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PARTICIPATIVE DECISION-MAKING AUTOMATION FUZZY DECISION-MAKING IN TERRITORIAL INTELLIGENCE

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ABSTRACT

This research work presented in this article aims to model participatory decision-making in an environment of territorial cooperation or territorial partnership. We will demonstrate the feasibility of the decision-making automation aid model for territorial actors and territorial experts of the participative decision. The realisation of this model is founded on fuzzy set theory, which is used to solve complex and uncertain system problems. The originality of this model lies in the fact that, in the process of territorial cooperation and territorial partnership, the influence of the characteristics of social and economic development, the disparities and weaknesses, the leadership and the interest in the service provided by each of them are taken into account. It uses territorial expertise as a source of knowledge to control each actor's contribution to the realization of territorial development projects.

Keywords: fuzzy logic, cooperation, participation, territorial intelligence, decision-making.

1. INTRODUCTION

Currently, the territorial actors are asserting themselves as one of the key pillars of local development.

Faced with the geographical, anthropological, historical, economic, sociological and political challenges of territorial action, the decision-making model aims to help actors in their action situations and to develop support mechanisms for development projects and monitoring actions are undertaken in the territories to promote transparency in cases of multi-level and multi-actor governance.

The involvement of the latter in the development of their territory becomes a requirement; this requirement of active involvement must be capable of being expressed through a clear and transparent decision to make.

This model could easily be used to solve the participation regulation problems in territory development; it takes into consideration the criteria of territory and the profile of the territorial actors.

Firstly, we describe the approach, and we define the indicators of the participation regulation platforms. Secondly, we present the modelling of these indicators by the membership function. Afterwards, we explain how to develop Fuzzy decision rules.

Finally, we present the defuzzification, and we show the result of the simulated situations of territory development participation.

2. THE PROPOSED APPROACH

The model starts with collecting the actor's territorial profile. This data is modelled with the membership functions by fuzzification.

The decisions are elaborated by fuzzy inference using the rules of decision-making. After the defuzzification, the model proposes strategies for regulating participation as decision classes to the territorial regulators and experts.

They can validate and apply the suggested decisions or suggest other decisions. These will be added to the expertise used by the model. We show by the simulations presented on the examples how much this methodology is applicable and how much it was interesting s to model knowledge and to make automatic the decision-making process.

3. THE TERRITORIAL INTELLIGENCE

«Territorial intelligence aims to engage the territorial community, actors and researchers in the field to know their territory better and master the means of its development. For actors to enter a learning process that will enable them to act effectively and efficiently, they must take ownership of the various information and communication technologies as well as the information itself » [20].

Territorial intelligence is « An informational and anthropological process, regular and continuous, initiated by physically present and / or distant local actors who appropriate the resources of space by mobilising and then transforming the energy of the territorial system into project capacity. As a result, territorial intelligence can be assimilated to the territoriality that results from the phenomenon of appropriation of the resources of territory and then to the transfer of skills between categories of local actors of different cultures. This approach aims to ensure, literally as well as figuratively speaking, to allow the territorial level to develop what we have called formal territorial capital ». [21]

4. THE FUZZY MODEL

Criterion modelling is made by fuzzification. The fuzzification is the Numerical/Linguistic conversion of different variables characterising the different criteria.

5. THE FUZZY MODEL IN TERRITORIAL INTELLIGENCE

The actors and the experts of the territory are faced with complexity due to the financial, technological, legal and human components of the territory, this environment

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dominated by the uncertainty and the complexity as well as a daily volume of the exchanges of the individual or collective information. Actors and experts know how to decide to grant credit to information and the establishment of communication networks and transfer of skills.

Hence the interest of taking into account the experiences acquired by the actors and the experts of the territory, the fuzzy logic offers the possibility of the decision-making of the participatory decision.

6. THE PRESENTATION OF DIFFERENT INDICATORS

The following paragraph shows the formula of different indicators influences the territory development participation.

