PROPOSAL FOR A SPATIAL DECISION SUPPORT SYSTEM IN TERRITORY PLANNING: A HYBRID APPROACH: LINEAR PROGRAMMING, FUZZY MEASUREMENT, MULTICRITERION METHODS AND GIS

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ABSTRACT

Our study falls under the perspective which aims at optimizing the quality of decision brought to the space-time decision-making process. Our aim is to claim with an extensible, generic, deterministic and multicriterion model based on the axiomatic of models representing decision strategies and authorizing interaction between criteria. The suggested approach is constructive, interactive and based on uncertainty theories (fuzzy logic, possibility theory, fuzzy integrals) and linear programming. We define a new approach as well for the description of available information as for their use and suggest replacing the additivity property in the performance aggregation phase by a more reliable property: the growth using non- additive aggregation operators resulting from the capacity theory and largely known as fuzzy measurements. The latter allow evaluating space compatibility between the available data by defining a weight on each subset of criteria and fuzzy integral, more specifically; the Choquet's integral is an aggregation operator able to consider the interaction among these criteria.We elaborate, in this paper a spatial decision support system. The latter is based on a combined use of Geographical Information Systems (GIS) and Multicriterion Analysis Methods namely the (ordinal and nominal) sorting approaches to claim the territorial (spatial) context analysis. This study allows the professionals to carry out a diagnostic and proposes adapted actions in the resolution of two Territory Planning problems: The first relates to the search of a surface better satisfying certain criteria and the second consists in realizing the land use plan.

Keywords: *Spatial Decision Support System (SDSS), Territory Planning (TP),Multicriterion Analysis (MCA), Geographical Information System (GIS), Fuzzy Measurement*

1. INTRODUCTION

The expression of human subjectivity in territorial problems, as well as the interaction phenomena modeling between environmental criteria constitutes significant aspects in the aggregation problems. This requirement leads to consider increasingly complex models, ready to represent subtle decision phenomena. The essence of this paper is to propose a spatial decision support system (SDSS) devoted to help deciders to better analyze the territorial context. The main benefit of this strategy is to optimize the aggregation phase by considering the interactive aspect between the identified criteria.

Context, Scope

Because the social aspiration to administrative decision transparency and information particularly in the environment field becomes a stake, the decision-making process bears deep changes from a traditional downward approach towards a new logic where the decisional power is redistributed. In parallel, the increase in the environment allocated place has generated a significant increase in the production of quantitative and qualitative information on the project impacts. In order to interpret and integrate these new data in his procedure, the environmentalist needs synthesis and decision-making tools. That implies that many parameters are considered during each decision or intervention, and that enormous information quantities are handled. The data-processing tools provide in such a context an appropriate support.

The placement of these tools is however not an easy matter to achieve and the treated problem is then summarized into the divergence between optimization and decision-making in urban engineering. This paper is organized as follow: Once the context of our study specified (who decides what and how?), section 2 briefly reviews TP models using the weighted arithmetical average. Section 3 describes our contribution and section 4 clarifies the limits of the additive models justifying the opportunity of exploiting the non-additive ones in the multicriterion aggregation. Section 5 will be devoted to a background of the proposed model (non-additive models, Fuzzy measurement, choquet's integral). In section 6, we present the fuzzy measurement identification model and two multeriterion sorting approaches by using choquet's integral (ordinal and nominal sorting) and we outline the ordinal sorting algorithm as well as the corresponding linear program developed over this model. In section 7, we describe in detail the main steps of the proposed decision-making strategy. The suggested decision-making process is accompanied by a case study described in section 8 focusing on the various phases of the process. Finally, section 9 concludes the paper by summarizing our work and providing a preview of future research.

2. RELATED WORKS

Decision-making methods are still scarcely used. The demand is, however, increasing in the environment and urban development sectors since the price objectives are no longer the only ones to justify a decision. Several authors have already showed the adequacy of innovative GIS association to multicriterion analysis methods to the service of TP decision-making. In [4], the author has approached the best adapted site for a factory of carpet manufacturing. In [15], many applications of multicriterion methods concerning the environment management and especially localization with a relatively restricted number of variants have been described. In [9], MEDUSAT is proposed for the localization of waste treatment site.

