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Parole chiave: *Piano Urbanistico Comunale, Piano Urbanistico Operativo, Analisi Decisionale Multicriterio, PROMETHEE, GAIA*

Keywords: *Municipal Urban Plan, Operation Urban Plan, Multi-Criteria Decision Aid, PROMETHEE, GAIA*

JEL: R140, Q51

Evaluation in Urban Planning: a multi-criteria approach for the choice of alternative Operational Plans in Cava De' Tirreni

The aim of the paper is to provide support to an evaluation in urban planning, creating a useful approach for the choice of future alternative Operational Plans in Cava De' Tirreni (Salerno). They represent planning tools that are usually formed after public announcements to select the interventions to be implemented in the areas of transformation identified by the general Municipal Urban Plan. A suitable system of territorial indicators to verify the achievement of such goals is also taken into account. With reference to three different urban areas, the evaluation has been carried out by Multi-Criteria Decision Aid (MCDA), using the PROMETHEE (Preference Ranking Organisation-al Method for Enrichment Evaluation) multi-criteria method and GAIA (Graphical Analysis for Interactive Aid) tool.

1. Introduction

Evaluation can be defined as a set of activities oriented to the appropriate organisation of the information necessary to make a choice, so that each actor involved in the decision-making process is able to take a balanced decision (Nijkamp et al., 1990). In this perspective, a Multi-Criteria Decision Aid (MCDA) approach represents a useful and effective instrument to understand the structure of the decision-making problem and the multiple and different dimensions that characterise it. Thus, it is possible to face conflicts that do not have unique solutions, but are characterised by variety and uncertainty (Fusco Girard et al., 2014), activating a process of dialogue and communication not only between technicians but between all those involved directly or indirectly by the plan choices. Therefore, MCDA can facilitate the decision-making process because it is frequently necessary to face situations in which several solutions are available, but different conflicting criteria must be considered (Mendas & Delali 2012).

In many studies, an integration between MCDA and Geographic Information System (GIS) has been proposed, where geo-referenced data is used (Vizzari 2011), developing a platform for the analysis, structuring and resolution of problems related to environmental and territorial management (Geneletti, 2000). Decision-makers can indeed be facilitated by the use of "spatial" tools to locate the boundary lines and the identification of current and potential land uses (Brabyn 2005) combining support to public decision-makers with territorial analysis (Roc-

chi et al., 2014; Massei et al., 2014). Spatial multi-criteria analyses refer to applications in which the elements of the problem have a clear and strong spatial dimension. The evaluation criteria in this case are associated with geographical entities and can be represented by maps (Malczewski 1999), implementing a so-called Multi-Criteria Spatial Decision Support System (MC-SDSS). This kind of association between MCDA and GIS has been especially developed in recent years, also with the aim of supporting urban planning.

The first attempt to integrate MCDA and GIS dates back to 1991 (Lidouh et al., 2011) but there are more recent cases of spatial integration of these two instruments, in relation to different fields of application, when it is necessary to use a certain amount of spatial information: this reflects the flexibility of application of this approach. The survey of literature highlights the heterogeneity of the areas where the MC-SDSS is applied, such as “land suitability analysis in the urban/regional planning, hydrology and water management and environment/ecology fields” (Ferretti 2012: 153). For example, Sharifi et al. (2009) use the AHP Multi-Criteria Method integrated with GIS for the selection of hazardous waste landfill in a typically underdeveloped region. Furthermore, Atici et al. (2015) use a GIS-based MCDA approach for wind power plant site selection, proposing a structural procedure for defining the most suitable sites with the use of the ELECTRE method. Tammi & Kalliola (2014) implement a spatial decision-making process in marine and coastal spatial planning; Iyalomhe et al. (2015) conduct a regional risk assessment for climate change impacts on coastal aquifers, integrating heterogeneous spatial data in a GIS; Latinopolous & Kechagia (2015) propose a GIS-based multi-criteria evaluation for wind-farm development projects site selection.

In addition to the above examples, there are many other cases in which the decision-making process has a clear spatial dimension (Zhang et al. 2013; Rikalovic et al., 2014; Coutinho-Rodrigues et al., 2011; Ferretti & Pomarico 2013; Sánchez-Lozano et al., 2014), attempting to realise a real integration between MCDA and GIS (Malczewski, 2006). This type of integration has proved to be very useful in the field of urban planning, considering the constant spatial connotation that characterises land use choices (Cerreta & De Toro 2012; Fusco Girard et al., 2012). Indeed, the planning activity, understood as a process of selection and distribution of resources aimed at achieving goals and planning for the future, is a specific typology of decision-making (Ferretti 2012). Furthermore, “land-use planning can be conceived as the process of dealing with conflicts among different land-use types through resolving the conflicts among stakeholders” with the aim of promoting sustainable development and “the economic, social and environmental processes involved in land-use planning are inherently spatial” (Zhang & Fung 2012: 2265).

It is also possible to identify three different levels of integration (Rocchi et al., 2014) between MCDA and GIS:

- the first is that of “indirect integration”, in which the two instruments share neither the same database nor the same interface and therefore they need an intermediate tool of connection;

- the second level is that of the so-called “Built-in MCDA-GIS”, in which the multi-criteria models are inserted in the geographic system as integrated components, while remaining independent from the logic and functional point of view;
- the third level is that of the “complete integration”, characterised by the use of a single interface and a single database.

