrixes. Through pairwise comparisons between the applicable elements, the weighted priority vector is calculated. This vector corresponds to the main eigenvector of the comparison matrix (Saaty, 1986)

Step III: Supermatrix formation.
The supermatrix elements allow for a resolution of interdependencies that exist among the elements of the system. It is a portioned matrix where each sub-matrix is composed of a set of relationships between and within the levels as represented by the decision maker's model (Step I). The general form of the supermatrix is described in Figure 3 where C_N denotes the Nth cluster, e_{Nn} denotes the nth element in the Nth cluster, and W_{ij} is a block matrix consisting of priority weight vectors (w) of the influence of the elements in the ith cluster with respect to the jth cluster. If the ith cluster has no influence to the ith cluster itself (a case of inner dependence), W_{ij} becomes zero. The supermatrix obtained in this step is called the initial supermatrix.

<table>
<tr><td colspan="2" rowspan="2"></td><td colspan="4">C_1</td><td colspan="4">C_2</td><td rowspan="2">….</td><td colspan="4">C_N</td></tr>
<tr><td>e_{11}</td><td>e_{12}</td><td>…</td><td>e_{1n1}</td><td>e_{21}</td><td>e_{22}</td><td>…</td><td>e_{2n2}</td><td>e_{N1}</td><td>e_{N2}</td><td>…</td><td>e_{NnN}</td></tr>
<tr><td rowspan="4">C_1</td><td>e_{11}</td><td colspan="4" rowspan="4">W_{11}</td><td colspan="4" rowspan="4">W_{12}</td><td rowspan="4">…</td><td colspan="4" rowspan="4">W_{1N}</td></tr>
<tr><td>e_{12}</td></tr>
<tr><td>…</td></tr>
<tr><td>e_{1n1}</td></tr>
<tr><td rowspan="4">C_2</td><td>e_{21}</td><td colspan="4" rowspan="4">W_{21}</td><td colspan="4" rowspan="4">W_{22}</td><td rowspan="4">…</td><td colspan="4" rowspan="4">W_{2N}</td></tr>
<tr><td>e_{22}</td></tr>
<tr><td></td></tr>
<tr><td>e_{2n2}</td></tr>
<tr><td></td><td></td><td colspan="4">…</td><td colspan="4">…</td><td>…</td><td colspan="4">…</td></tr>
<tr><td rowspan="4">C_N</td><td>e_{N1}</td><td colspan="4" rowspan="4">W_{N1}</td><td colspan="4" rowspan="4">W_{N2}</td><td rowspan="4">…</td><td colspan="4" rowspan="4">W_{NN}</td></tr>
<tr><td>e_{N2}</td></tr>
<tr><td></td></tr>
<tr><td>e_{NnN}</td></tr>
</table>

Figure 3: General structure of supermatrix

The eigenvector obtained from cluster level comparison with respect to the control criterion is applied to the initial supermatrix as cluster weight. This results is the weighted matrix.

Step IV: Final priorities.
In the final step, the weighted supermatrix is made to converge to obtain a long-term stable set of weights. The supermatrix is raised to limiting power such in equation (1) to get the global priority vector:

$$\lim_{k\to\infty} W^k \tag{1}$$

4 APPLICATION OF THE ANP TO THE STUDY CASE

4.1 Description of the project

The study refers to an urban-margin area located in the city of Nichelino, in the metropolitan area of Turin (Italy). At present this zone, that covers a total surface of 250.000 m^2, is a sowable land (Figure 4), partially subjected to landscape bond because of the historical Stupinigi Hunting Lodge and its Park (Millon, 1999). The area shows many deterioration signs (streams, power lines, etc.) that ask for a global reorganization and upgrading. Another remarkable element is represented by the infrastructure system, with particular reference to the motorway in the southern part of the parcel (Figure 5).

