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A Multivariate and Multicriterial Approach for the SWOT Analysis

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Abstract: The SWOT analysis (Strengths, Weaknesses, Opportunities and Threats) is generally developed through a reading of few variables that are a priori selected on the basis of the previous knowledge of the system under investigation. With reference to the analysis to support several municipality territorial Plan, we propose an approach like the SWOT analysis that it leaves from objectives of the Plan and the typology of interventions for their attainment; before it identifies a wide battery of variables in order to describe the knowledge requirement; then, it examines them through a multivariate statistics analysis in order to characterize the homogenous groups of municipalities; at last it describes the weak and strong points on the base of the variables who characterize the groups. In a second phase, the results from SWOT analysis are the inputs for an optimization model that allows representing, in percentage, the weight that every municipality must have as optimal allocation of the financial resources managed from the plan. The ideal allocation of the financial resources shows the expectations of the each municipality constructed on the basis of the physical, environmental and cultural characteristics and of their coherence with the projects proposed by the Plan.

Key words: SWOT analysis, multidimensional analysis, constrained optimization

INTRODUCTION

The territorial plans, above all those finalized to the local development, are concluded with a series of planning proposals; some are under the directed control of the local administrations, others demand the active participation of other private and public operators. Moreover, it is advised to carry out a preliminary localization about the projects that involves material investments, at least to the scale of the municipality where the realization is planned. Sometimes the localization in a specific area is correlated to the nature of the project: it is substantially constrained and it does not allow spaces for alternative choices. More often, the characteristics of the interventions allow to choose between more possible localizations without etching significantly in terms of environmental and social-economic impacts at the level of large scale plane; this is always true about the immaterial investments.

In these cases the choice of localization proposed from the plan is not technically explained on the basis of the characteristics of the territory but it is substantially found on the decisional criteria based on common sense. Also the knowledge of the territory where to operate is not structured enough to support the plan proposals and even less to evaluate its coherence. Usually, the knowledge of the territory is organized as a SWOT analysis (Strengths, Weaknesses, Opportunities, Threats) (Akca, 2006); this is a rational analysis of sectorial or regional context in which a program of actions is realized. The analysis aim is to define the developmental opportunities of a territorial area through the valorisation of strong points and the containment of weak points on the basis of the opportunities and the risks that result from the external conjuncture.

That analysis allows concentrating the attention on the critical elements of the interested places that is on the determining issues for the decisions assumption.

Normally, the analysis is developed on the basis of an a priori knowledge system model under investigation. The analysis is developed through few variables reading: they are examined separately with a univariate approach.

This approach does not allow extending the analysis more than the reduced number of variables previously considered as relevant. Instead, the necessity to analyze, at the same time, a great number of variables can be carried out with a multidimensional data analysis technique (AMD) (Fabbris, 1983), like the analysis in principal component (ACP) and the group analysis (Cluster Analysis).

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The factorial analysis is born just in order to analyze together the interrelations between more aspects of a single system. It concurs to analyze a set of variables, summarizing them in a simpler visualization and interpretation. Obviously, the variables to insert in the analysis, even if very numerous, must be selected between those more correlated with the phenomenon under consideration. The principal component analysis (the ACP) has a fundamental role in the factorial analysis. It explains the correlation between the observed variables on the reduced number of factors. Subsequently, through the cluster analysis, the statistic units (the municipalities) are assigned to categories not defined a priori, creating homogenous groups inside but heterogeneous between each other outside (Bock, 1988).

Once identified the homogenous cluster of municipalities, every cluster will be characterized from the presence/absence of some variables strongly differentiated from the others cluster; the identified variables define each cluster characteristic and they could be read in terms of strong and weak points as demanded from the SWOT analysis (Mahdavi *et al.*, 2008).

The weak and strong points that have been identified will be explicable from the values of the variables that characterize them; the final result is somehow demonstrated and linked to definitions that are disconnected from statistical evidence. However, the obtained results must be integrated with other territorial analysis and with a direct knowledge of the territory; in particular, it is possible to refer to data on specific fields of particular interest for the territory and for the aim of the plan, in order to define an opportunity and risk outline.

To this point, the data is complete in order to develop the SWOT analysis and it can support the generation and appraisal phase of the plan. In our opinion, the obtained results are a useful support also in order to compare the final results of the plan, in terms of planning projects and localization on the territory, with those ideals, coherent with the expectations of the same territory.

