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PARTICIPATIVE DECISION-MAKING IN TERRITORIAL INTELLIGENCE

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ABSTRACT

In territorial cooperation or partnership context, the participation of the territorial actors and experts in public action can generally only be calculated by observing the geographical, anthropological, historical, economic, sociological and political stakes of territorial action. This research work proposes an improvement of our models of participatory decision-making in an environment of territorial cooperation or territorial partnership [1]. The main improvement of our model and the enhancement of the expertise and experience of actors and territorial experts, given the extreme importance of the latter in the regulation, orientation and negotiation of territorial action, this improvement based on fuzzy set theory, which used to solve complex and uncertain system problems.

Keywords: *Fuzzy Logic, Cooperation, Participation, Territorial Intelligence, Indicators, Decision-Making.*

1. INTRODUCTION

Assessing the impact of territorial action and determining development actions appropriate to a target territory, reducing development deficits has expanded worldwide. Faced with the geographical, anthropological, historical, economic, sociological and political issues of territorial action, the involvement of experts and territorial actors in the development of their territory becomes a critical and primordial requirement, this requirement which manifests itself through the degree of participation in territorial expansion and the influence of their profile on the clear and transparent decision-making to be taken.

Participatory decision-making bases on collecting information and indicators of each territory dimension, and it has become a mathematical approach[17]. This decision-making involves many criteria and sub-criteria used to classify and prioritize the alternatives of a decision, but also the profile of the experts and actors themselves according to an index of influence [5] according to sectoral interests, particular interests, even values and own conceptions of the public good, of conflicts/cooperation of territorial action.

Internal consistency describes how all the items chosen by the experts and actors measure the same concept. The complexity, the extent of the valuable information to evaluate each territorial dimension, and the choice of the essential items impose an internal coherence analysis. The Alpha index developed by Lee Cronbach in 1951 allows the measurement of the internal consistency of items helpful in evaluating each dimension. The Alpha index expresses as a number between 0 and 1.

The improvement of our decision model [1] aims to help actors and experts in their situations of territorial action by taking into account their expertise and their experience in the target territory; the latter is perceived in different aspects by several researchers from various disciplines show that the notion of "territory" is dynamic and multidimensional.

These dimensions are summarized by [3] in three dimensions, as shown in Figure 1, the physical aspect, the social and cultural dimension and the economic dimension.

After the first phase of our model consists in taking into account the expertise and experience of the actors in the choice of the most significant indicators of each dimension of the territory,

Moreover, the aggregation of these to produce the dimensional index following an analysis of the indicators most used to measure territorial action, a fuzzy model has been developed to use data sampled from different dimensional territorial indices, processed through fuzzy logic algorithms to represent uncertain data and handle ambiguous situations where traditional mathematics is ineffective.

This approach aims to provide experts and territorial decision-makers with an intelligent

multidimensional expert system for evaluating territorial participation via an intelligent and representative indicator.

Applying this expert system to the management of territorial action allows actors and experts to consider the subjective side of their decision-making. In addition, the flexible inference rules allow regulation of territorial action following unexpected risks.

2. THE PROPOSED APPROACH

The work aims to give territorial actors and experts a means of estimating the territorial participation index of different actors in territorial actions and help them make decisions concerning territorial development initiatives.

To do this, It will start with a brief overview of the concept of territorial participation and the importance of the multidimensional assessment of the state of territorial development as one of the needs the solutions for evaluating territorial action and, at the same time, time a factor that will determine the action regulation strategies to implement.

So we will introduce the main concepts used to improve our participation calculation model and show how to introduce these concepts to improve our models. We will then present the main territorial characteristics cited in scientific literature and the primary studies that demonstrate to what extent these characteristics can influence the impact of territorial action and the behaviour of actors and experts concerning this action.

This impact will lead us to propose our new model for calculating territorial participation using one of the AI techniques, which is Fuzzy Logic and taking into account the experience and expertise in the management of the territory.

We will first present the multidimensional concept of territory, its principles and rules of use, and then define the input and output variables according to the needs of our study, the membership functions, the linguistic values, the results and finally, a simulation will be carried out.