Figure 4: The study case area

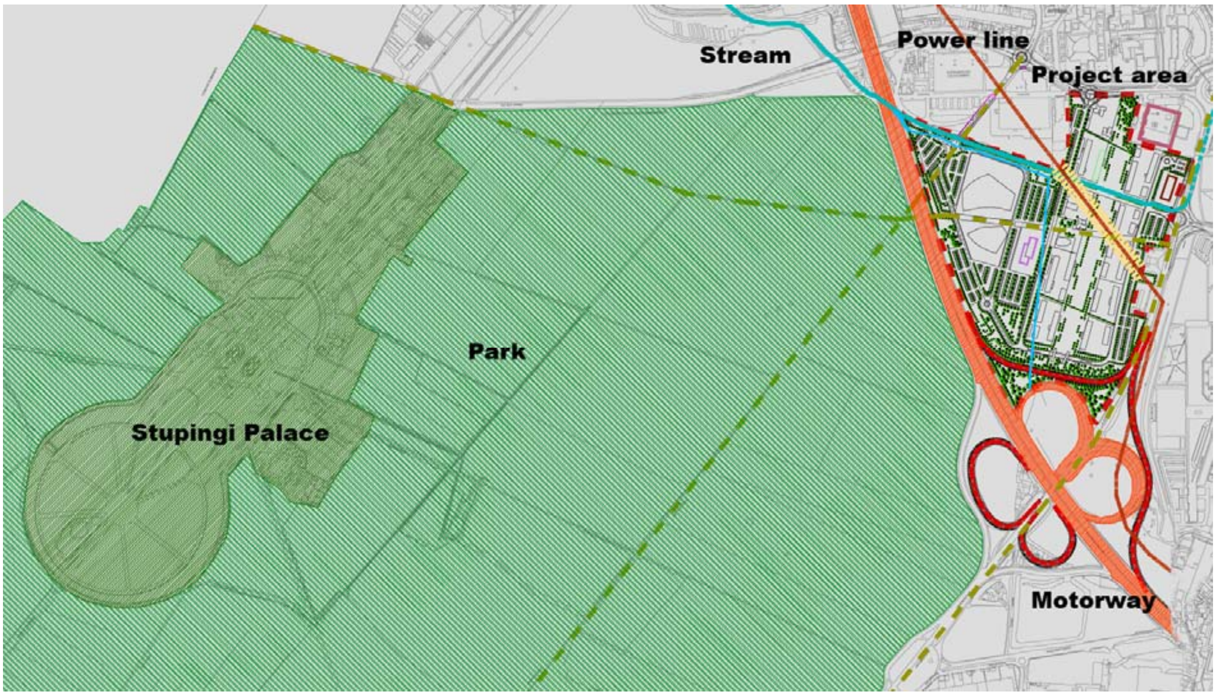

Figure 5: Representation of the main territorial elements of the study case area

With reference to the study case, three options have been considered, that correspond to three different phases of the planning and decision making process: the first step corresponds to the area with its consolidated functions (option 0), the second step corresponds to the initial project that has been improved through the participation of the main actors involved in the operation in order to arrive to the final project.
Particularly, three are the transformation scenarios considered for this area:

- Zero option: this option represents the situation without any project and this state has always to be taken into account in territorial transformation assessments. The area is an agricultural land and it assumes a particular environmental value in a built-up zone with several critical elements;
- Initial project: it is the first proposal for transforming the area and it identifies a number of projects targeted basically at improving the recognisability of the city of Nichelino in the Torino metropolitan area. This project, developed by the architect Massimiliano Fuksas, moves from considering the ancient role of dormitory town played by Nichelino in the 60's and 70's and tries to give it new functional values;
- Final project: it represents the final proposal for the area. This project, edited by Fuksas as the initial one, goes into the fundamental criteria of the plan in

order to achieve higher levels of environmental sustainability and to minimize landscape impacts.