The following indicators influence the participation and contribution of actors and experts in the development of the territory:

- The indicator of financial performance (measured in particular by their fiscal capacity, the fiscal effort and local revenue making…)
- The multi-dimensional local development indicator (evaluate the local impact of public policies).
- The indicator of the interest of the service rendered (the number of students, roads and other networks...).

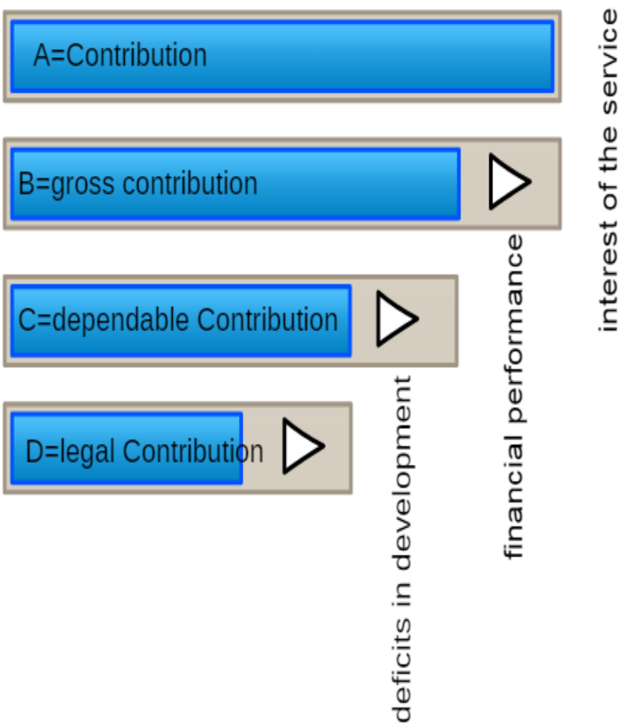

Figure-1. The formula of indicator of territorial participation.

$$ITP = \frac{A}{B} \, X \, \frac{C}{B} \, X \, \frac{D}{C} \; \ldots\ldots\ldots\ldots. (1)$$

$->$ ITP (Indicator of territorial participation).

$->$ $\frac{A}{B}$ (Indicator of Interest).

$->$ $\frac{C}{B}$ (Indicator of Performance).

$->$ $\frac{D}{C}$ (Indicator of Capacity).

7. THE INDICATORS MODELING BY FUZZIFICATION

The indicator modelling is made by fuzzification. The fuzzification is the Numerical/Linguistic conversion of different variables characterising the different indicators.

The different indicators are presented by the same membership functions μ(x).

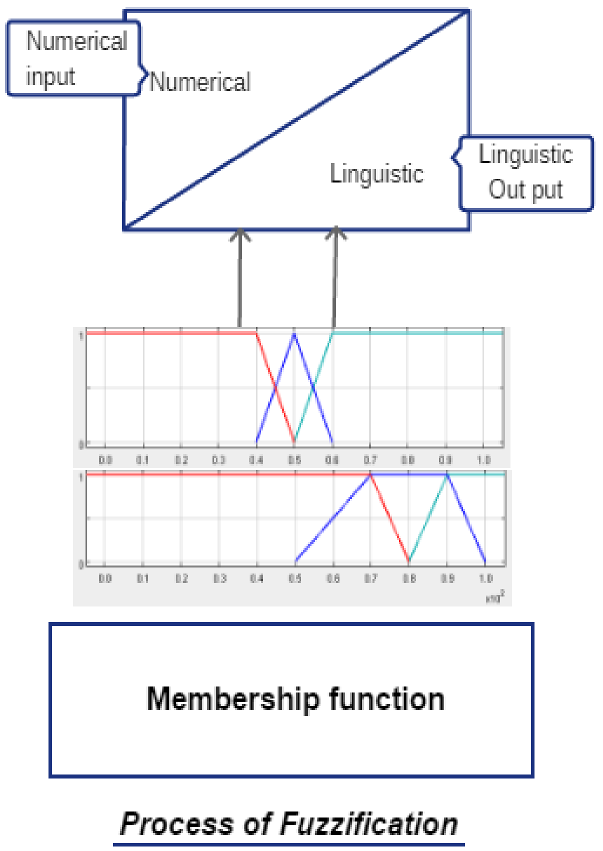

Figure-2. The formula of indicator of territorial participation.