Finally, a discussion of the results will highlight the advantages and limits of this improvement and a conclusion that draws up the perspectives of this research.

3. RESULTS

3.1. The Territory as a Multidimensional Space

Many scientific studies have treated the notion of territory and considered it as a multidimensional notion.

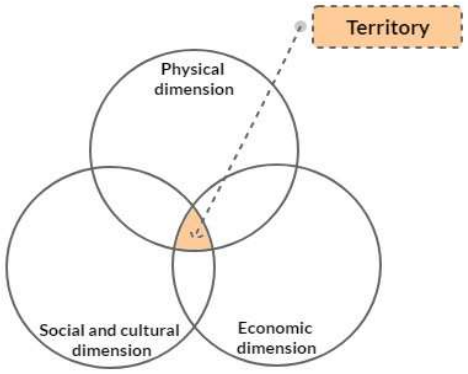
For Armand Frémont, (1976) [19]. The notion of territory imbue with cultural values, practices, representations and the spatial imaginations of the actors. For Guy Di Méo (1996), it expresses the social appropriation [18] of the geographical space by groups that give themselves an identity representation and finally translates the primordial link between Man and the Earth.

The territory [20] is also considered as a set of experimental conditions that ensure the existence of an individual or a group of individuals, it is represented [25] by any form of productive organization with shared rules and a border, a place of relations that can [21] be hierarchical, of domination, solidarity and complementarity and that cannot be explained by a single factor [22].

It is about the construction (Brunet, Ferras and Théry, 2009, quoted in Baudelle, Guy and Merenne-Schoumaker 2011: 16) of an abstract 'geographically delimited' space into a space of identity appropriated and managed by a social group that has a feeling of belonging and which is also aware of this appropriation.

The territory thus becomes a place (Pecqueur, 2014) in constant construction of actors' strategies and production of endogenous solutions based on a valorization of territorial resources.

These cited definitions of these researchers from various disciplines show that it is essential to understand that the concept of "territory" is a dynamic character and multidimensional. These dimensions are summarized by (Rebaï, 2016) in three dimensions, as shown in the figure, the physical aspect, the social and cultural dimension and the economic dimension.



Source: Diagram based on Rebaï, 2016 cited by Martinez Godoy, Diego 2016.

Figure 1: The Territory Understood As A Multidimensional Space.

3.2. The role of actors in the management of their territory

The participation of actors in territorial management is based on the common interest represented by the future and the territory's characteristics.

A territorial action is only viable if collectively designed and appropriated by all actors.

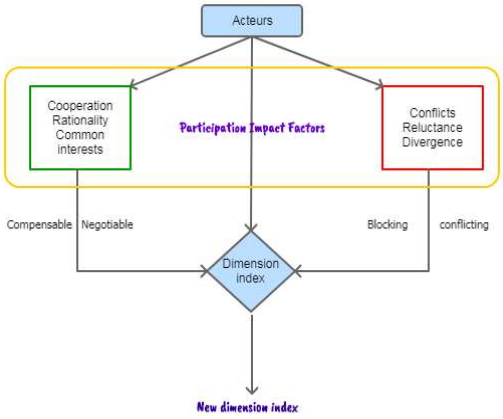


Figure 2: The participation impact factors.

The actor's involvement in the process of territorial action depends on all the factors that allow them to fit into the context of this action.

This involvement generates an influence due to the profile of the actors on each dimensional index of the territory, and this influence can be [5] Negotiable, Compensable, conflictual, Blocking or without interest.

3.3. Territorial Participation Methods and Discussion.

3.3.1. The territorial action

The current era of territorial action aims to improve the quality of human life by providing better opportunities in education, health, living standards, economic activity, housing and social services. Employment, a healthy environment guaranteed the physical well-being and the spirit of humans for local communities, hence [24] the need to think and plan at the territorial level, relying on the contribution [Roméo, L .2015] of actors operating at several scales and brings added value to territorial development efforts.

The territory is a system of action and actors [Guy Di Méo 2006] where an actor is a person who acts, more broadly, as an authority or an organization or a social group, possesses intentional and strategic skills and has a to operate and a power to provoke territorial action.