The project develops along three directions that foresee the realization of new residences, a multi-function installation and a shopping centre. Table 3 highlights the main differences between the initial and the final project, with reference to the three above mentioned components.
The main difference between the initial and the final project is the pursuit of compatibility between the environmental ecosystem and the human system, in order to harmonize and valorise the former through the correct management of the latter. The objective of this work is to understand if and how much the activated decision making process has led to a really environmental, social and economic sustainable project.

Table 3: Main differences between initial and final project

	Initial project	**Final project (differences)**
RESIDENCES	From 4 to 6 floors houses for a total floor space of 75.000 m^2, the buildings are lined up along the main boulevard and they leave a green pedestrian space in the internal part. The facing of the walls is of clear stone. The project includes four 60 m high 19 floors towers. Parking is underground.	• One tower is eliminated; • The houses are slightly moved in order to respect the historical courses and the visual cones; • The power line is underground; • A tri-generation power plant is inserted in the parcel.
MULTI-IFUNCTION INSTALLATION	The building has a floor space of 10.000 m^2 and its shape is a conic ellipsoid that is open in the higher part. The centre includes areas for services (offices, bars and restaurants) and spaces for fitness, sauna. The 3000 m^2 parking is underground.	• The floor space is decreased (8.200 m^2); • The surface water system is reorganized; • A new school is included in the plan.
SHOPPING CENTER	The centre has a floor space of 20.000 m^2 and it is structured on two levels with a central distribution on which circular shapes are aggregated. The parking is in part underground (6.500 m^2) and in part on the roof of the building (6.500 m^2).	• The floor surface is decreased (15.000 m^2); • The surface water system is reorganized.

4.2 Structure of ANP model

The real study case derives from a decisional process in which three alternatives have been considered; in the ANP model the three alternatives are organized in an autonomous cluster.
The criteria taken into account come out from the intrinsic characteristics of the area that, in a very strong relation with the Stupinigi Palace, is part of a complex system that sums environmental, cultural and productive aspects. There are three relevant objectives for the future quality for the area:

- Environmental sustainability: according to a cycles closure approach, a thorough analysis of the ecological problem grants the minimization of the impacts of the projects and a very high attention to fundamental themes, such as efficiency, resources optimization, well-being. With reference to this objective, the factors taken into account are air, water, energy and material cycles, declined according to the elements that characterize a big territorial transformation;
- Correct relation with the landscape: in the creation of new urban landscapes, the historical values have to maintain an equilibrium between beauty and utility, to respect to the traditions and the so-called “genius loci”, without forgetting the innovation in the social and environmental sustainable sense;
- Socio-economic sustainability: the feasibility of a project is linked non only to its impacts on natural components, but also to the improvement of the quality of life for future inhabitants, above all in an urban margin area.

These three sustainability objectives determine three clusters strongly interconnected with both inner and outer dependences. All the elements in the clusters are connected to the alternatives.
The cluster and the elements considered in this application are described in Table 4.

Table 4: Clusters and elements considered in the ANP model

CLUSTER		ELEMENTS
Transformation alternatives	A	Zero option
	B	Initial project
	C	Final project
1. Environmental sustainability	1.a	Soil permeability
	1.b	Water system efficiency
	1.c	Acoustic climate
	1.d	Correct waste management
	1.e	Energy efficiency
	1.f	Air quality
2. Correct relation with landscape	2.a	Correct relation with Stupinigi Palace
	2.b	Respect of visual cones and historical courses
	2.c	Correct introduction in the skyline of the hill
3. Socio-economic sustainability	3.a	Landmark
	3.b	Urban margin completion
	3.c	New services for the inhabitants
	3.d	Creation of new jobs
	3.e	Solution of critical relations with the current state

Figure 6 represents the network for the evaluation of the study case while Figure 7 identifies the related supermatrix.