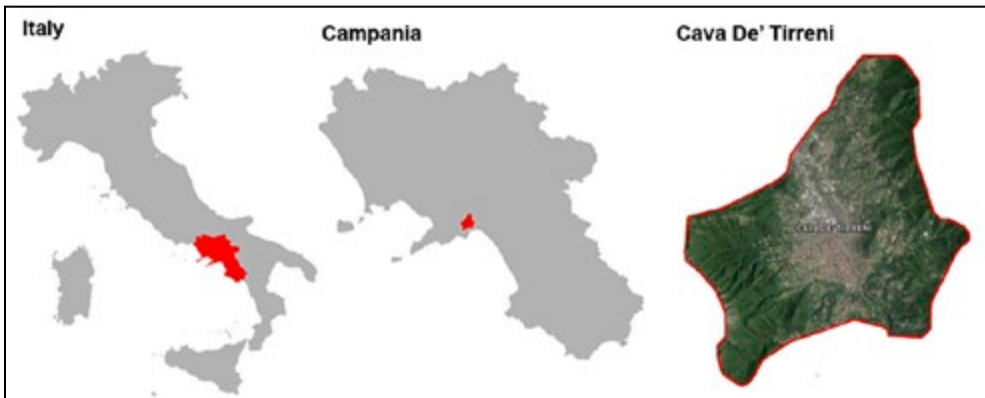
In the present paper, an indirect integration is explored where the evaluation criteria are associated with geographical entities and can be represented by maps. As will be seen in the next sections, the combined use of multi-criteria methods and GIS will be able to provide an important support to the problem posed, thanks to the quantification and visualisation of the decision criteria.

In particular, the structure of the paper is as follows: in Section 2, the characteristics of the case study are presented; in Section 3, the evaluation approach is described applying PROMETHEE and GAIA methods and in Section 4, some conclusions are proposed.

2. Aims of the decision-making problem

The proposed application concerns the territory of Cava De’ Tirreni, in the province of Salerno (Italy), a town that acts as a hinge between Nocera countryside and the urban area of Salerno, and a gateway to the Amalfitan Coast and the Regional Park of Lattari mountains, playing a significant connective and strategic function (Figure 1).

Figure 1. Location of Cava De’ Tirreni.



The goal is to create a useful approach for the choice of future alternative Operational Plans; they represent planning tools that are usually formed after public announcements to select, in a competitive way, the interventions to be implemented in the areas of transformation identified by the general Municipal Urban

Plan. In addition, they are formed in a period of validity of the general Plan and in accordance with its prescriptions with the aim of disciplining the interventions of protections, enhancement, recovery, urban renewal, redevelopment and location of the works and services to be subjected to expropriation.

The current proposal of the Municipal Urban Plan (Gasparrini 2012) is characterised by a dynamic interaction of analytical and design components, as follows:

- Systems and Networks, which represent the main components related to the settlement, environmental and infrastructure of the territory, considered in their specific identity and in their mutual relations, for which the Municipal Urban Plan provides regulatory requirements related to their structuring character, and specific design choices that define the discipline of the municipality with the value of directives and guidelines.
- Guide-Projects, defined mainly by natural and landscape components and historical paths or new formation, in which, also for the presence of urban and environmental critical conditions, interventions of conservation and transformation and individual works with different functional use are established, on which the Municipality will focus its efforts, in order to give substance to the objectives and strategic guidelines of the Municipal Urban Plan.
- Landscape Areas, which are parts of the municipal area with a specific and recognisable identity, due to the peculiar presence of one or more constituent structural components of the systems and networks, as well as specific historical, cultural, ecological, perceptual and functional relations between these components.

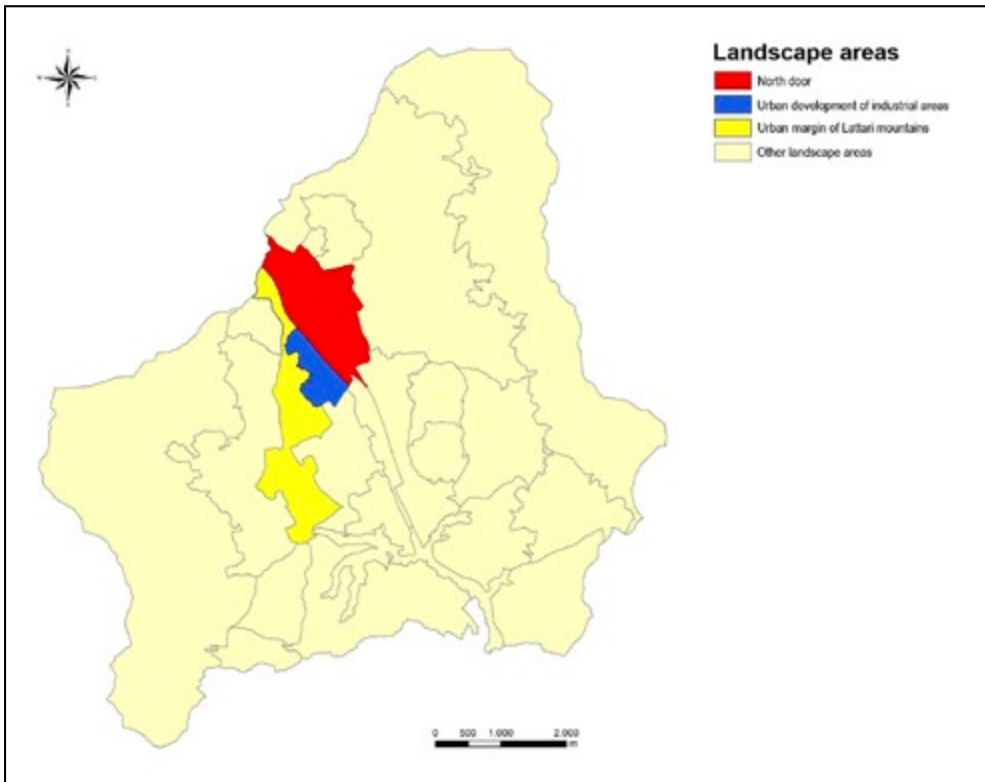
The Plan is also accompanied by a Strategic Environmental Assessment (SEA). Its explanatory document, represented by the Environmental Report, was carried out during its development. SEA is a process that must be undertaken at each stage of a Plan, in order to increase the quality and transparency of the decision-making process. It can be seen as the integration of five different phases: information, participation, planning, evaluation and monitoring. In this perspective, it is possible to create an integrated sustainable planning, in which the elaboration of an adequate information system (data collection, identification of indicators, use of simulation models, etc.), the involvement of all the stakeholders (public, private and social private) and the evaluation of the proposed actions are most important (Fusco Girard & De Toro 2007).