3.3.2. The participation concept

Participation [2] is used to characterize the integration of actors or groups of actors in a decision-making process that depends on a territorial action. The measurement of the participation index is a crucial parameter in the planning and implementation of the territorial activity.

Participation [16] is a mainspring of governance, anticipation, and its tool—the participation of local actors by creating collective wealth and sharing knowledge. Participation [15] defines territorial intelligence as an approach oriented towards the actors, therefore based on the accessibility of information technologies and cooperation between the actors.

The calculation of the participation indicator can be done by collecting indices and aggregating different indicators of each dimension of the target territory of the territorial action.

However, this estimation method requires establishing various information systems dedicated to data collection and analysis and communication systems between actors and groups of actors and significant facilities in terms of infrastructure.

The territory [2] simultaneously opens up participation to three different fields of constraints that overlap: the limit, the local and the spatial. A territorial decision implies considering the organization of the space concerned by the decision.

3.3.3. The new model

The improved model starts with:

The definition by the experts and the actors of a database of relevant indicators distributed by territorial dimensions, the internal consistency of the selected indicators is expressed in the form of an Alpha figure between 0 and 1.

Internal consistency describes how all items in a test measure the same concept or construct and are related to the interdependence of items within the test. We adopt the synthetic index defined by Lazarsfeld, which aims to produce, from the fundamental indicators, a single value intended to condense the information contained in the primary indicators constituted by the aggregation of the data contained therein.

The definition of the influence index of the profile of actors and experts by the territorial dimension of the nature of the territorial action is translated by different degrees of the membership function index.

Modeling of collected data with membership functions by fuzzification.

Decisions are made by fuzzy inference using decision-making rules.

After defuzzification, the model proposes participation regulation strategies as decision classes to regulators and territorial experts. They

can validate and apply the suggested decisions or suggest other decisions.

Finally, we show by the simulations presented on examples to what extent this methodology is applicable and how interesting it was to model knowledge and automate the decision-making process.

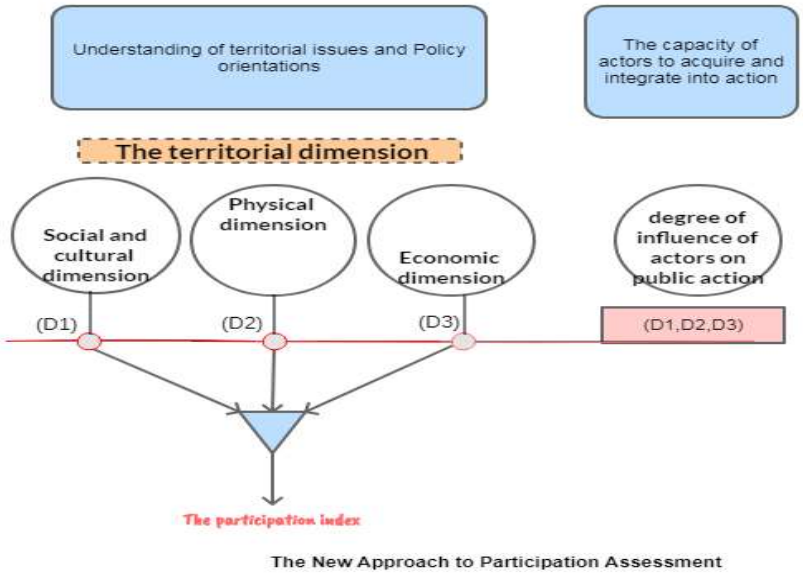


Figure 3: The New Approach To Participation Assessment.

4. DISCUSSION

4.1. Construction of indicators

The construction of a synthetic index by Lazarsfeld aims to produce, from the fundamental indicators, a single value intended to condense the information contained in the primary indicators constituted by the aggregation of the data contained therein.

The figure shows that the measurement of the synthetic index consists of aggregating the different indicators into a single significant indicator; fundamental indicators expressed in a collective unit, having no meaning individually.