The proposed approach starts from the objectives of the Plan and from the articulation of the possible projects.

Subsequently, with an expressed quali-quantitative appraisal from the planners of the Plan, for every municipality homogenous cluster a coherence index of the projects is constructed. After, the coherence index, equal for all the municipalities pertaining to the same cluster, is differentiated for each municipality on the basis of the particular characteristics of every municipality (for example, the cultural and environmental resources). The obtained synthetic variable can be read like the unitary benefit associated to the expense resources in that municipality and it allows to calculate an ideal division (the expectations) between several municipalities of the financial resources in order to finance the coherent projects proposed from the Plan (Belton, 2004). Then, the comparison between the ideal allocation and that consequent from the choices of Plan allows to express a judgment on the goodness of the proposed allocation and eventually to improve it in the direction of that idealization. In that it follows we will try better to clear the proposal contents through a specific application.

AN EXEMPLIFICATION

The application reported in this work refers to the plan aimed to the natural and cultural resource protection and exploitation. The geographical contest of reference is that of protected areas of Caserta, Benevento and Naples, in the Campania region. Totally, the area is 1.5000 km^2 wide, with a resident population of 430.000 people, in 2006.

The multidimensional analysis is conducted, considering 74 indicators, related to several macro-areas: land and population, health and social security, general economic situation, employment, standard of living, manufacturing-, credit and insurance, agriculture and hotel activity.

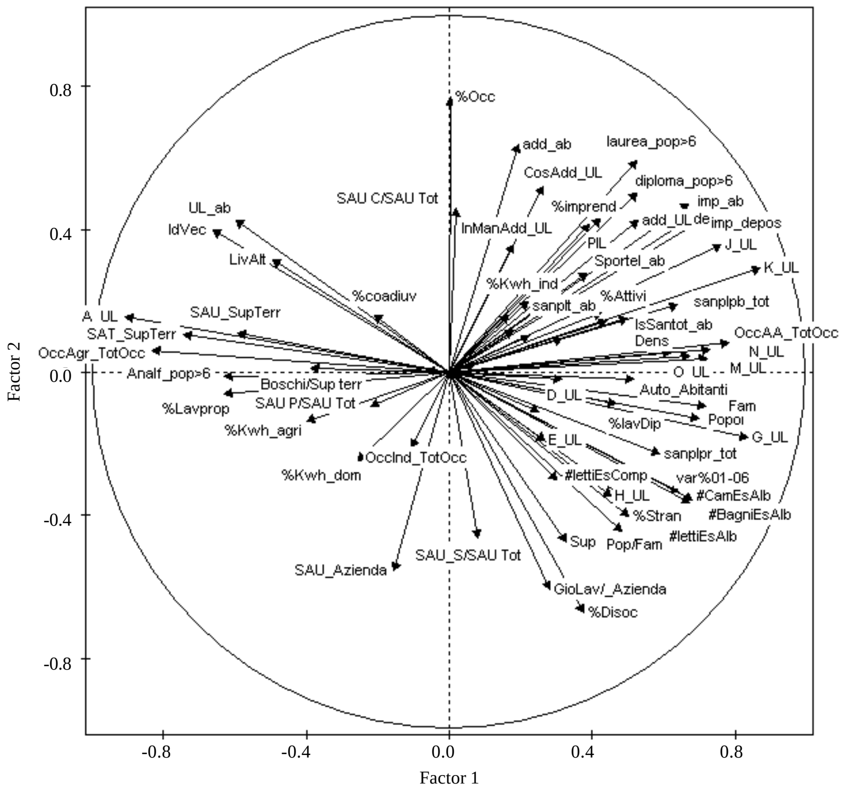
In relation to the principal component analysis outcomes, thanks to the absolute contribution of each variable in the determination of factorial axis, it has been possible to interprete the first factorial axis, the abscissa ones, in terms of opposition between land urbanisation/rurality.

The factorial plan (Fig. 1) shows that the first axe, on the right side, is strongly (high coordinate value) characterized by the presence of variables related to the municipality urbanization level, considered in this work (population density, employed in the services-producting sector, services to enterprises and persons).

The second factorial axis is positively correlated with the indicators that mean a more high level of economic well-being (high rate of employment, big size enterprises, high instruction level) and negatively with the indicators that mean situation of more rearward economy, mostly agricultural, with an elevated rate of unemployment.