In this context, multicriterion classification methods, traditionally, employed compartmentalize the complex interaction phenomena among the criteria. Indeed, the most classical procedure in the multicriterion evaluation consists in considering a simple weighted arithmetical average to incorporate information characterizing decision maker's preferences on the set of criteria. This supposes that criteria are preferentially independent. However, in reality and especially in a complex field as TP, the criteria interact (correlation, interchangeability, complementarity, etc.) and the assumption of preferential independence hypothesis is seldom checked [11].

3. CONTRIBUTION

Our decision-making aid approach out of TP will be in the context previously described and in particular must be voluntarist, but not interventionist, decentralized, flexible, opened and participative.

Our work deals primarily with decision-making systems for the territorial (spatial-temporal) process control. For this purpose, in the developed decisional activity, problems of a ***Space, Multi Scale, Multi Actor, Multi Objective, and Multi Criterion*** nature are raised. The present research aims to propose procedures which allow installing effective software tools to support two TP problems:

- The punctual management problem which consists in searching for a surface for a better satisfaction of certain criteria; such as the localization of an infrastructure of the type: Construction for dwelling, administrative building, purification station, etc.
- The problem which consists in the geographical chart segmentation in areas: designing a polygon network where each polygon determines the land use type: such as the design of plans of zones by considering the vicinity of these zones and the total organization of the suggested plan.

Thus, we envisage means of assistance to the decisional step out of TP, relatively to the issues of the various decision-making process phases. However, a first step consists in identifying thematically the environmental criteria considered. In the second step, we deal with the complex phenomena of interactive criteria (correlation, interchangeability, complementarity and preferential dependence) and we introduce fuzzy measurements as solutions to the compensation problem between the criteria into the aggregation phase, primarily into the weight determination process [8]. This report has led us to use discrete Choquet's integral as an aggregation operator in both sorting methods. This operator aims to improve the multicriterion analysis power by generalizing the arithmetic weighted average [6].

4. WEIGHTED ARITHMETICAL AVERAGE: CRITICISM

In the multicriterion decision-making procedure, when the preferential independence between criteria is supposed, it is frequent to consider the classical additive model within the phase of performance aggregation. The most used aggregation operator is the weighted arithmetical average, an additive operator of the form:

$$M_\omega(x)=\sum_{i=1}^{n}\omega_i x_i \quad / x\in[0,1]^n, \sum_i \omega_i = 1 \;\; et \;\; \omega_i \geq 0, \forall\, i \in N \qquad (1)$$

Where N= {1... n} indicates the set of n indices relative to the identified criteria and ω_i the weight (or the importance coefficient) of the criterion i. To reduce the notations, we write criterion i instead of index criterion i.

It is acquired that the set function additivity is not always a required property in real situations, particularly in the presence of human reasoning where the preferential independence hypothesis is seldom checked. Indeed, the weighted arithmetical average is unable to model any interaction, and led to mutual preferential independence among the criteria. Also, this operator [7]:

- Gums the possible conflicting character of the criteria;
- Eliminates from the Pareto-optimal[1] alternatives which can be interesting;
- Can favor the extreme alternatives;
- A weak weight variation can involve great consequences on the total preference.

[1] An alternative a is Pareto-optimal or effective if it is not dominated by any other one. It cannot be improved with regard to a criterion without deteriorating it for another one.

5. NON-ADDITIVE MODELS

In the multicriterion aggregation, we have recourse to the non-additive models when the separability property is not checked. The latter were proposed by [17] to generalize additive measurements and seek to express synergies between criteria. Among the most used non-additive aggregation functions, we cite: the ordered weighted averages (OWA); the non-additive integrals with regard to a capacity: the most known are Choquet's integral and Sugeno's integral.

5.1. FUZZY MEASUREMENTS

A fuzzy measurement on N is a monotonous overall function $v: 2^N \rightarrow [0,1]$, $v(S) \leq v(T)$ each time $S \subseteq T$ ($S, T \subseteq N$) and checks the limiting conditions $v(\{\ \})=0$ and $v(N)=1$. For any $S \subseteq N$, *v(S)* can be interpreted as the weight of the combination of criteria S [12]. Better still; it is its capacity to make alone the decision (without intervention of the other criteria). The growth expressed by this operator means then that the importance of combination cannot decrease when we add an element to it.