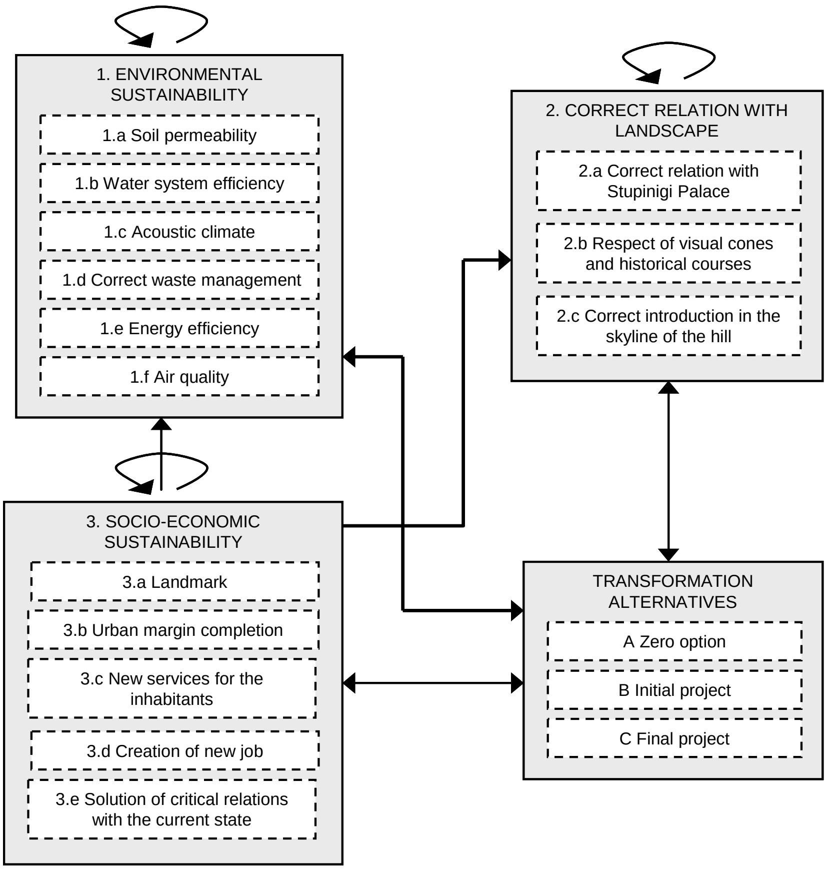

Figure 6: ANP structure for the study case

<table>
<tr><th colspan="2" rowspan="2"></th><th colspan="3">Transformation alternatives</th><th colspan="6">1. Environmental sustainability</th><th colspan="3">2. Correct relation with landscape</th><th colspan="5">3. Socio-economic sustainability</th></tr>
<tr><th>A</th><th>B</th><th>C</th><th>1.a</th><th>1.b</th><th>1.c</th><th>1.d</th><th>1.e</th><th>1.f</th><th>2.a</th><th>2.b</th><th>2.c</th><th>3.a</th><th>3.b</th><th>3.c</th><th>3.d</th><th>4.e</th></tr>
<tr><td rowspan="3">Transformation alternatives</td><td>A</td><td colspan="3" rowspan="3">0</td><td colspan="6" rowspan="3">W_{12}</td><td colspan="3" rowspan="3">W_{13}</td><td colspan="5" rowspan="3">W_{14}</td></tr>
<tr><td>B</td></tr>
<tr><td>C</td></tr>
<tr><td rowspan="6">1. Environmental sustainability</td><td>1.a</td><td colspan="3" rowspan="6">W_{21}</td><td colspan="6" rowspan="6">W_{22}</td><td colspan="3" rowspan="6">0</td><td colspan="5" rowspan="6">W_{24}</td></tr>
<tr><td>1.b</td></tr>
<tr><td>1.c</td></tr>
<tr><td>1.d</td></tr>
<tr><td>1.e</td></tr>
<tr><td>1.f</td></tr>
<tr><td rowspan="3">2. Correct relation with landscape</td><td>2.a</td><td colspan="3" rowspan="3">W_{31}</td><td colspan="6" rowspan="3">0</td><td colspan="3" rowspan="3">W_{33}</td><td colspan="5" rowspan="3">W_{34}</td></tr>
<tr><td>2.b</td></tr>
<tr><td>2.c</td></tr>
<tr><td rowspan="5">3. Socio-economic sustainability</td><td>3.a</td><td colspan="3" rowspan="5">W_{41}</td><td colspan="6" rowspan="5">0</td><td colspan="3" rowspan="5">0</td><td colspan="5" rowspan="5">W_{44}</td></tr>
<tr><td>3.b</td></tr>
<tr><td>3.c</td></tr>
<tr><td>3.d</td></tr>
<tr><td>3.e</td></tr>
</table>