Moreover, by the Cluster Analysis, it has been possible to individuate 5 homogenous classes, formed by 11, 26, 8, 2 and 3 municipality, respectively (Fig. 2). After the individuation of those groups, it has been verified, by V-test, which variables, on the bases of their presence or absence, higher or lower to the general mean, characterize those groups more than others.

When the whole area in 5 classes has been divided, the next step consists in developing a SWOT analysis for



Legend of principal indicators:

A_UL
Registered Local Units-Agriculture, hunting and forestry/Total U.L.

K_UL
U.L. – Business services/Total U.L

N_UL
U.L.-Health and other social services/Total U.L

SAT_SupTerr
Total Agricultural Surface/Territorial Surface

SAU_Azienda
Utilised Agricultural Surface/A_U.L.

% Occ
Employment rate

OccAgr_TotOcc
Agriculture-Employed by sector/Total employed

OccAA_TotOcc
Other Activities-Employed by sector/Total employed

IdVec
Old-age index

Fig. 1: Factoral plan related to the first two principal component

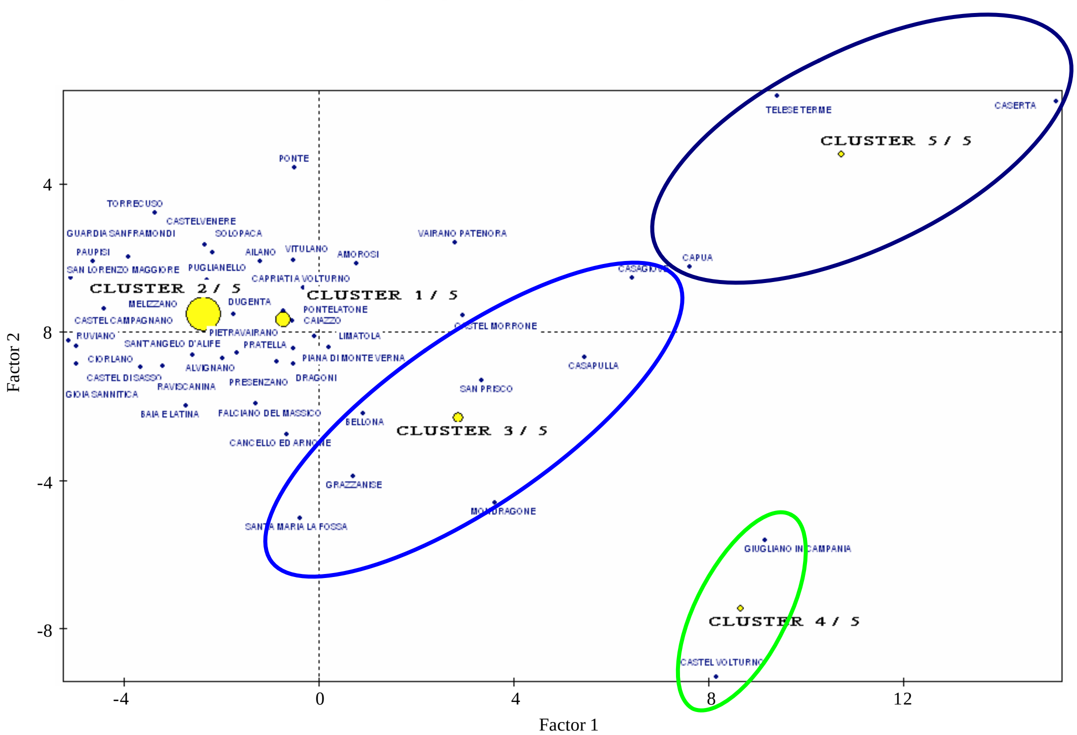


Fig. 2: Cluster representation on factoral plan, related to the first two principal component

Table 1: SWOT analysis outcomes for cluster 2/5

Strength
- Areas with an agricultural vocation
- Upgrading supply process
- Low anthropic pressure
- Presence of wine-growing production in the area of Benevento

Weaknesses
- High index of old age
- Gradual areas depopulation
- Productive fragmentation and insufficient tendency to form associations
- Very low hotel facilities

Opportunities
- More attention of customers toward farming products salubrity, quality and typicality
- Farming, biological production development
- Farming enterprise modernization
- Competitive development by agricultural and food cooperation support towards new agriculture company's models
- Presence of rural areas with a strong landscape- naturalistic value, with potential of integrated development

Threats
- Competition on International market Competition of farming products

Table 2: Coherence index for cluster 2/5

Coherence index with Macro-group activities (points from 1 to 9):
- Preservation and protection direct activities:..................................8
- Exploitation activities, by direct fruition of the goods:.....................5
- Indirect activities regarding sustainable development:.......................7

each class. The analysis is based on descriptive indicators of each class, on those ones of other outcomes resulting by surveys and on a direct knowledge of the area. To give an idea of the outcomes, we report an example regarding class 2 (Table 1).