For example, Fuzzification of performance indicator:

The membership functions characterising the fuzzy subsets use the following linguistic terms: {Low, Moderate, High}.

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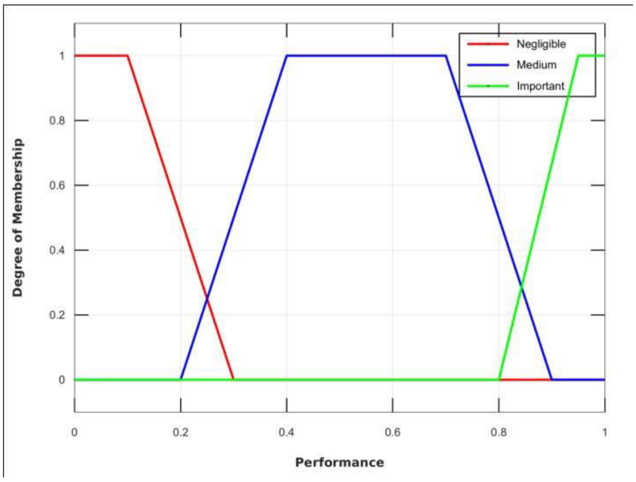

Figure-3. Fuzzification of performance indicator.

The other indicators are modelled by the same method using the same membership functions characterising the fuzzy subsets and using the following linguistic terms: {Negligible, Medium, and Important}.

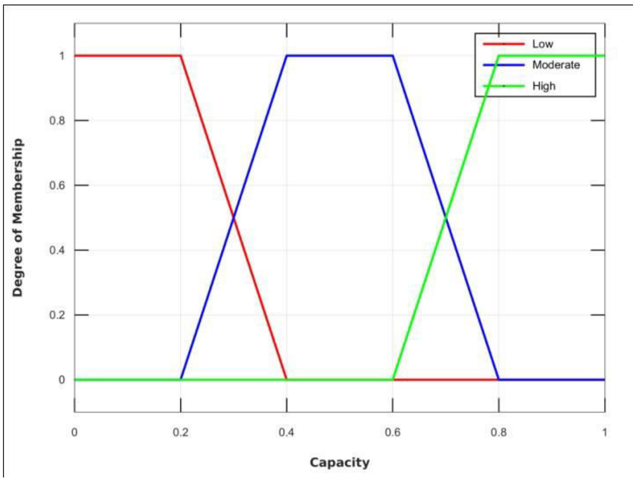

Figure-4. Fuzzification of the capacity indicator.

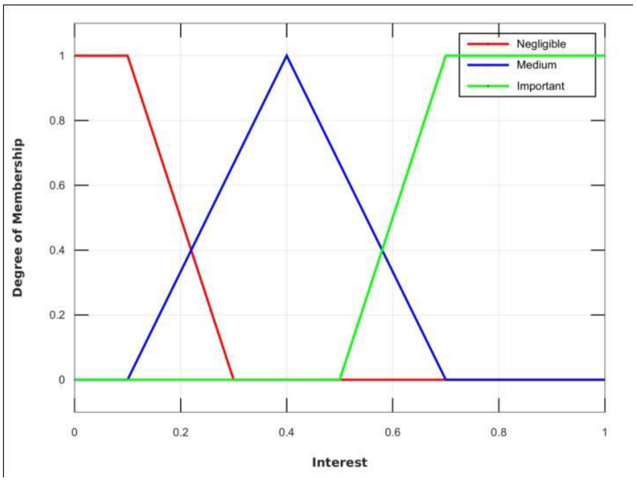

Figure-5. Fuzzification of Interest indicator.