In the present case study, three different Landscape Areas were selected (Figure 2), characterised by a series of criticalities but also considerable transformative potentials. They are:

1. "North door", which is a portion of the municipal area formed by a series of industrial halls mixed with historical fabrics and residential buildings.
2. "Urban development of industrial areas", which is a portion of the urban area that is almost complete, disciplined by the plan for the Industrial Development Area of Salerno.
3. "Urban margin of Lattari mountains", which is located in an intermediate position, giving the area a very heterogeneous aspect.

In addition, the Municipal Urban Plan has proposed five "city visions", which are formed through a mechanism that is part of the Strategic Environ-

Figure 2. Landscape areas.



mental Assessment. Local actors and the authorities operating in the area have identified these visions during a process of participation, integrating common knowledge and expert knowledge. This group of people was subjected to a series of questions related to the future vision of the city and the urban changes desired. Analysing the answers, five different city visions were identified and proposed in the SEA:

1. "Cava as a beautiful and identity city", with the aim of improving tourist accommodation;
2. "Cava as a concrete and productive city", which aims to maximise the city's economy;
3. "Cava as a regenerated and hospitable city", aimed at improving the housing needs;
4. "Cava as an ecological city", for the environmental protection;
5. "Cava as a territorial hinge", to improve the road system.

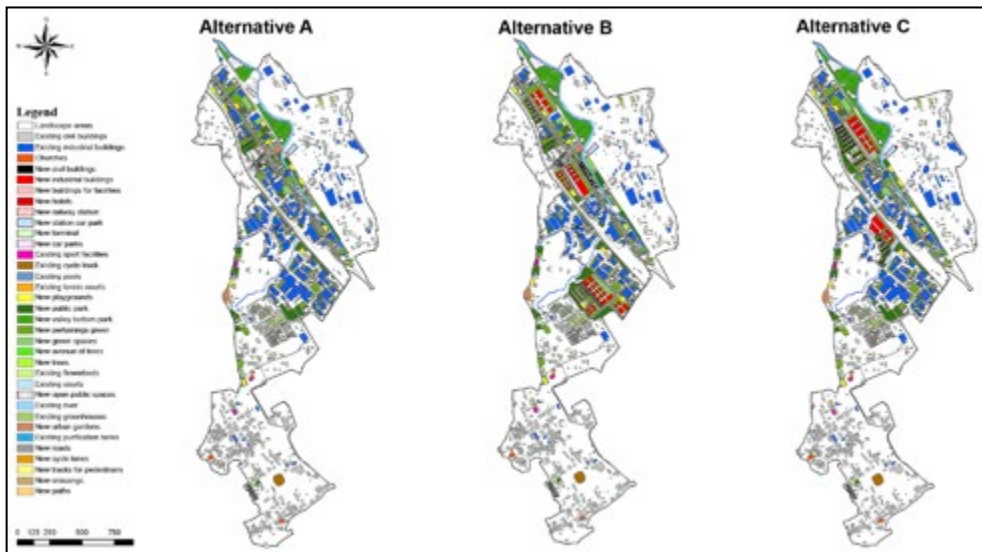
These visions are articulated in:

- General Objectives that must be consistent with the planning framework of reference;

- Strategic Guidelines acting as intermediaries between the general objectives and their practical implementation;
- Strategic Actions that are connected to the projects-guide to which the Municipality will refer during the operational phase, in order to guide the programming acts.

Taking into account the information provided by the Municipal Urban Plans (i.e. general objectives, strategic guidelines and strategic actions associated to the visions) with reference to the three Landscape Areas selected, we have developed three alternative Operation Plans (Figure 3), in order to simulate a possible future situation in which a number of Operational Plans could be proposed by various private bodies: the Municipality must choose one to be implemented.

Figure 3. Alternative Operational Plans.



The three alternatives represent, therefore, the simulation of three different Operational Plans with three different land use proposals. Alternative A is characterised by a more conservative view, based on the fact that it does not propose any changes to the built environment, but only to the configuration of the open spaces. Alternatives B and C are characterised not only by changes to the open spaces but also by a building reconfiguration, through the addition of new industrial, civil and scholastic buildings, supplemented by different types of facilities. The three alternatives, while being truthful in following the strategic objectives contained in the “city visions” developed during the SEA, are exclusively the result of a hypothetical processing based on the construction of scenarios to apply the proposed methodology. They are not meant to reflect the interventions feasible in the context of the specifications given by the Municipal Urban Plan.

In particular, quantitative characteristics of each alternative option are shown in Table 2 (paragraph 3.3) because the indicators connoting them are also used as performance evaluation criteria.