5.2. CHOQUET'S INTEGRAL, DEFINITION AND INTUITIVE APPROACH

Choquet's integral can be seen as the simplest means to extend, to any alternatives, a decision maker's reasoning on binary alternatives. This concept has been initially introduced in the capacity theory [4]. Its use as a fuzzy integral compared to a fuzzy measurement has been then proposed by Murofushi [17].Choquet's integral of the function x: N $\rightarrow$ IR compared to ν is defined by:

$$C_v(x) = \sum_{i=1}^{n} x_{(i)} \left[v(A_{(i)}) - v(A_{(i-1)}) \right] \qquad (2)$$

Where (.) indicates a permutation of N such that:
$x_{(1)} \leq k \leq x_{(n)}$

As an aggregation operator, Choquet's integral is a monotonous increasing function, defined of $[0, 1]^n$ in [0, 1] limited by two values ($C_v(0,\ldots,0)=0$ and $C_v(1,\ldots,1)=1$) and satisfying particularly remarkable properties of continuity, idempotence and decomposability [12].

5.3. K-ORDER ADDITIVE FUZZY MEASUREMENT

In the decisional problems including n criteria, to be able to consider interaction among the criteria in the decision maker's preference modeling, we need to define 2^n coefficients representing the fuzzy measurement ν , where each coefficient corresponds to the weight of a subset of N. However, the decision maker cannot provide the totality of information allowing identifying these coefficients. In the best cases, he can guess the importance of each criterion or each pair of criterion. In order to avoid this problem, [5] has proposed the concept of Fuzzy measurement Additivity of order k .In the suggested sorting approaches, we will use a model of order 2 of Choquet's integral allowing modeling the interaction among the criteria by using only $n + C_n^2 = n(n+1)/2$ coefficients to define the fuzzy measurement.

5.4 MULTICRITERION SORTING PROBLEMS AND CHOQUET'S INTEGRAL

Let F a coherent criteria family and A a set of actions, a multicriterion sorting problem consists in partitioning A, according to F. It consists in posing the problem in terms of actions sorting by categories, in consideration of the revisable (and/or transitory) character of A. This problem either recommends acceptance or rejection for certain actions, or proposes a methodology based on an assignment procedure to categories of all the appropriate actions for a possible repetitive and/or automated use.

According to the problem structure, we distinguish two types of sorting [14]: In the case where the categories are ordered and characterized by a limiting reference actions sequence. Each category is represented by two families of reference actions; one is lower (constituting the lower limit) and the other higher (constituting the upper limit), this class of problems is known as "the ordinal sorting problems" or "multicriterion segmentation". If the categories are not ordered and are characterized by one or more standard actions (actions of central reference), this class of problems is known as "the nominal sorting problems" or "multicriterion discrimination".

In the literature, the multicriterion decision-making problems of reference (Choice, Sorting, Description and Arrangement) are approached by methods which do not consider the concept of interactive criteria, and suppose rather that the criteria are preferentially independent. However, in a complex field as TP, the criteria interact and the preferential independence hypothesis is seldom checked. In the following, we will consider interactive criteria aspects in the sorting approaches developed.

6. PROPOSITION OF A FUZZY MEASUREMENT IDENTIFICATION MODEL

Marichal and Roubens's model [11] according to Choquet's integral is based on a partial quasi-order in the set of actions A and on certain semantic considerations around the criteria. The latter concern: the Importance of Criteria and their Interactions. This model represents information concerning the criterion importance by a partial preorder in F. This information is ***"poor"*** because the fact of defining a partial arrangement on F according to the criterion importance coefficients ω_j / $j \in$ F does not identify precisely the criteria importance coefficients ω_j. Consequently, to make this model of fuzzy measurement identification more deterministic as for the calculation of the importance coefficients and the interaction indices among the criteria, we consider, moreover, the limits of ω_j by the intervals of the form$[\omega_j^-, \omega_j^+]$ / $j \in F$ [6].