Figure 7: Schematic representation of the supermatrix for the study case

4.3 Development of the ANP model

4.3.1 Clusters comparison

The first operational step in the model development consists in the comparison among the clusters. At this level, there are four 4 x 4 matrixes containing the judgements made in pairwise comparisons established from time to time. According to the influence and interdependence relations decided for the elements of the network, these matrixes contain numerical values or zero values.
For cluster comparisons, as well as for elements comparison, the relative weights in the pairwise comparison matrixes of ANP have been obtained through discussion with groups of experts of sustainability assessment.
Table 5 and 6 represent, for example, the comparison among the four considered clusters from the point of view, respectively, of socio-economic and environmental sustainability. The pairwise comparison matrixes at this level allow to evaluate the relationships existing between the different sustainability aspects and the transformation scenarios. For example, it is possible to ask: “From the point of view of the achievement of the social-economic objectives, is it more important to respect the relation with the landscape or to pursue environmental sustainability objectives?”. In this case, we decided to give more importance to environmental sustainability (score 5) and this judgment is visible in the second entry of the third column in Table 5 (intersection between relation with environmental sustainability and landscape). Alternatively, it is possible to ask: “From the point of view of the achievement of the environmental sustainability objectives, how important is the presence of alternative territorial transformation scenarios?”. In this case, the environmental sustainability has been given higher importance: the score 3 is inserted as second entry in the first column of Table 6 (intersection between environmental sustainability and alternatives).

Table 5: Pairwise clusters comparison matrix with respect to the socio-economic sustainability

Socio-economic sustainability	Alternatives	Environmental sustainability	Correct relationship with landscape	Socio-economic sustainability	Priority vector
Alternatives	1	5	7	7	0.63
Environmental sustainability	1/5	1	5	1/3	0.11
Correct relationship with landscape	1/7	1/5	1	1/3	0.05
Socio-economic sustainability	17/	3	3	1	0.21

Table 6: Pairwise clusters comparison matrix with respect to the environmental sustainability

Environmental sustainability	Alternatives	Environmental sustainability	Correct relationship with landscape	Socio-economic sustainability	Priority vector
Alternatives	1	1/3	0	0	0.75
Environmental sustainability	3	1	0	0	0.25
Correct relationship with landscape	0	0	0	0	0
Socio-economic sustainability	0	0	0	0	0

The final priority vectors that result from the four clusters comparison matrixes determine the columns of the matrix containing the cluster weights. (Table 7)

Table 7: Cluster matrix

	Alternatives	Environmental sustainability	Correct relationship with landscape	Socio-economic sustainability
Alternatives	0	0.75	0.83	0.63
Environmental sustainability	0.21	0.25	0	0.11
Correct relationship with landscape	0.11	0.00	0.17	0.05
Socio-economic sustainability	0.68	0.00	0	0.21

4.3.2 Elements comparison

Once that the clusters comparison is over, it is necessary to study in depth the problem through the analysis of the model's elements (or nodes). Also in this case, the judgments attribution is made by means of the compilation of the pairwise comparison matrixes that are made according to the influence and interdependence relations set in the network. Table 8 and 9 give some examples of comparison matrixes created at this level. Table 8 represents the standard comparison among the three alternatives with reference to one element of the network, while Table 9 gives an example of the so-called feedback of the ANP model, that allows to evaluate the influence of different elements on the considered alternatives.