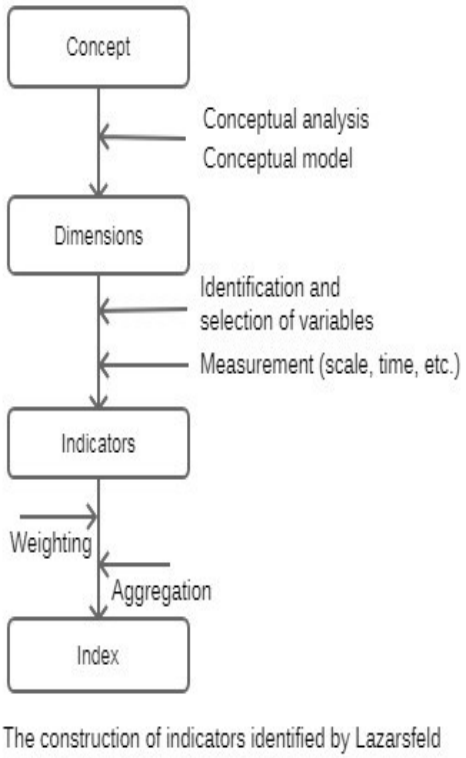


Figure 4: The Construction Of Indicators Indentified By Lazarsfeld Cited By Paul-Marie Boulanger 2004.

Given the scope of the territorial indicators, the reliability of the measurement of the synthetic index of the different indicators must select the significant items to measure the same concept.

Lee Cronbach in 1951 to provide an alpha measure of the internal consistency of a test or scale; it expresses as a number between 0 and 1.

After that, statistical tests of homogeneity are applied to the indicators grouped by dimension, and these indicators make it possible to retain elementary indicators which express the cumulative achievement for each dimension.

The dimensional index is a composite measure following an aggregation approach of several cumulative progress indicators for each dimension of the territory, calculated by the simple arithmetic mean:

idem : dimensional index of each dimension between 0 and 1.

$$idem = \frac{\sum_1^n index_i}{n} \quad (1)$$

Zadeh offered a powerful tool for modelling complex systems with approximate or imprecise specifications by introducing fuzzy set theory. Unlike classic models that describe a relationship by mathematical law, the fuzzy model describes it linguistically, with an unprecedented ability to synthesize information and process imperfect, incomplete, approximate and vague knowledge and subject to measurement errors.

The fields of application of fuzzy logic have multiplied since the end of the sixties. The fuzzy set theory used in several varied fields: medicine and biology, industrial engineering, technology, economy, defence, ecology, human sciences, and scientific research.

The fuzzy classification is characterized by:

- Ability to manipulate linguistic values, as is the case with humans.
- The representation of imprecision and uncertainty of a human expert. This property is fascinating because human knowledge often inspires the fuzzy model.

The model's configuration shown in Figure 1 is composed of different sets of knowledge levels. Inputs for each level of knowledge represent parameters that can supply by the user or composite indicators collected at other levels of expertise. Expert system inputs are combined with varying degrees of the membership function index Table 1 to produce a composite output indicator that represents an input to the next level of knowledge

Table 1:*The Degree Of The Membership Function Index*

Degree of fuzzy membership	Numeric Value	Influence situation actors
not	-	Blocking situation
somewhat	.05	Conflicting situation
very	.20	Negotiable situation
extremely	.30	Motivating situation

4.2. Presentation of Fuzzy Logic

Fuzzy logic is a logical system presented by Professor Lotfi A. Zadeh (University of California, Berkeley) in 1965, the application of this logic has considerably increased in recent years in several fields, particularly in the control of industrial processes to help systems to the decision and in many problems, uncertainties in knowledge and inaccuracies in the quantities measured various applications.

Fuzzy logic is conceptually easy to understand, straightforward reasoning with a more intuitive approach without great complexity, flexible and tolerant of inaccurate data.

The three components of a logic system are fuzzification, fuzzy inference engine, and defuzzification.

4.3. The fuzzification

The actors and experts of the territory confront the complexity due to the territory's financial, technological, legal and human components, an environment dominated by uncertainty and a daily volume of information resulting from individual or collective exchanges.