According to the rules of the Municipal Urban Plan, the process of selection of Operational Plans, to be submitted to the Municipality, is divided in three different phases:

1. "Check of conformity": in the light of the prescriptions contained in the Municipal Urban Plan's various documents, it is possible to make a preliminary selection of the proposals characterised by the best grade of coherence with the prescriptions.
2. "Check of the economic and financial feasibility": the municipal territory is divided into equivalence areas and the implementation mechanism of the Plan is the urban equalisation. This is characterised by an equal distribution of the development rights, which are freely marketable between the owners who are part of the same areas of transformation, that can lead to the realisation of urban standards or of integrated settlements. The economic criteria adopted is the transformation value; that is the increase of the market value after the buildings' potentials and the use classifications attributed by the Municipal Urban Plan, determined by the difference between the market value of the buildings after the urban transformations and their initial value, taking into account the costs and taxes needed to carry out the expected transformations. Considering the possibility that the private actors gives to public property areas and other real estate beyond the standards of law, it is possible to find the alternative that best preserves the balance between "public benefit" and "private benefit".
3. "Performance of the plan actions": on the basis of the construction of suitable indicators by which to compare the proposed alternatives (i.e. different Operational Plans) with the aim to obtain a ranking between them, through the use of an appropriate multi-criteria approach.

In the present case study, we have focused only on the third phase. The three proposed alternatives all comply with the Municipal Urban Plan prescriptions but, of course, it is necessary to the their check of conformity and conduct a study of economic and financial feasibility. In any case, these two, more traditional operations can be simply carried out by the Municipality offices while it is necessary to test a multi-criteria evaluation approach of possible alternative Operational Plans, so that the Municipality can easily proceed to the selection. In Section 3, we propose the use of the PROMETHEE multi-criteria evaluation method.

3. Evaluation proposal

3.1 *Choice of the evaluation method*

An important question concerns the choice of the appropriate evaluation method for the decision context being examined; for this aim, various studies have been

conducted with different perspectives. Ferretti et al. (2014) considered, on one hand, the field of application (i.e., reuse of historical buildings, energy planning, biodiversity preservation, urban planning, etc.) and on the other hand, the MCDA method used, also taking into account the possible integration with GIS in spatial planning.

To ease the selection of the appropriate method for a specific decision-making situation, a list of quality criteria was developed in De Montis et al. (2004). It can be used to reveal strengths and weaknesses of MCDA methods with respect to three main aspects: 1) operational components of MCDA methods; 2) applicability of MCDA methods in the user context; 3) applicability of MCDA methods considering the problem structure. Roy & Slowinski (2013) have instead formulated some key questions (in hierarchical order, from the most general and crucial to the secondary) that may help an analyst to choose a MCDA method suited to the decision context (simulating twelve representative and realistic decision contexts).

Another very useful and interesting approach has been developed with reference to a sustainability assessment (Cinelli et al., 2014), highlighting that MCDA has been interpreted as a suitable set of methods to perform sustainability evaluations. Sometimes, researchers do not define the reasons for choosing a certain method over another. This study has considered the performance of some MCDA methods that have been examined with regards to 10 criteria, as in Table 1.

Scientific literature on the subject shows that different methods have different characteristics demonstrating various strong and weak points. The PROMETHEE method has several strengths, such as:

1. qualitative and quantitative information can be handled;
2. weights can be used as importance coefficients and trade-offs;
3. thresholds can be used (indifference and preference);
4. compensation degree is partial;
5. uncertainty treatment is full;
6. sensitivity analysis is possible;
7. software available with good graphical capabilities;
8. learning dimension is simple with scenario analysis.

Two partial weaknesses can be the following:

1. rank reversal can sometimes occur;
2. the ease of use is "medium".

Taking into account the different strengths, PROMETHEE is considered suitable for use in the decision-making problem of this case study.

3.2 PROMETHEE and GAIA approach

In the present case study, the proposed alternatives have been assessed using PROMETHEE (Preference Ranking Organisational METHod for Enrichment Evaluation), a multicriteria approach belonging to the family of outranking methods that provides the comparison of the alternatives for each separate criterion. PROMETHEE I was developed by Brans (1982) and allows a partial ranking obtained by the calculation of the positive and the negative outranking flows that can also

Table 1. Evaluation criteria for MCDA methods (source: Cinelli et al., 2014).

Criteria groups	Evaluation criteria	Direction
Scientific soundness referring to input data	Use of qualitative and quantitative information	Capability of including information which is qualitative and quantitative in nature
	Life cycle perspective	Possibility of including the life cycle of the assessment target
Scientific soundness referring to calculation method	Weights typology	Significance of the weights used to assign importance levels to the criteria
	Thresholds values	Thresholds represent turning points values that can be used to model complex preference structures and uncertain information
	Compensation degree	The level of compensation among sustainability spheres determines the distinction between approaches based on strong and weak sustainability concepts
	Uncertainty treatment/sensitivity analysis	Capability of handling uncertain, imprecise or missing information
	Robustness	Influence of addition or deletion of alternatives on the assessment results
Feasibility	Software support and graphical representation	Availability of tools to implement the method, manage the information and show the results in a clear and multi-perspective manner
	Ease of use	Intelligibility of the method, simplicity of its structure based on users (i.e. decision makers) perspective
Utility	Learning dimension	Possibility of revaluating results if new information becomes available (e.g. alternatives or criteria)

give different results. PROMETHEE II was developed by Brans & Vincke (1985) and provides a full ranking that can be more useful to communicate the results to decision-makers. New different versions of PROMETHEE were developed to face more complicated decision-making problems, also offering tools for sensitivity analysis to test the results while changing the weights (Brans & Mareschal 2005).