8. FUZZY INFERENCE

The fuzzy inference allows us to develop a decision by using the decision rules. Linguistic terms describe decision rules, for example:

1. If (Performance is Negligible) and (Interest is Negligible), then (ITP is Negligible) (1).
2. If (Performance is Negligible) and (Interest is Medium), then (ITP is Medium) (1).
3. If (Performance is Negligible) and (Interest is Important), then (ITP is Important) (1).
4. If (Performance is Medium) and (Interest is Negligible), then (ITP is Medium) (1).
5. If (Performance is Medium) and (Interest is Medium), then (ITP is Medium) (1).

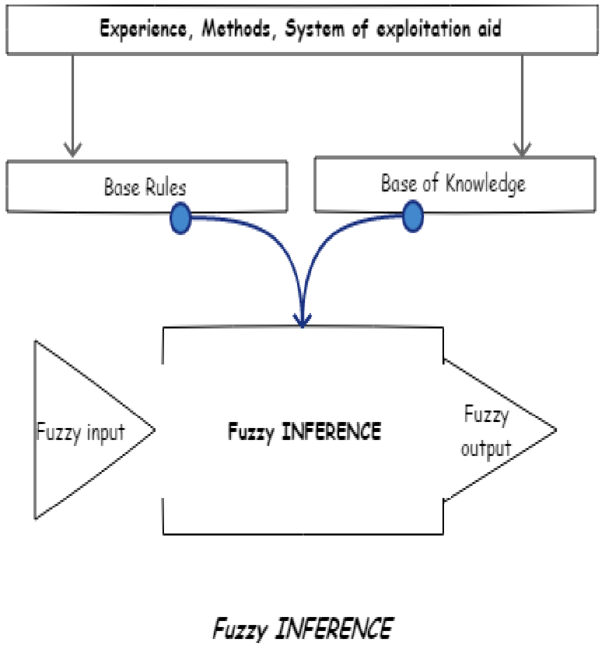

Figure-6. Fuzzy INFERENCE.

Rules of inference:

R_1: if X_1 is $A_{11}$and X_2 is A_{12} ...and X_n is A_{1n} then y is C_1
.
.
.
R_m: if X_1 is $A_{m1}$and X_2 is A_{m2}…and X_n is A_{mn} then y is C_m

$X = (X_1, X_2 ....X_n)$: Vector of inference.
$A = [Am, n]$...................... : Characteristic Matrix.
$C = (C_1, C_2.....................C_m)$: Result Vector.

$$\mu_m = \prod_{j=1}^{n} \mu_{mj}(Xn) \qquad \text{..................} (2)$$

μ_m: the degree to belong to membership function decision class.
μ_{mj}: the degree to belong to membership function criterion.

Example of the rules base:
II: an indicator of interest

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IP: an indicator of performance
IC: an indicator of capacity
ITP: an indicator of territorial participation

A = [Am, n] C

$$\text{If} \begin{bmatrix} \text{Important} & \text{Negligible} & \text{Negligible} \\ \vdots & \ddots & \vdots \\ \text{Important} & \text{Important} & \text{Medium} \end{bmatrix} \text{then} \begin{bmatrix} \text{Negligible} \\ \vdots \\ \text{Medium} \end{bmatrix}$$