Therefore, it is essential to take into account the experiences acquired by the actors and experts of the territory.

Fuzzy logic offers the possibility of making decisions and modelling indicators by fuzzification, which transforms the actual variables to be studied as input and output into a numerical/linguistic conversion by assigning them degrees of belonging to fuzzy subsets.

The same membership function, μ(x), represents all the different indicators.

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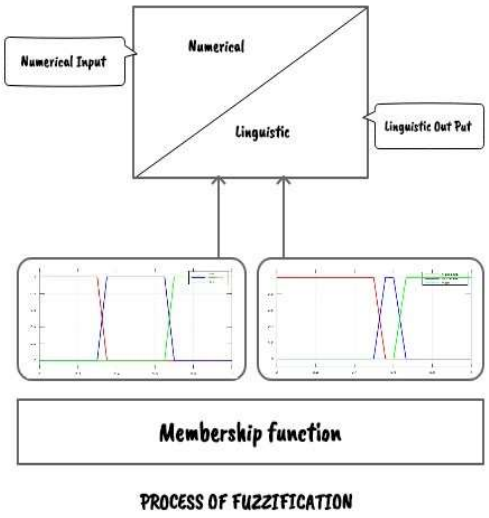

Figure 5: *Process Of Fuzzification[1].*

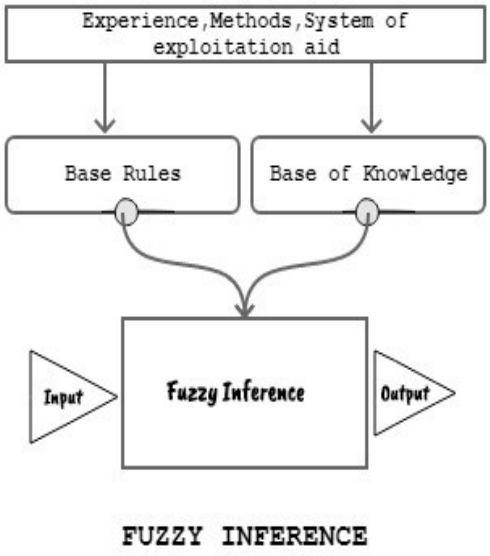

Figure 6: *Fuzzy Inference [1]*

4.4. The Fuzzy Inference engine

Unlike classical binary logic, where membership in the set must be "true" or "false", fuzzy logic admits degrees of membership in a given set.

Fuzzy inference allows us to develop a decision using the decision rules to express the degree of membership.

The influence of the actor profile on the index of the membership function is expressed as follows:

"not" - add a minus sign to the index of the membership function to denote a deadlock situation.

"a little" - add ".05" to the index of the membership function to denote a conflict situation.

"very" - add ".20" to the membership function index to denote a Negotiable situation.

"extremely" - add ".30" to the membership function index to denote a motivating situation.

Actors and experts can customize the degree of their influence and define justified values by adding .xy, where XY is the degree to which the membership value should be increased, to the index of the membership function.

If (in_1 is very Developed) and (in_2 is not Developed) and (in_3 is Developed) then (out_1 is somewhat Developed) (1).

4.5. Defuzzification

Fuzzification is the Linguistic/Numerical conversion of different variables characterizing the overall efficiency. The method that uses here is the centre of gravity method. This method takes into account all available information.

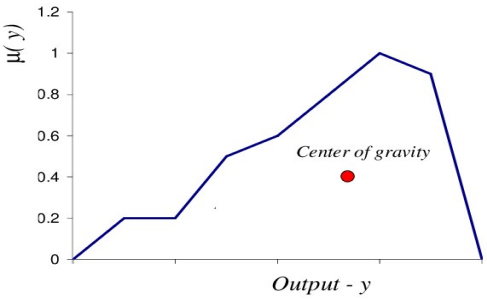

Figure 8*: Center Of Gravity[1].*

$$y_0 = \frac{\int_y^Y y \times \mu(y)dy}{\int_y^Y \mu(y)dy} \dots\dots\dots\dots\dots\dots\dots\dots (1)$$

The output variable of the model is represented by a fuzzy index which indicates the intelligent monitoring of the territorial participation index concerning the applied territorial actions (ITP). This index comes in the linguistic form described as “Negligible”, “Medium”, and “Important”.