With the aim of modelling decision making-problems, a graphical complement to the PROMETHEE rankings has been developed (Brans & Mareschal 1994), named GAIA (Graphical Analysis for Interactive Aid). This method can represent decision-makers' preferences and their implications in a two-dimensional view (Ishizaka & Nemery 2011).

From an operational point of view, it is necessary to define the m alternatives to evaluate and the n evaluation criteria, so that it is possible to build a $m \times n$ decision matrix. For each criterion it is also possible to make a choice between six dif-

ferent types of “preference functions”, which express the importance of the relative difference between the alternatives. They are the following (Vinodh & Jeya Girubha 2012; VP Solutions 2013):

- Type I (Usual preference function): the very simple case without any threshold.
- Type II (U-shape preference function): always used for qualitative criteria and it uses a single indifference threshold which should be fixed.
- Type III (Linear preference function): the case of a criterion with linear preference up to a preference threshold and it is to be determined.
- Type IV (Level preference function): used in the case of an indifference and a preference threshold which must be fixed.
- Type V: (V-shape preference function): a special case of the linear preference function where the indifference threshold is equal to 0.
- Type VI (Gaussian preference function): an alternative to the linear version with a smoother shape; preference increases and it follows normal distribution, of which the standard deviation must be fixed.

In PROMETHEE, it is also possible to assign weight to the criteria, expressing their relative importance (Brans & Vincke 1985; Macharis et al., 2004).

From a mathematical perspective, for each criterion a pair-wise comparison of alternatives is carried out. If a and b are two alternatives, their pair-wise comparison is indicated by a preference indicator $P_j(a,b)$ for each criterion j . All preference indicators for the different criteria are gathered together by the formula:

$$\pi(a,b) = \sum_{j=1}^n P_j(a,b)w_j$$

where n is the number of criteria, w_j is the weight of the criterion j , with $w_j \in [0, 1]$ and

$$\sum_{j=1}^n w_j = 1.$$

The positive and negative outranking flows are calculated by the following equations:

$$\Phi^+(a) = \frac{1}{m-1} \sum_{x \in A} \pi(a,x)$$

$$\Phi^-(a) = \frac{1}{m-1} \sum_{x \in A} \pi(x,a)$$

where m is the number of alternatives, x is the generic alternative different from a , and A is the set of alternatives.

The net dominance is calculated by the equation:

$$\Phi(a) = \Phi^+(a) - \Phi^-(a)$$

and higher is Φ better is the performance of the alternative a .

More information about PROMETHEE are provided by Figueira et al. (2005).

3.3 Application of PROMETHEE to the case study

The assessment has been structured starting from the construction of a suitable impacts matrix (Table 2), in which the evaluation criteria have been organised into six groups according to a hierarchical structure (Corrente et al., 2013):

- G1. Residence;
- G2. Productive and service activities;
- G3. Agriculture;
- G4. Land consumption;
- G5. Public space;
- G6. Urban mobility.

For each evaluation criteria, a positive direction has been indicated, as it is possible that the preferability of an alternative compared to the others is obtained in the case where the value of the considered indicator has the greater intensity (impacts to maximise), or in the case in which that value has the lower intensity (impacts to minimise) (Bernardini et al., 2014). In the first case it has associated the symbol “max” to the unit of measurement; in the second case, the symbol “min”. Furthermore, it has specified the impact’s unit of measurement, whose values have been calculated for each alternative through the construction of specific geo-referenced themes.

Indeed, all the values associated with the criteria of the evaluation matrix have been calculated using the GIS, considering the characteristic of each alternative. This means that these values do not refer to the current municipal territory, but represent a simulation for each alternative proposal. Table 3 shows the characteristics of the evaluation criteria necessary for the application of the PROMETHEE method. In addition to the data that refers to the range of variation of the values associated to the criteria and to the relative deviation standard, the issues concerning the identification of thresholds and weights are particularly significant. In both cases, the software *Visual PROMETHEE 1.4*, developed under the supervision of Bertand Mareshcal at VP Solution (2013), has been useful.

In particular, the internal part of the software has been developed as a “preference function assistant” to help make the right choice of preference function and thresholds according to the following steps:

1. Type selection: choice of one of the following types of preference function: usual, linear, V-shape, U-shape, level and Gaussian.
2. Threshold type: choice of absolute thresholds (i.e., expressed on the criterion scale of measurement) or percentage thresholds (i.e. expressed as percentages).
3. Threshold assessment: depending on the preference function type that has been selected, up to two thresholds (indifference or preference) have to be assessed.

In the present case, according to the features of the evaluation criteria and the values associated with them, it has been used for the typologies of preference functions (usual, linear o V-shape) associating one or two threshold types to them (indifference and/or preference).

Table 2. Evaluation matrix.