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1.If (Performance is Negligible) and (Interest is Negligible), then (ITP is Negligible) (1)
2.If (Performance is Negligible) and (Interest is Medium), then (ITP is Medium) (1)
3.If (Performance is Negligible) and (Interest is Important), then (ITP is Important) (1)
4.If (Performance is Medium) and (Interest is Negligible), then (ITP is Medium) (1)
5.If (Performance is Medium) and (Interest is Medium), then (ITP is Medium) (1)
6.If (Performance is Medium) and (Interest is Important), then (ITP is Important) (1)
7.If (Performance is Important) and (Interest is Negligible), then (ITP is Medium) (1)
8.If (Performance is Important) and (Interest is Medium), then (ITP is Important) (1)
9.If (Performance is Important) and (Interest is Important), then (ITP is Important) (1)
10.If (Capacity is Low) and (Interest is Negligible), then (ITP is Negligible) (1)
11.If (Capacity is Low) and (Interest is Medium), then (ITP is Medium) (1)
12.If (Capacity is Low) and (Interest is Important), then (ITP is Important) (1)
13.If (Capacity is Moderate) and (Interest is Negligible), then (ITP is Negligible) (1)
14.If (Capacity is Moderate) and (Interest is Medium), then (ITP is Medium) (1)
15.If (Capacity is Moderate) and (Interest is Important), then (ITP is Important) (1)
16.If (Capacity is High) and (Interest is Negligible), then (ITP is Medium) (1)
17.If (Capacity is High) and (Interest is Medium), then (ITP is Important) (1)
18.If (Capacity is High) and (Interest is Important), then (ITP is Important) (1)
19.If (Capacity is Low) and (Performance is Negligible), then (ITP is Negligible) (1)
20.If (Capacity is Low) and (Performance is Medium), then (ITP is Medium) (1)
21.If (Capacity is Low) and (Performance is Important), then (ITP is Important) (1)
22.If (Capacity is Moderate) and (Performance is Negligible), then (ITP is Medium) (1)
23.If (Capacity is Moderate) and (Performance is Medium), then (ITP is Important) (1)
24.If (Capacity is Moderate) and (Performance is Important), then (ITP is Important) (1)
25.If (Capacity is High) and (Performance is Negligible), then (ITP is Medium) (1)
26.If (Capacity is High) and (Performance is Medium), then (ITP is Important) (1)
27.If (Capacity is High) and (Performance is Important), then (ITP is Important) (1)
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Figure-7. List of rules by OCTAVE.

9. THE DEFUZZIFICATION

The fuzzification is the Linguistic/Numerical conversion of different variables characterising the global efficiency. The method which is used here is the method of the centre of gravity. This method takes into account all available information.

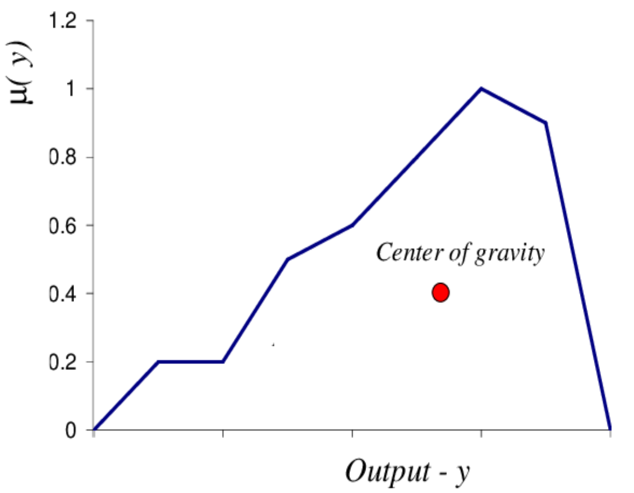

Figure-8. Center of gravity.

$$y_0 = \frac{\int_y y \chi \mu(y)\, dy}{\int_y \mu(y)\, dy} \quad \text{……...…………(3)}$$

10. SIMULATIONS RESULTS

According to importance, several particular cases will be treated.

Example:

Case N°1: (X, Y, MED)

The indicator of capacity is fixed in advance: Medium.

X Indicator of Interest.
Y Indicator of Performance.
MED Indicator of Capacity.