4.6. Our Method of participation estimation

The characteristics of the territorial actors (Bressers, 2004) (motivation, information and

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balance of powers) have the power to influence the probability of implementing a territorial action.

The territorial dimension of participation aims to consider the characteristics of the stakeholders and the territory in territorial decisions.

We wish to make the automation and digitization of information from different dimensions of territory and profile actors to reveal other opportunities/constraints to participation.

In this article, we will present an improvement in calculating the territorial participation index (ITP). For this, we have seen in the literature how the territory represents in the form of three dimensions (the physical aspect, the social and cultural dimension and the economic dimension) and how the dimensional index can be calculated from sub-dimensional indices and finally, how the profile actors can influence territorial action. We will use the terms "low", "medium", and "high" to describe the ITP index.

The formula of the different indicators influencing participation in the development of the territory:

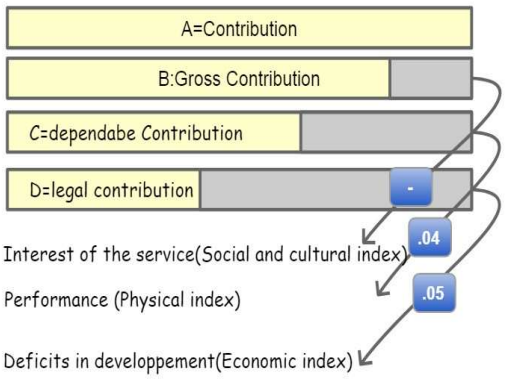

Figure 7: The Formula Of Indicator Of Territorial Participation.

$$ITP = \left(\frac{A}{B}\right)^{d1} x \left(\frac{C}{B}\right)^{d2} x \left(\frac{D}{C}\right)^{d3} \quad (2)$$

ITP est l'indice de participation territorial.

II est l'indice dimensionnel représentant la dimension sociale et culturelle du territoire objet de l'action territoriale.

$$II = \left(\frac{A}{B}\right)(indicateur\ de\ l'interet)$$

IP Is the dimensional index representing the economic dimension of the territory covered by the territorial action.

$$IP = \left(\frac{C}{B}\right)\ (indicateur\ de\ performance)$$

IC Is the dimensional index representing the physical dimension of the territory subject to the territorial action.

$$IC = \left(\frac{D}{C}\right)(indicateur\ de\ capacité)$$

di The degree of actors influences each dimension of the target territory of the action.

4.7. Our fuzzy system

Our new model begins with defining a database of indicators based on the expertise and accumulated experience of experts and actors.

The actors and experts also define the vector of influence of their profiles on each dimension of the territory of the planned action.

The next step is the aggregation of the fundamental indicators of each dimension.