Table 8: Pairwise alternatives comparison matrix with reference to "soil permeability"

Soil permeability	Zero option	Initial project	Final project	Priority vector
Zero option	1	7	5	0.70
Initial project	1/7	1	1/3	0.06
Final project	1/5	3	1	0.24

Table 9: Pairwise comparison matrix among the elements of "social-economic sustainability" cluster with respect to "initial project"

Initial project	Landmark	Urban margin completion	New services for the inhabitants	Creation of new jobs	Solution of critical relations with current state	Priority vector
Landmark	1	0	3	0	0	0.83
Urban margin completion	0	0	0	0	0	0
New services for the inhabitants	1/3	0	1	0	0	0.17
Creation of new jobs	0	0	0	0	0	0
Solution of critical relations with current state	0	0	0	0	0	0

4.3.3 Supermatrix formation and final priorities

Once that all the pairwise comparison matrixes have been compiled, the totality of the related priority vectors forms the unweighted supermatrix (Table 10). As described in Paragraph 3, the unweighted supermatrix has to be multiplied for the cluster matrix (Table 7) in order to obtain the weighted supermatrix (Table 11). In the end, the columns of limiting matrix provide the final priorities (Table 12).

Table 10: Unweighted supermatrix

		Alternatives			1. Environmental sustainability						2. Relation with landscape			3. Socio-economci sustaianbility				
		A	B	C	1.a	1.b	1.c	1.d	1.e	1.f	2.a	2.b	2.c	3.a	3.b	3.c	3.d	3.e
Alternatives	A	0.00	0.00	0.00	0.70	0.09	0.52	0.32	0.10	0.33	0.64	0.64	0.61	0.10	0.67	0.05	0.09	0.07
	B	0.00	0.00	0.00	0.06	0.17	0.14	0.22	0.26	0.26	0.10	0.10	0.09	0.67	0.47	0.47	0.45	0.28
	C	0.00	0.00	0.00	0.24	0.74	0.33	0.46	0.64	0.41	0.26	0.26	0.27	0.23	0.47	0.47	0.45	0.65
1. Environmental sustainability	1.a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.17	0.00	0.00
	1.b	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1.c	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1.d	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.83	0.00	0.00
	1.e	0.00	1.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1.f	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2. Relation w.landscape	2.a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.75	0.00	0.00	0.00	0.00
	2.b	0.00	0.75	0.17	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00
	2.c	0.00	0.25	0.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3. Socio-economic sustainability	3.a	0.50	0.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3.b	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00
	3.c	0.50	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3.d	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
	3.e	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 11: Weighted supermatrix

		Alternatives			1. Environmental sustainability						2. Relation with landscape			3. Socio-economci sustaianbility				
		A	B	C	1.a	1.b	1.c	1.d	1.e	1.f	2.a	2.b	2.c	3.a	3.b	3.c	3.d	3.e
Alternatives	A	0.00	0.00	0.00	0.53	0.09	0.53	0.24	0.10	0.33	0.53	0.64	0.62	0.06	0.07	0.03	0.09	0.07
	B	0.00	0.00	0.00	0.04	0.17	0.14	0.1	0.26	0.26	0.09	0.11	0.09	0.43	0.47	0.31	0.45	0.28
	C	0.00	0.00	0.00	0.18	0.74	0.33	0.34	0.64	0.41	0.22	0.26	0.30	0.14	0.47	0.31	0.45	0.65
1. Environmental sustainability	1.a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.20	0.00	0.00
	1.b	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1.c	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1.d	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1.e	0.00	0.21	0.66	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	1.f	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2. Relation w.landscape	2.a	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00
	2.b	0.00	0.08	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.00	0.01	0.00	0.00	0.00	0.00
	2.c	0.00	0.03	0.28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3. Socio-economic sustainability	3.a	0.50	0.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3.b	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.00	0.00	0.00	0.00
	3.c	0.50	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3.d	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.22	0.00	0.00
	3.e	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 12: Final vector with global priority deriving from limiting matrix