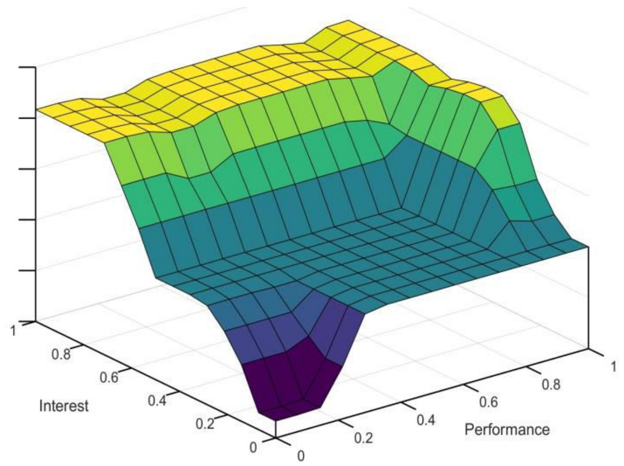

Figure-9. The curve of the case N°1 (X, Y, MED) result.

The interpretation of the curve of the case N°1:

The curve above shows us clearly that the ITP is null when the two indicators (Interest and Performance) are null. However, it's medium when one of them is medium, and the other is null. It's important when the two indicators are important. In this point, the ITP (Indicator of territorial participation) is the maximum possible.

Case N°2: (MED, X, Z)

The indicator of interest is fixed in advance: Medium.

MED Indicator of Interest.
Y Indicator of Performance.
Z Indicator of Capacity.

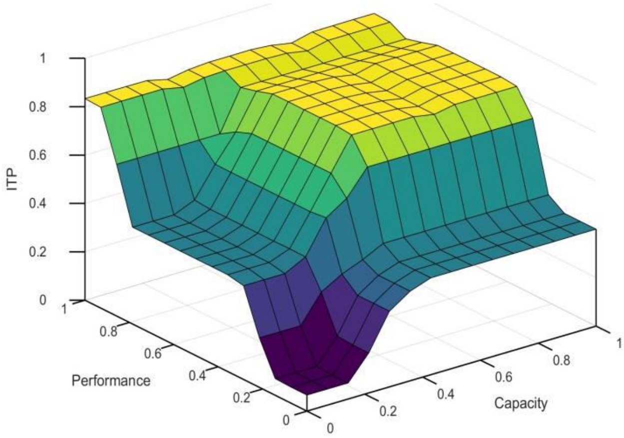

Figure-10. The curve of the case N°2 (MED, X, Z) result.

The interpretation of the curve of the case N°2

The curve above clearly shows that the ITP can vary according to the rules and inference rules. The ITP (Indicator of Territorial participation) is important when one of them is important, and the other is negligible.

This result is impossible in classical logic. Here we find the difference between fuzzy logic and classical logic. In the classic logic, when one of the indicators is null, the ITP is null.

11. RESULT AND DISCUSSIONS

The modelling of the various indicators chosen by the principles of fuzzy logic allowed us to highlight this strong dependence and interaction between the three selected indicators at the beginning.

The purpose of this presentation is to allow the modification of the result according to the decision rules established by experts of the territory.

The expert can pilot the result from a knowledge base translated into decision rules and the importance of each chosen indicator.

12. CONCLUSIONS

In this article, we presented our approach using fuzzy logic techniques to help territorial actors and territorial experts to solve the problems of participation in the development of their territory in a framework of cooperation or territorial partnership. We showed the result of the simulation in different cases.

Our main objective is to demonstrate the usefulness of a knowledge-based system expert model in a collaborative decision-making territory and to allow actors and experts to capitalise on their experiences gained over time and to cope with to problematic situations that only one actor cannot handle alone.

This proposed technique assumes that actors and territorial experts have made a hard choice of indicators influencing decision-making in their territory.

The construction of the territorial participation indicator (ITP) is done based on the data of the profile of the actors and the experts of the territory.

We will propose an improvement of this model based on the aggregation approach of profile criteria of actors and experts, indicators of the territory, the nature of the territorial action and the dimensions of human development.

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