Formally, in the proposed model, the most important input data are:

A={$a_1,\ldots,a_n$} : the set of actions ; B={b_0 ,….., b_p} : the set of the limiting reference actions; C={C_1 ,..,C_n}: the considered ordered categories; F={$g_1,\ldots,g_n$}: the criterion family ; $B^h = \{b_p^h | h=1,\ldots,k \text{ et } p=1,\ldots,L_h\}$: the set of actions of central h[eme] category reference; $B = \bigcup_{h=1}^{k} B^h$: the set of all the central reference actions (h[eme] category); a partial quasi-order in A $\geq_A$ (a partial arrangement of the actions according to their total performances); a partial preorder $\geq_F$ in F (a partial arrangement of the criterion according to their importance coefficients) ; a partial preorder $\geq_P$ in the set of criteria pairs P(a partial arrangement of the criteria pairs according to their interaction indices); the sign of certain interaction indices $\omega_{ij} > 0$, $=0$ or < 0 representing a positive synergy, an independence or a redundancy between the criteria .

All these data are modeled in terms of equations or linear inequations according to Môbius's representation of a fuzzy measurement ν [11].

6.1. ORDINAL SORTING

This sorting strategy implies a synthesis outclassing approach which rests on a preferences model accepting the situations of incomparability between the actions and not imposing any transitivity property. This method allows assigning the action $a_i \in A$ to a category C_h of the ordered categories set C= {C_1 ,..,C_h }.The multicriterion evaluation is carried out through two phases: the category modeling procedure and the assignment (conjunctive and disjunctive) procedure**.**

Ordinal Sorting Algorithm

$q_j(b_h)$, $p_j(b_h)$, $v_j(b_h)$ are respectively the indifference, the preference and the veto thresholds; λ : the cut value[2]

BEGIN
For i=1 to m **Do**
  For h=0 to p **Do**
    For j=1 to n **Do**
     Calculate the partial agreement index $c_j(a_i,b_h)$;
     Calculate the partial disagreement index $d_j(a_i,b_h)$;
    Enddo;
  Calculate the total agreement index $C(a_i,b_h)$;
  Calculate the credibility index (a_i,b_h);
  Enddo; Enddo;
END.

1. Conjunctive Assignment Procedure (Optimist)
Begin
For i= 1 to m **Do**
  For h=p downto 0 **Do**
    If $d(a_i , C_h) \geq \lambda$ **then** break;
  Enddo;
    Assign a_i to the category C_{h+1} ;
Enddo;
End;

2. Disjunctive Assignment Procedure (Pessimist);
Begin
For i=1 to m **Do**
 For h= 0 to p **Do**
   If $\sigma(b_h ,a_i ,) \geq \lambda$ and $\sigma(a_i , b_h) < \lambda$ **then** break;
 Enddo;
   Assign a_i to the category C_h ;
Enddo;
End;

[2] This parameter ensures that the action compared with a category profiles satisfies the principle of majority.

6.2. NOMINAL SORTING

We deal with the nominal sorting procedure by considering the interactive aspect between the criteria; it aims at helping the decision maker to choose the most possible categories to the assignment of an action $a_i \in$ A.

This procedure belongs to the supervised classification methods. It allows the determination of the fuzzy resemblance relations by generalizing the indices (agreement and disagreement indices) used in method ELECTRE III [1]. It allows assigning an action to the category of which the membership degree is maximal. The determination of the importance coefficients ω_j and the interaction indices among the criteria ω_{ij} (the corresponding fuzzy measurement) is ensured by solving the corresponding constraint satisfaction linear program.

The following linear program is devoted to the ordinal sorting method.

$$\text{Maximise} \quad z = \varepsilon$$

$$\begin{cases} w_i - w_j \geq \varepsilon & \text{if } i \succ_F j \\ w_i = w_j & i \sim_F j \end{cases} \quad \textbf{An arrangement of the criteria}$$

$$\begin{cases} w_{ij} - w_{kl} \geq \varepsilon & ij \succ_P kl \\ w_{ij} = w_{kl} & ij \sim_P kl \end{cases} \quad \textbf{An arrangement of the criteria pairs}$$

$$w_{ij} \geq \varepsilon \ (\text{resp} \leq \varepsilon) \quad \textbf{If wij} \geq \textbf{0 (resp <0)}$$

$$w_{ij} = 0 \quad \textbf{Else}$$

$$\begin{cases} \sum_{i \in F} w_i + \sum_{\{i,j \in F\}} w_{ij} = 1 \\ w_i \geq 0 & \forall i \in F \\ w_i + \sum_{j \in T} w_{ij} \geq 0 & \forall i \in F, \forall T \subseteq F - \{i\} \end{cases} \quad \textbf{Conditions of limits and monocity}$$

$$w_j^- \leq w_j \leq w_j^+ \quad \forall j \in F \quad \textbf{The limits of wj}$$

$$\sum_{i \in F} w_i c_i(a_r, b_h) + \sum_{\{i,j \in F\}} w_{ij} \left[c_i(a_r, b_h) \wedge c_j(a_r, b_h) \right] < \lambda$$

$$\sum_{i \in F} w_i c_i(a_r, b_{h-1}) + \sum_{\{i,j \in F\}} w_{ij} \left[c_i(a_r, b_{h-1}) \wedge c_j(a_r, b_{h-1}) \right] \geq \lambda$$