Criteria groups		Evaluation criteria		Direction	Units	Alternative A	Alternative B	Alternative C
G1. Residence	C1.1.	Number of inhabitants		max	number	10,179	10,299	10,299
	C1.2.	Number of rooms		max	number	12,879	13,019	13,059
	C1.3.	Number of residents per room		min	index	0.79	0.79	0.79
	C1.4.	Degree of use of residences		max	percent	99.7	99.3	99.4
	C1.5.	Number of residential buildings		max	number	1,094	1,094	1,079
	C1.6.	Residential buildings in a bad state of conservation		min	number	210	193	184
	C1.7.	Surface of civil buildings		max	m ²	239,234	238,692	240,565
G2. Productive and service activities	C2.1.	Number of accommodation		max	m ²	4	4	5
	C2.2.	Number of beds		max	number	174	174	206
	C2.3.	Number of shops		max	number	94	191	329
	C2.4.	Number of industrial buildings		max	number	149	154	150
	C2.5.	Surface of industrial buildings		max	m ²	216,271	197,044	222,252
	C2.6.	Number of facilities		max	number	11	11	12
	C2.7.	Surface of facilities		max	m ²	16,874	16,874	17,758
G3. Agriculture	C3.1.	Surface of the agricultural, woodland and farming activities		max	m ²	107,910	121,930	119,643
	C3.2.	Surface of the productive cultivation		max	m ²	234,672	228,673	210,697
	C3.3.	Surface of the crops under way		max	m ²	608,979	608,953	567,398
	C4.1.	Surface of urbanized areas		min	m ²	2,003,471	2,012,392	2,134,349
G4. Land consumption	C4.2.	Surface of built areas		min	m ²	463,241	440,553	468,379
	C4.3.	Surface of permeable areas		min	m ²	1,146,337	1,220,304	1,184,442
	C4.4.	Surface of impermeable areas		min	m ²	1,916,832	1,917,293	2,071,250
G5. Public space	C5.1.	Surface of the open public spaces		max	m ²	106,276	126,974	106,351
	C5.2.	Surface of urban green		max	m ²	149,302	191,439	176,843
	C5.3.	Surface of green for inhabitant		max	m ²	14.67	18.59	17.17
	C5.4.	Number of fine and ornamental trees		max	number	4,358	4,764	4,353
G6. Urban mobility	C6.1.	Surface of limited traffic zones (residents, cycle and pedestrian areas, etc.)		max	m ²	12,456	12,456	12,456
	C6.2.	Surface of public parking		max	m ²	18,367	32,878	24,890
	C6.3.	Surface of the interchange centres		max	m ²	1,292	1,292	2,772

Table 3. Criteria characteristics.

Evaluation criteria	Range	Standard deviation	Preference function	Thresholds type	Indifference threshold	Preference threshold	Weight
C1.1. Number of inhabitants	120	57	V-shape	absolute	0	137	1,43
C1.2. Number of rooms	180	77	V-shape	absolute	0	179	1,43
C1.3. Number of residents per room	0,0	0,0	Usual	absolute	0	0	1,43
C1.4. Degree of use of residences	0,4	0,2	V-shape	absolute	0	0,4	1,43
C1.5. Number of residential buildings	15	7	V-shape	absolute	0	17	1,43
C1.6. Residential buildings in a bad state of conservation	26	11	V-shape	absolute	0	24	1,43
C1.7. Surface of civil buildings	1,873	787	V-shape	absolute	0	1,795	1,43
C2.1. Number of accommodation	1	0	V-shape	absolute	0	1	2,86
C2.2. Number of beds	32	15	V-shape	absolute	0	36	2,86
C2.3. Number of shops	235	96	V-shape	absolute	0	215	2,86
C2.4. Number of industrial buildings	5	2	V-shape	absolute	0	5	2,86
C2.5. Surface of industrial buildings	25,208	10,754	V-shape	absolute	0	24,839	2,86
C2.6. Number of facilities	1	0	V-shape	absolute	0	1	2,86
C2.7. Surface of facilities	884	417	V-shape	absolute	0	1,006	2,86
C3.1. Surface of the agricultural, woodland and farming activities	14,020	6,141	Linear	absolute	5,079	14,425	3,33
C3.2. Surface of the productive cultivation	23,975	10,187	V-shape	absolute	0	23,456	3,33
C3.3. Surface of the crops under way	41,581	19,595	V-shape	absolute	0	47,304	3,33
C4.1. Surface of urbanized areas	130,878	59,705	Linear	absolute	55,508	142,760	6,25
C4.2. Surface of built areas	27,826	12,090	V-shape	absolute	0	28,264	6,25
C4.3. Surface of permeable areas	73,967	30,202	V-shape	absolute	0	66,770	6,25
C4.4. Surface of impermeable areas	154,418	72,685	V-shape	absolute	0	175,413	6,25
C5.1. Surface of the open public spaces	20,698	9,740	V-shape	absolute	0	23,503	5,00
C5.2. Surface of urban green	42,137	11,250	V-shape	absolute	0	39,342	5,00
C5.3. Surface of green for inhabitant	3,92	1,62	V-shape	absolute	0	3,64	5,00
C5.4. Number of fine and ornamental trees	411	193	V-shape	absolute	0	464	5,00
C6.1. Surface of limited traffic zones (residents, cycle and pedestrian areas, etc.)	0,0	0,0	Usual	absolute	0	0	5,00
C6.2. Surface of public parking	14,511	5,934	V-shape	absolute	0	13,146	5,00
C6.3. Surface of the interchange centres	1,480	698	V-shape	absolute	0	1,684	5,00

Also for the weights assignment to the evaluation criteria, the used software has a guide (“criteria hierarchy assistant”). In this case, it is possible to define a three-level hierarchy of criteria:

1. Clusters at the top level.
2. Criteria groups at the intermediate level, where each group belongs to a cluster.
3. Individual criteria at the bottom level, where each criterion belongs to a group.

In this case study, it has been considered a single cluster to which six criteria groups belong and 28 evaluation criteria, according to the hierarchical structure of Table 2.

Taking into account the general objectives of the city Visions, as regards the considered areas, it has been attributed weights to the different groups so that their sum was equal to 100, according to the following format: residence (10), Productive and service activities (20), agriculture (10), land consumption (25), public space (20), urban mobility (15).