		Priority vector
A	Zero option	0.10
B	Initial project	0.15
C	Final project	0.20
1.a	Soil permeability	0.02
1.b	Water system efficiency	0.00
1.c	Acoustic climate	0.00
1.d	Correct waste management	0.01
1.e	Energy efficiency	0.17
1.f	Air quality	0.00
2.a	Correct relation with Stupinigi Palace	0.01
2.b	Respect of visual cones and historical courses	0.03
2.c	Correct introduction in the skyline of the hill	0.06
3.a	Landmark	0.14
4.b	Urban margin completion	0.03
3.c	New services for the inhabitants	0.07
3.d	Creation of new jobs	0.01
3.e	Solution of critical relations with the current state	0.00

4.4 Final results

The priority list for the alternatives (Figure 8) gives a great deal of importance to the final project with respect to the other possibilities. It is important to underline that this result corresponds to the final choice made by the Municipal Authority in the real decision making process. Furthermore, it is interesting to point out that the initial project is in the middle of the priority list: this means that the discussion work made in the process led to useful improvements.

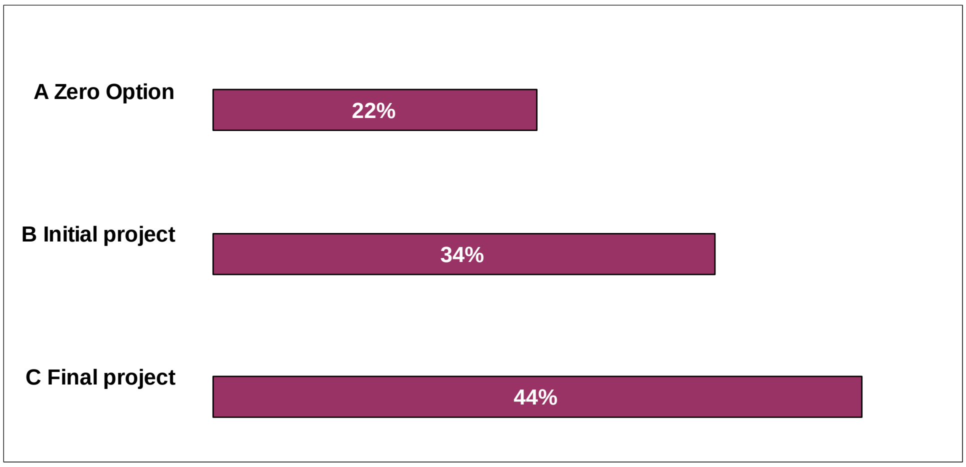

Figure 8: Synthesized priorities for the alternatives

These marks are shown also in Figure 9, representing the final priorities obtained.
The results are in line with the transformation strategies of the Municipal Authority which are reflected in the high priorities give to the followings:

- “Energy efficiency”, that represents one of the main goals of the City in the field of environmental planning;
- “Landmark”, that is a is a very important element for a new territorial image for Nichelino;
- “New services for the inhabitants”, that is a fundamental factor for improving the quality of life of the population.