7. THE MODEL DESCRIPTION

In this work, we develop a multicriterion decision-making process (Figure 1) which integrates a territory model and a multicriterion model. The suggested procedure refers to the use of discrete Choquet's integral as an aggregation operator in the two sorting approaches. The latter, thus, can be regarded as an extension of the sorting method ELECTRE Tri [1].

7.1. THE TERRITORY MODEL

The spatialized information is a privileged vector for decision-making. Through this model, we will try to show how GIS, turned for a long time to description, is integrated for the realization of effective communication support in the phases of multicriterion decision-making dialogue and justification. However, the couple (GIS, simulation model) constitutes a model allowing describing the territory. It is the support of spatial analysis procedures. When the decision makers manage to identify the actions and the criteria, these procedures (can concern the evaluation of sun durations, risks of pollution, etc.) allow attributing relatively, to the various actions, a value (performance) according to each criterion. The set of actions and their performances for each criterion constitutes the **"evaluation matrix" (or table of performances)**.The actions are attached to places and the evaluation matrix can thus be represented in the form of chart. The link between the actions and territory is maintained throughout the procedure. This feature is advantageous, since it constantly allows locating the actions in their environment [7].

7.2. THE MULTICRITERION MODEL

The analysis of the various actions is then made by the use of a multicriterion method (ordinal or nominal sorting) by generating one or more propositions. These two procedures do not seek to give an optimal decision because of the conflicts and transformations which intervene during the course of the decision procedure, but provide rather a suitable decision resulting from a compromise action. Moreover, they allow implying the decision maker in the phase of model construction so that he can integrate his preferences (elaboration of a concerted territory diagnosis) [9].

The multicriterion classification methods use only comparisons between the action to be affected and the class reference objects. This comparison is made by a relational preference model. Thus, these methods avoid the recourse to distances and allow the use of quantitative and/or qualitative criteria. Moreover; they allow avoiding the encountered problems when data is expressed in different units.

Problem 1: To treat the problems which consist of searching for a surface better satisfying certain criteria, it is enough to apply an ordinal sorting (the procedure is presented in section 6.1) to the set of actions belonging to an area on the chart such that the number of categories is equal to three. The low category A_1 constituted by actions issued too bad, category A_3 gathering actions issued sufficiently good (actions which define the required site) and category A_2 containing the actions which can be classified neither in A_1, nor in A_3. This allows the decision maker, if he meets boundary constraints, to modify the researched site limits in the zone constituted by these average actions.

Problem 2: The decision maker can choose the various types of land use, and then defines for each type a set of prototypes. It is enough later, to apply a nominal sorting), which will allow assigning each action to a type of land use. The elaborated model proposes that the actors implied are related to each other by the negotiation relations. These negotiations can relate either directly to the proposals resulting from the multicriterion sorting, or to the subjective parameters stated during the action analysis. We can, for example, ask each actor to fix his own subjective parameters to obtain a proposition by actor. Given the space character of the problems concerned with this model, these propositions will generally have the shape of a chart. The superposition of the different charts established for each actor can thus contribute to the emergence of a consensus.

7.3. THE USE PROCEDURE OF THE SUGGESTED MODEL

A decision-making procedure consists in using a model **"to reproduce"** the decision maker's problems and preferences. This is by stressing the distance which separates the real problems and the simplified representation used in particular for a decision-making. Among the most famous decision models we cite: Simon's model [16], Pictet's model [13] and that of Tsoukias [2].

The multicriterion and complex nature of spatial problems makes that the linear model of Simon and its extensions insufficient to answer the decisional complexity of these problems. They neglect three key elements of the decision-making in a spatial context: Participation, Negotiation and Consultation.