A more effective use of SWOT analysis, as a support to plan generation and evaluation, consists in the individualization of the main type of activities consistently with the plan objectives, aimed to the natural and cultural resources protection and exploitation; therefore, these types of activities have been divided in macro-groups (Table 2). Then for each homogenous cluster of municipality, an index of coherence with that kind of macro-groups activities is set out, by using an quali-quantitative evaluation defined by a plan designer (Table 2); finally, this index has been better defined, as regards to the specific group of a macro-group.

The coherence index, originally the same for all municipalities of the same cluster, has been distinguished for each municipality, depending on several characteristics of the areas (specifically, some discrimination factors are the level of attraction, linked to cultural and environmental resources, to environmental sensitivity and to situations of criticality, like those concerning the presence of uncontrolled landfills).

In that way it is possible to obtain a matrix of coefficients c_{ij}, representing the coherence index corrected on the basis of the level of attraction of the municipality i-th as regards to the activity group j-th. These coefficients can be interpreted as a measure of benefit spending, when the activity location and activity group change, depending on the socio-economic characteristics of the area and on the level of attraction linked to the cultural and environmental presence of resources.

These coefficients can be used in an optimization problem as a measure of unitary benefits, obtained by the spending of a certain amount of resource, considering several constraints.

When the amount of resources, that have to be allocate in the various activity groups and located in different municipalities, is 100, the aggregated outcomes for each municipality represents the optimal amount of resources that could be localized in that municipality, considering an optimal allocation process: so, that percentage means the expectations of that municipality, as regards to the plan choices. These expectations can drive the definitive choices to be compared with them in the final plan configuration.

Obviously, actions are characterized by discontinuity and indivisibility. So that, they can't determine an allocation distribution that completely respects the optimum allocation expectations.

It is a question of allocating specific actions, that for their nature can have alternative locations, particularly in that sites where they can work for a catchment area characterized by an high deficit of expectations to satisfy.

The remaining part of the work analyzes in detail the model used in the application and the obtained outcomes.

THE ALLOCATION MODEL

With reference to the model formalization, the adopted algorithm in this specific case is based on the linear programming where every decisional variable, that represents the amount of resources to assign to every municipality for the various set of proposed projects, is associated to a continuous variable x_{ij} pertaining to interval [0, 1](Cefarelli *et al*., 2008).

The objective function to maximize represents the total score obtained from the product of the financial resources and the coefficients of the matrix of the weighted coherences c_{ij}, previously described:

$$\max f(x) = \sum_i \sum_j c_{ij} x_{ij} \text{ with } i = 1,..., 50 \text{ and } j = A_1, A_2,..., C_4 \quad (1)$$

The constraints of the decisional problem are organized in two different sets that impose limits to the resources attribution in respect to the municipalities and the set of projects.

The first constrain set assigns to all the municipalities at least a minimal resource equipment; this constrain has become necessary for an equity allocation problem, that is to guarantee to all a minimum amount like right of belongings to a social and territorial determined entity.

Since there are strong differences between the municipalities, in terms of occupied surface and of resident population, in order to the equity the double constrains becomes necessary.

Let us define:

$$S = \frac{K}{\sum_i kmq_i}, \quad P = \frac{K}{\sum_i residents_i} \quad \text{with } i = 1,...,50 \qquad (2)$$

Where:

- K : 100 total financial equipment;
- S : Mean coefficient related to the territorial surface;
- P : Mean coefficient related to the resident population at 2006

For both parameters, it was suggested to associate with each municipality minimum financial equipment equal to 30% of the mean coefficient.