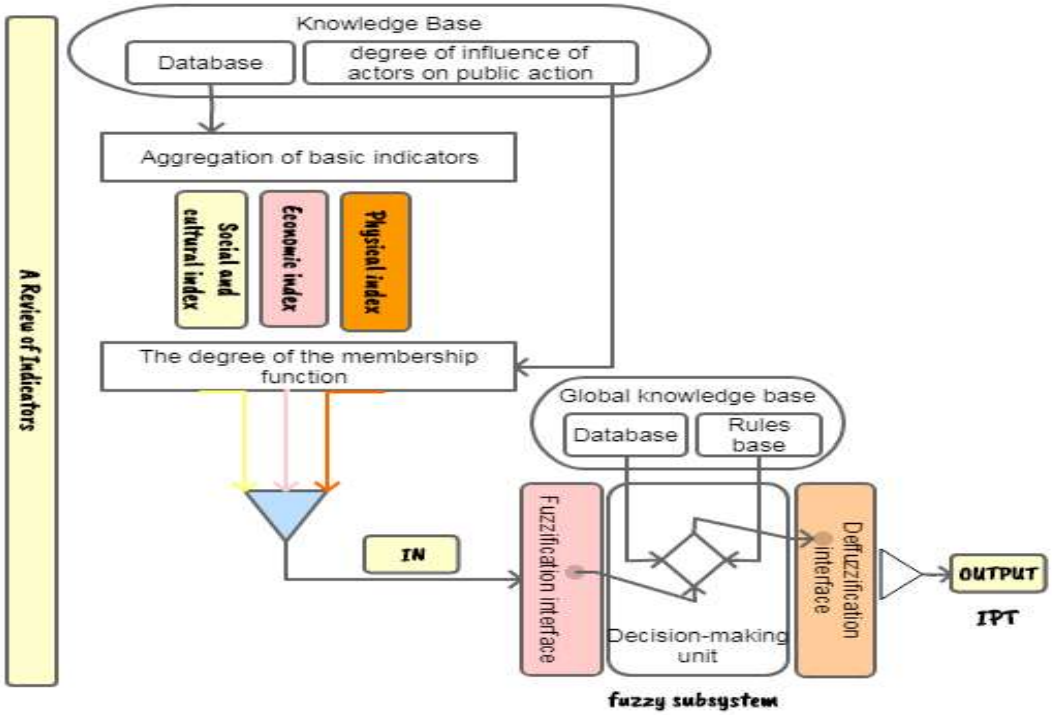

Figure 9: The Model To The Review Of ITP Indicator.

4.8. Results interpretation

After having built our new fuzzy inference system with the new improvements that emphasize the importance of the involvement of actors in the process of territorial action, we will be able to read, interpret and analyze the results of the defuzzification.

The graphical interpretation of the solution will allow us to understand the relationship between the territory's three-dimensional indicators and identify the influence of the involvement and commitment of territorial actors on the territorial participation index.

To do this, we take the two cases covered by our article [1], and we will integrate the new parameter of the influence of the actors.

Use case N°1: Medium Capacity index.

If the territorial action represents a significant common interest for all the territory actors, this involvement of the actors positively influences the dimensional indicators of the territory defined above.

In the case where the value of the IC indicator is set to the average value: (X, Y, MED), The indicator of capacity is fixed in advance: Medium.

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

It is assumed that the actors maintain a negotiable position about the economic dimension of the territory and an extreme satisfaction concerning the social and cultural dimension.

The influence vector (Vp,Vi,NaN):

Vp: vector of influence on the performance dimension (.05, .20, .0)

Vi: vector of influence on the interest dimension (-, .30, .0)

Example of a new model fuzzy inference rule:

- If (The performance index is Negligible) and (The interest of service index is **extremely** Medium), then (The territorial participation index is Medium) (1).

The Old solution curve:

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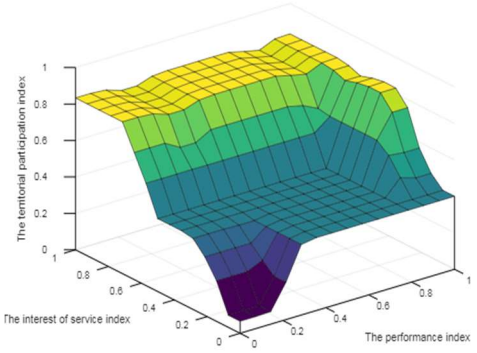

Figure 10: The Curve Of The Case N°1 (MED, X, Z) Result.

The new graphical representation:

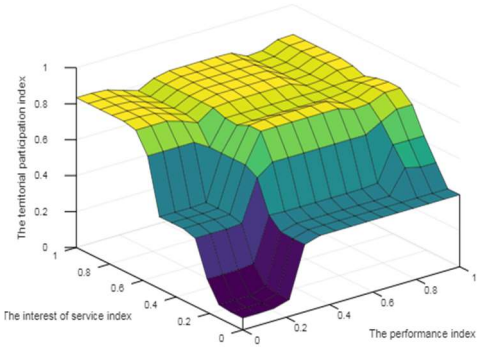

Figure 11: The Curve Of The Case N°1 (MED, X, Z) Result.