Subsequently the weight of each group has been equally distributed between the criteria belonging to it. This means that a weight equal to 1.43 has been attributed to each of the seven criteria of G1; a weight equal to 2.86 to the seven criteria of G2; a weight equal to 3.33 to the three criteria of G3; a weight equal to 0.25 to the four criteria of G4; a weight equal to 5.00 to the four criteria of G5 and a weight equal to 5.00 to the three criteria of G6.

The possibility of assigning weights to the evaluation criteria is indeed congruent with the drafting of a competitive announcement by the City Council, in which the relative importance between the evaluation criteria on which the selection Committee has to express its judgment are fixed a priori.

The software *Visual PROMETHEE 1.4*, allows to compute two different rankings:

- the PROMETHEE I “partial ranking” is based on the computation of two preference flows (Φ^+ and Φ^-). It allows for incomparability between actions when both Φ^+ and Φ^- preference flows give conflicting rankings;
- the PROMETHEE II “complete ranking” is based on the net preference flow (Φ).
- The results of the assessment show the following ranking (Table 4):
- 1^a position: Alternative B;
- 2^a position: Alternative C;
- 3^a position: Alternative A;

where both the “positive outranking” (Φ^+) and the negative outranking (Φ^-) show the preference for the Alternative C (Figure 4). In particular, we can note the following (VP Solutions, 2013):

- in the partial ranking Φ^+ (positive or leaving flow) is a measure of strength and it is represented on the left-side bar with the best (largest) values in green, at the top of the bar, and the worst in red, at the bottom;
- in the complete ranking Φ^- (negative or entering flow) is a measure of weakness and it is represented on the right-side bar with the best (smallest) values in green, at the top of the bar, and the worst in red, at the bottom;
- in PROMETHEE diamond, the square corresponds to the (Φ^+ , Φ^-) plane where each alternative is represented by a point; the plane is angled at 45° so that the vertical dimension gives the Φ net flow, where Φ^+ scores increase from the left to the top corner and Φ^- scores increase from the left to the bottom corner.

Table 4. Alternatives ranking.

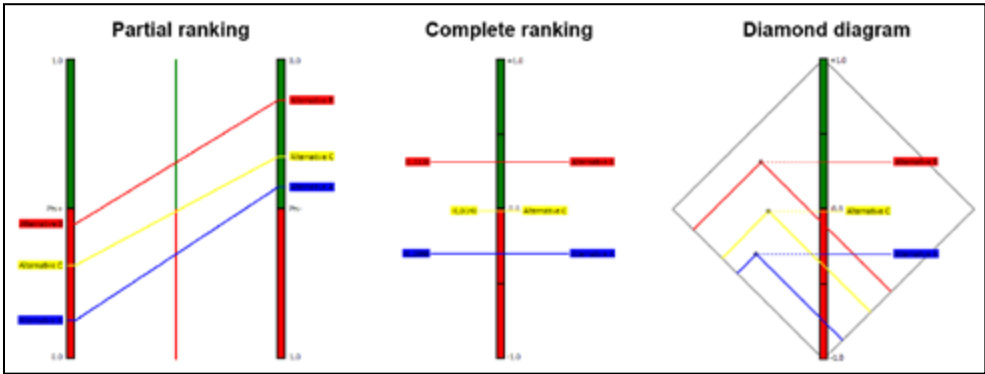
Rank	Alternative	Φ^+	Φ^-	Φ
1	B	0,4510	0,1372	0,3138
2	C	0,3116	0,3256	- 0,0134
3	A	0,1281	0,1281	- 0,2998

It is also possible to deduce the positive and negative outranking with respect to each evaluation criterion (Table 5). It shows the following results (Figure 5):

- Alternative C has a greater number of criteria and is preferable to the other two alternatives with respect to Residence and Productive and service activities;
- Alternative B has a greater number of criteria and is preferable to the other two alternatives with respect to Agriculture, Land consumption and Public space;
- both Alternative B and Alternative C have a criterion rendering them preferable to Alternative A for the Urban mobility.

These results can be viewed through the GAIA Webs, making it possible to make a full quality diagnosis through “spider webs” charts showing the profiles of individual alternatives (Figure 6). Also in this case, graphics show the performance of each alternative with respect to each criterion.

Figure 4. Partial and complete ranking of the alternatives.