The territorial and urban decision-making processes, such as those of R.Laouar [10], F.Joerin [9] and S.Chakhar [2] produce conceptual executives integrating these elements.

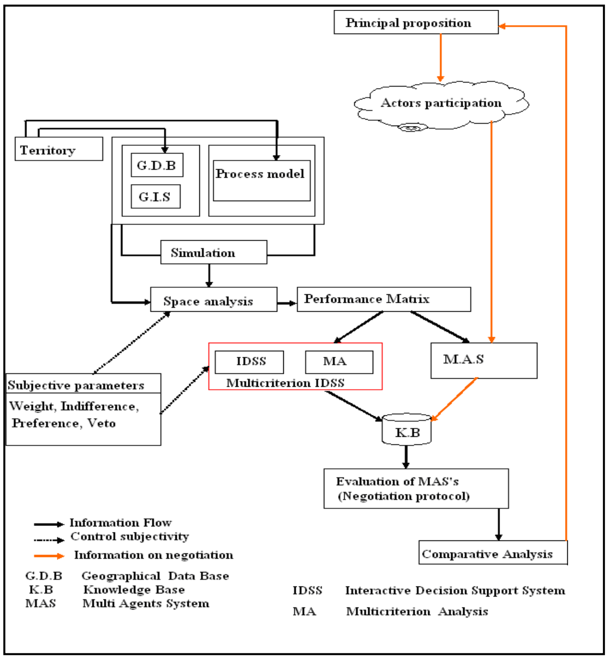

Figure 1: The Proposed Decisional Model

8. CASE STUDY

The user has the choice between the treatments of various TP problems. Once the choice determined, a window displays the performance matrix as well as the various associated parameters (Criteria's weight, Threshold of indifference, Threshold of preference and threshold of veto).The results of the multicriterion analysis can be displayed under a textual form or a graphic mode in the geographical chart.

The problem of localization clearly defined and approached by Joerin [9] using the Tricotomic

Segmentation (independent criteria) constitutes an ideal context to test the application of our multicriterion model founded on Choquet's Integral. In order to evaluate the performance of our model, we illustrate our step on the same example proposed by [10] and which consists at establishing a land suitability map for habitation (Where construct?). The choice of the area test results from the great number of space data at disposal. Our model is dynamically used according to the procedure proposed by Pictet [13]. It includes three principal phases:

8.1 THE STRUCTURING OF THE MODEL

In this phase, we consider the different means at disposal in the area of study: Geographic chart, data, evaluation methods, etc.

- Delimitation of the area of study: situated in the canton of Vaud, to approximately 15 km in the north of Lausanne. Its geographical limits in the system of coordinates Swiss are 532.750-532 500 m and 158.000-164 000 m. The surface of this area is of 52.500 km^2.

- Identification of the actions: a total of 650 zones (actions) cover entirely the studied area. The limiting reference actions[3] are also defined.

- Identification and evaluation of the criteria: According to each identified criterion, a set of factors (sub-criteria) relative to the site or to the vicinity is associated. It happens that several factors are gathered in the same criterion (semantic aggregation) (Table 1).

Criteria	Type	Factors (sub-criteria)	Evaluation Method
Harm	Natural	Air Pollutions, Odors	Attribution of a note
Noise	Social	Motorways, Railways	Attribution of a note
Impacts	Social	Sectorial plan	Attribution of a note
Geotechnical and Natural Risks	Natural	Constraints, Landslides, Flood,Seism, Firescriptsize	Consultation of the experts
Equipment	Economic	Distance to: Gas, Electricity, Water, Roads	Balanced distances for the various networks
Accessibility	Social	Distance to localities	Attribution of a note
Climate	Natural	Sun, Fog, Temperature	Attribution of a note

Table 1. The Identified Criteria.

8.2. THE EXPLOITATION OF THE MODEL

It is the analytical part of the process. The spatial analysis allows evaluating the criteria and the multicriterion sorting analysis (the preferences aggregation) classifies the actions into categories.

To treat the considered problem, we apply an ordinal sorting (the procedure is presented in Section 6.1) to the set of the identified actions. The actions are classified in three categories of suitability. The low category A_1 constituted by actions issued too bad, the category A_3 gathering actions issued sufficiently good (actions which define the required site) and the category A_2 containing the actions which can be classified neither in A_1, nor in A_3. The actions belonging to A_2 facilitate the task of the required site limit determination. To treat the second problem, the decision maker can choose the various types of land use, and then defines for each type a set of prototypes according to the preferences of the decision maker. It is enough later, to apply a nominal sorting to assign each action to a type of land use.