The influence of the position of the actors concerning the territory action is apparent on the graph. The comfort zone of the index is much improved following the influence of this favourable position is favourable to the actors for the action.

Use case N°1: Medium interest index.

It is assumed that the actors maintain a conflicting position with the economic dimension of the territory and satisfaction with the physical dimension of the territory.

The indicator of interest is fixed in advance: Medium.

(MED, X, Z)

MED Indicator of Interest.

Y Indicator of Performance.

Z Indicator of Capacity.

The influence vector (Vp,NaN,Vc):

Vp: vector of influence on the performance dimension (.0, .05, .05)

Vc: vector of influence on the interest dimension (.0, .20, .0)

Example of a new model fuzzy inference rule:

- If (The capacity index is **very** Moderate) and (The performance index is **somewhat** Important), then (The territorial participation index is Medium) (1)

The old solution curve:

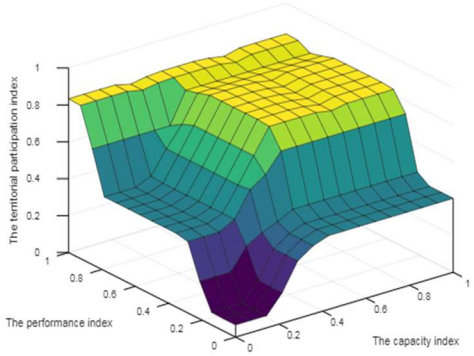

Figure 13: *The curve of the case N°1 (MED, X, Z) result.*

The new graphical representation:

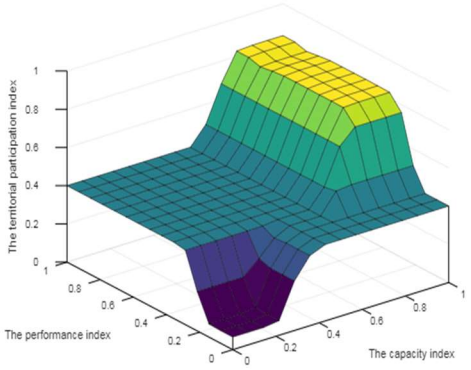

Figure 14: The Curve Of The Case N°1 (MED, X, Z) Result.

The influence of the conflicting position of the actors in relation to territorial action limits the comfort zone of the territorial participation index.

4.9. The contribution and limitations of our paper

Given that there are several indicators for each dimension of the territory involved in the management of territorial action, it turns out that the indicators cannot be subject to a direct and observable influence.

The indicators choice is the work of the experts, and we have presented an approach to follow in our model. This work does not cover the automatic selection of the indicators to consider for our fuzzy expert system.

The originality of our method for estimating territorial participation is, on the one hand, useful upstream of any territorial action.

On the other hand, it does not content itself with observing and piloting territorial action in its development and implementation at the territorial level but goes beyond and takes into account several dimensional indicators of the territory to understand the future of the action and its impact also to predict the degree of commitment of the actors vis-à-vis a given action.

5. CONCLUSION AND PERSPECTIVES

In this article, we have presented our approach using fuzzy logic techniques to help territorial actors and territorial experts solve the problems of participation in developing their territory in a framework of cooperation or territorial partnership. We have shown 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 allow actors and experts to capitalize on their experiences acquired over time and deal with problematic situations. A single actor cannot manage alone.

This proposed technique highlighted the expertise of the actors on two levels. The first is the difficult choice of indicators influencing the decision-making for each dimension of their territory, based on the approach of aggregation of elementary indicators to produce a significant dimensional indicator of the territory and the nature of the territorial action, and the second level is the self-assessment of the influence of their profile on the different dimensions of the target territory of the territorial action.

An improvement of our model is based on the aggregation of fuzzy logic and the notion of emotion.

The objective of this aggregation is to describe participatory decision-making in a hedonistic way and to translate the attitude, attachment, and solidarity of an actor towards his territory (Lalli, 1992; Mc Andrew, 1994; Frisou, 2011).

The selection of the action and its deployment on the scale of the territory supposes a particular relational link between the actors and the territory [Syrine Ben Slymen 2014] and, finally, an application to the Moroccan context.

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