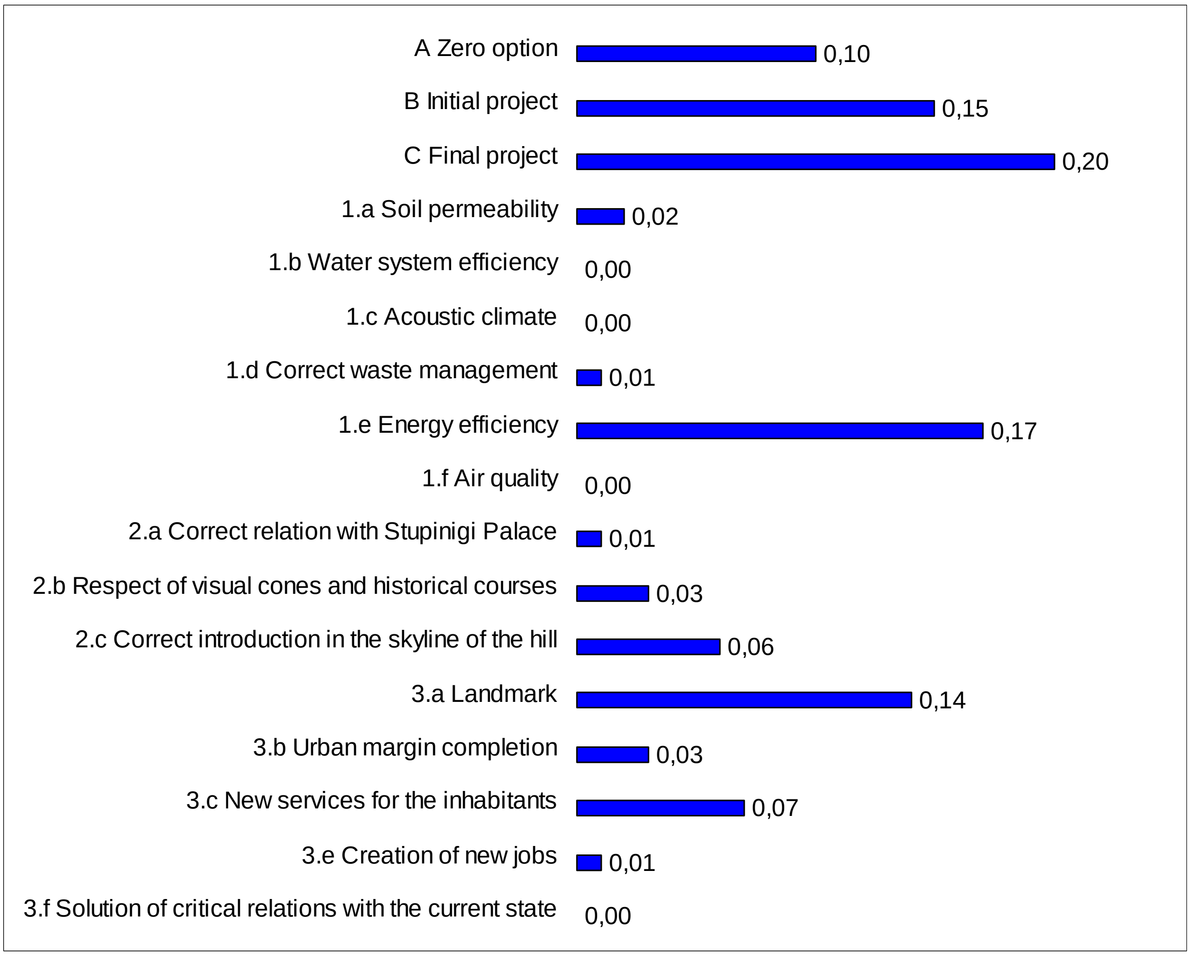

Figure 9: Final priorities

5 CONCLUSIONS

In the work the application of a multicriteria technique, the Analytic Network Process (ANP), has been discussed with reference to the sustainability evaluation of territorial transformation scenarios.

The multiplicity of the aspects involved and the presence of several stakeholders in the decision making process suggested the application of a procedure suitable for dealing, in a transparent way, with the complexity of the problem.

From the point of view of the results of the project, it has been observed that the approach that has been used in the decision making process contributed in putting in evidence the most relevant criteria for the sustainability of the project.

Form the methodological point of view, the ANP is a suitable tool for the analysis and the evaluation of complex systems, because it allows to clarify the relations among the various components of the problem. Nevertheless, it is necessary to point out that some simplifications have been performed in order to make the network structure more readable.

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