8.3. THE CONCRETIZATION OF THE RESULTS

It aims primarily at the social acceptance of the result.

8.4 EXPERIMENTAL RESULTS, DISCUSSION

In this case study, the criteria 5 **(Equipment)** and the criteria 6 **(Accessibility)** are dependent. They are positively correlated, the calculated coefficient of correlation is $\mathbf{r_{5,6} = 0.60047}$. The presence of the one implies the other and to suppose that these criteria are independent can harm the final decision because of the data redundancy.

The obtained results (Figure3) are checked against those obtained in [9] (Figure2) considering the same reference actions and the same subjective parameters.

The concessions granted by the study made by [9] accept that the edge of the motorway is qualified as doubtful. Indeed, the classification illustrated by the (Figure2) resulted from a multicriterion aggregation considering that the criteria (Equipment and Accessibility) are independent by the use of a simple arithmetic average. However, our model of multicriterion aggregation using the integral of Choquet dealt with the dependence between these two criteria and decided that the doubtful zones near the motorway are bad. Consequently, the numbers of the good and doubtful actions dropped considerably (Figure 3).

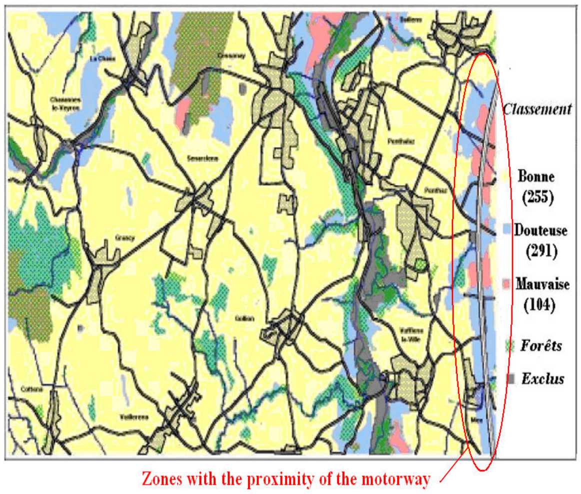

Fig. 2. The chart of territory adequacy for the habitat realized from the subjective parameters chosen by the amenagist given in [9].

[3] The actions of reference are used as the limits for the categories to which the potential actions will be affected.

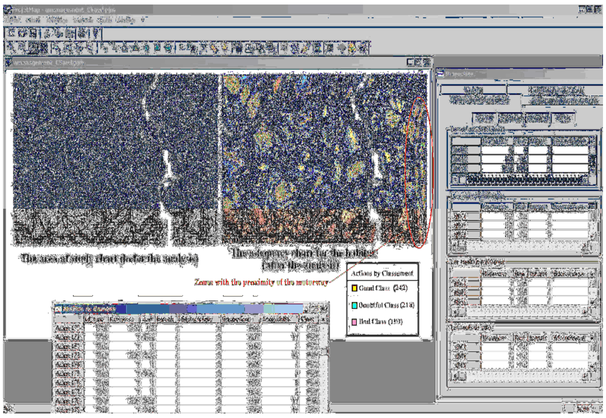

Fig. 3. Window Displaying the table criteria-parameters and the Results

9. CONCLUSION

In this paper, we have proposed a coherent decision support system, starting from the definitions of the set of potential alternatives, all the way to the final choice of the best scenario. We have, also, addressed the problem of interactive criteria in the multicriterion decision making. Moreover, the ultimate goals of this interdisciplinary study were to:

- Yield a precise description of the environmental project and identify its most notable actions.
- Demonstrate the importance of GIS and of spatial analysis in particular in the evaluation of the considered criteria.
- Evaluate and compare multiple scenarios to determine the best solutions.

The obtained results are of a theoretical, methodological and algorithmic order. Finally, this research may be considered as a step forward encouraging us to follow the undertaken researches to treat the phenomenon of interactive criteria in another type of urban problems and to evaluate the feasibility of our approach in a context as real as possible. Also, our SDSS must allow the participation of multiple parties with conflicting and often opposing view points.

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