The constraint is formalized by the following expression:

$$K_i \geq I_i \qquad \forall\ i = 1,...50 \qquad (3)$$

where, K_i is the financial equipment to allot to i-th municipality:

$$\sum_j x_{ij} = K_i \qquad \text{con } j = A_1, A_2, ..., C_4 \quad \forall\ i = 1,...,50 \qquad (4)$$

where, I_i is the lower limit-minimum value of resources to allot to i-th municipality:

$$I_i = \max(30\% \cdot S \cdot kmq_i\ ;\ 30\% \cdot P \cdot residents_i) \qquad \forall\ i = 1,...50 \quad (5)$$

Besides the minimum constrain has been set, for all the municipalities, also a maximum limit of resources that are allowable equal to 4 times the lower limit, up to a maximum of 6%:

$$K_i \leq S_i \quad \forall\ i = 1,...,50 \text{ con } S_i = \min(4 \cdot I_i\ ;\ 6) \quad \forall\ i = 1,...50 \quad (6)$$

where, S_i is the upper limit-maximum value of resources assigned to i-th municipality.

The second constrain set concerns each set of projects; for each of them upper and lower bounds have been set: 5 or 10% of financial resources as lower bound and three times them for the upper.

CONCLUSION

The model supplies the optimal values of the allocation of resources between several municipalities and for each group of projects (Rostirolla and Monacciani, 2008). Now, we read to the level of Macro-groups of activities (Fig. 3) and of clusters (Fig. 4) in order to carry out a comparison with the obtained allocation from the choices of Plan.

In particular, Table 3 shows the allocation, inside of the plan, between the five clusters of municipalities: the total expense of 37,15 million euro for the three Macro-groups of activities A, B and C. Comparing the percentage allocation values between the clusters with those turning out from the optimization model we can observe that the clusters 1 and 2 the choices of plan have nearly totally satisfied the expectations of those territories.

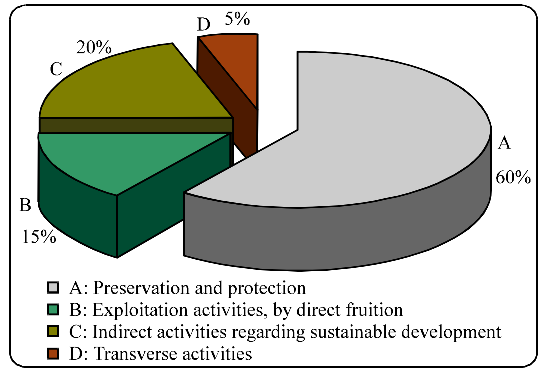


Fig. 3: Optimal division of the resources between the macro-groups of activities

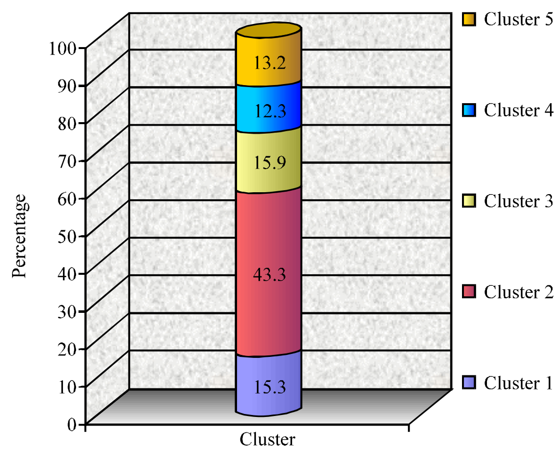


Fig. 4: Optimal allocation of the resources for cluster

Table 3: Allotted/expectation

	Resources			
Cluster	Allotted (€)	Allotted (%)	Expectation (%)	Allotted/expectation
1	5.272.589	14.2	15.3	0.93
2	14.950.061	40.2	43.3	0.93
3	4.236.111	11.4	15.9	0.72
4	11.113.889	29.9	12.2	2.45
5	1.577.350	4.2	13.3	0.32
Total	37.150.000	100.0	100.0	

The cluster 4 has gone very well to the detriment of cluster 5 and partially 3.

On the basis of these considerations, the drafters of the plan could generate other improvements in the equity or introducing new projects or modifying the localization of those for which such choice was practicable. Obviously, the presence of discontinuity and technical/territorial ties on the localization choice of some projects cannot allow to obtain totally coherent choices with those optimal.

The proposed approach helps to arrive to shared choices from the social actors on the priorities of the projects and on the resource allocation between the interested territories.

It integrates information that comes from the bottom, that is from the territory and afferent to the main economic and cultural sectors, with financial information tied to the objectives of the Plan.

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