4. Conclusions

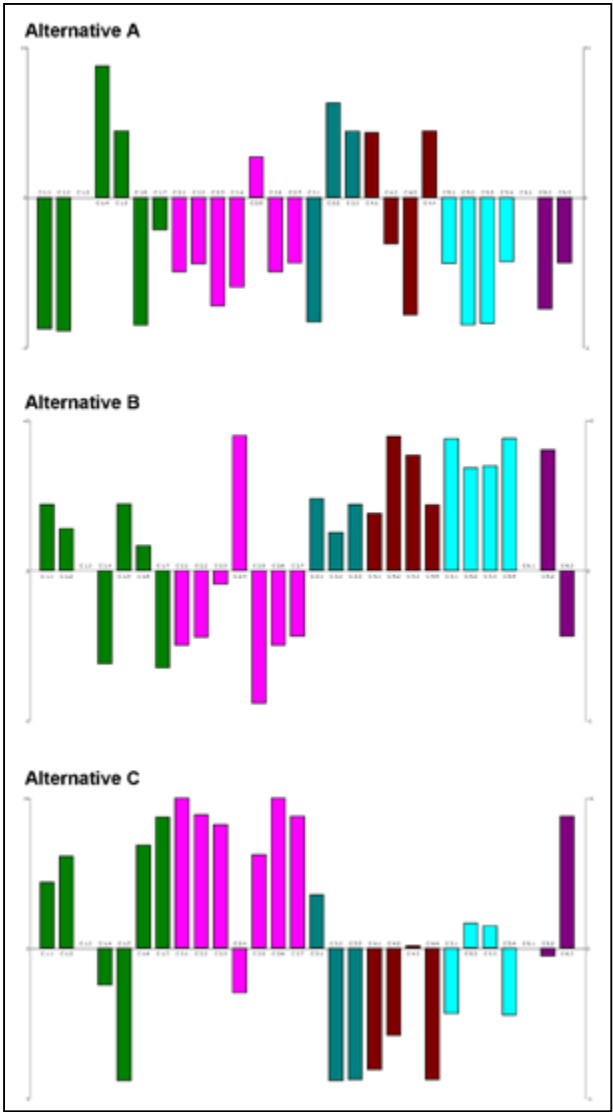
The necessity to offer an easy and useful tool for evaluating future alternative proposals of Operational Plans to the Municipality of Cava De' Tirreni (within the prescriptions of the general Municipal Urban Plan) has led to test a possible approach to evaluation, with reference to three alternatives of intervention, rep-

Table 5. Alternatives performance for each criterion.

Evaluation criteria	Alternative A (F)	Alternative B (F)	Alternative C (F)
C1.1. Number of inhabitants	- 0,8787	0,4393	0,4393
C1.2. Number of rooms	- 0,8913	0,2795	0,6118
C1.3. Number of residents per room	0,0000	0,0000	0,0000
C1.4. Degree of use of residences	0,8750	- 0,6250	- 0,2500
C1.5. Number of residential buildings	0,4412	0,4412	- 0,8824
C1.6. Residential buildings in a bad state of conservation	- 0,8542	0,1667	0,6875
C1.7. Surface of civil buildings	- 0,2198	- 0,6510	0,8708
C2.1. Number of accommodation	- 0,5000	- 0,5000	1,000
C2.2. Number of beds	- 0,4444	- 0,4444	0,8889
C2.3. Number of shops	- 0,7256	- 0,0953	0,8209
C2.4. Number of industrial buildings	- 0,6000	0,9000	- 0,3000
C2.5. Surface of industrial buildings	0,2666	- 0,8870	0,6204
C2.6. Number of facilities	- 0,5000	- 0,5000	1,0000
C2.7. Surface of facilities	- 0,4394	- 0,4394	0,8787
C3.1. Surface of the agricultural, woodland and farming activities	- 0,8343	0,4783	0,3560
C3.2. Surface of the productive cultivation	0,6279	0,2553	- 0,8832
C3.3. Surface of the crops under way	0,4398	0,4390	- 0,8787
C4.1. Surface of urbanized areas	0,4319	0,3808	- 0,8127
C4.2. Surface of built areas	- 0,3105	0,8936	- 0,5831
C4.3. Surface of permeable areas	- 0,7853	0,7685	0,0168
C4.4. Surface of impermeable areas	0,4415	0,4375	- 0,8790
C5.1. Surface of the open public spaces	- 0,4419	0,8791	- 0,4371
C5.2. Surface of urban green	- 0,8500	0,6855	0,1645
C5.3. Surface of green for inhabitant	- 0,8434	0,6951	0,1484
C5.4. Number of fine and ornamental trees	- 0,4321	0,8804	-0,4483
C6.1. Surface of limited traffic zones (residents, cycle and pedestrian areas, etc.)	0,0000	0,0000	0,0000
C6.2. Surface of public parking	- 0,7481	0,8038	- 0,0557
C6.3. Surface of the interchange centres	- 0,4394	- 0,4394	0,8789

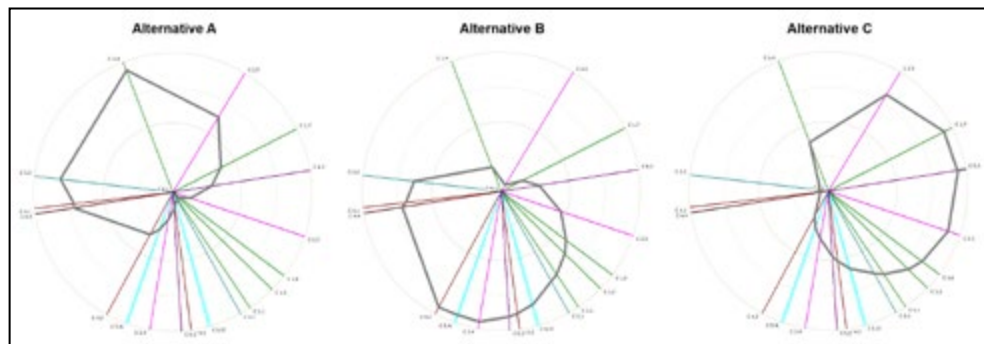
representing three possible Operational Plans. For the evaluation of the three alternatives, a system of indicators has been identified, some of which derive from the city Visions that were formed through the involvement of the local community,

Figure 5. Alternatives profile.



and with reference to three Landscape Areas. In this case, the use of a GIS has not been integrated within the MCDA method but it appears to be particularly significant to build an informative framework of reference and for easily calculating the indicators. The evaluation has been characterised by the application of the PROMETHEE multi-criteria method and has been made possible by the use of a software, suggesting that some evaluation tools, easily usable by the Municipality, are able to ensure scientific rigour and transparency to the process of selection of the possible proposals for evaluation.

Figure 6. GAIA Webs.



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