FUZZY IMPACT ASSESSMENT ON THE LANDSCAPE: THE KOBOLD PLATFORM IN THE STRAIT OF MESSINA CASE STUDY

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This paper introduces a new semi-quantitative method to model a landscape assessment, by using a fuzzy analysis approach. The main aim of this research is to evaluate the landscape impact of the Kobold prototype in the Straits of Messina. The Kobold turbine, patented in 1998, is a prototype used to extract energy from the marine currents utilizing a vertical axis turbine. The site where the plant is positioned is very close to Ganzirri (Italy), on the Straits of Messina, near the Sicilian coast, at a distance of about 150 – 200 m from the shore. The results allow us to state that the measure of the impact landscape has been a huge success. In fact, the fuzzy variable representing the impact is 98% below the tolerance threshold.

Keywords: *kobold prototype, landscape assessment, fuzzy analysis*

JEL Classification: *D78, R11, Q21*

1. INTRODUCTION

All sources of renewable energy such as wind, photovoltaic panels, biomass and marine currents are becoming an important source of energy for a growing number of communities in developing countries. The rapid growth of population, the increasing demand for energy, the need for a better quality of life especially in rural areas, attract more attention and interest on renewable energy sources.

To address this important issue of social and economic development, the use of a independent system production of energy from marine currents could provide an appropriate solution.

The main aim of this paper is to evaluate the landascape impact of Kobold platform in the Strait of Messina. This is a prototype that uses the marine current to extract energy.

The landascape evaluation have the beauty as fundamental criterion because the people of Faro and Ganzirri are placed in full sharing and consistency with the broad community, that through the European Landscape Convention, presented for the subscription of the Member States of the Council of Europe October 20, 2000, enshrines the principle that the whole landscape should be of concern and recognizes that the landscape is everywhere an important element of quality of life for people: in urban areas and the countryside, in degraded areas, as in those of high quality, in areas considered to be exceptional, as in those of everyday life (the European Landscape Convention, 2000). Throughout the territory means that the European Convention includes land, inland and marine waters (European Landscape Convention, 2000).

2. PLATFORM DESCRIPTION

The Kobold turbine is the result of many years of development from an idea of Ponte di Archimede SPA; his technology was patented in 1998. The main concept is to extract energy from the marine current utilizing a vertical axis turbine. The advantages of the vertical axis turbines are the building simplicity and that always rotates in the same direction.

The Kobold turbine has been designed to satisfy, at the highest possible level, the environment safeguard and efficiency needs, as well as the necessities of low construction and maintenance costs. The characteristics of the Kobold turbine are the following:

- Direction of rotation independent of marine current direction;
- A very high starting torque, which makes the turbine able to start spontaneously, also in loaded conditions, thus eliminating the necessity of a starting devices.

The airfoil used for the turbine blades is a new concept unsymmetrical profile, so called HILIFT 18, designed for this purpose by the Department of Aeronautical Engineering of the University of Naples using numerical codes, taking into account both the maximization of the turbine performances and the risk of the cavitation which would quickly damage the blades. The main turbine and platform dimensions are the following (see Figure 2.1):

Turbine

- Diameter: 6 m
- Chord: 0.4 m
- Blade span: 5 m
- N° of blades: 3

Platform

- Diameter: 10 m
- Depth: 2.5 m
- Metacentric height: 5 m
- Draught: 1.5 m
- Steel weight: 25.0 t
- Displacement: 35.0 t

The 3-bladed turbine rotor is mounted under a round shaped platform of 10 m diameter. The buoy was built in steel according to the Italia Shipping Register (RINA) regulations for steel ships and was certified by RINA.

The metacentric height parameter indicates the stability characteristics of the floating platform: the bigger is the metacentric height, the higher is the platform stability. If compared to a standard ship with the same displacement, the platform stability is about 6 times greater.

The measured global efficiency was around 25%, which is comparable to the long time well developed wind turbines and so this first results can be considered excellent even because on-going improvements in the mechanical transmission system will certainly rise the global efficiency very soon.

The plant has been permanently connected to the Italian electric grid. The energy is produced by the system at any angular velocity and, since there is no blade-pitch control, the turbine rotates at any velocity, depending only on the current speed.

To meet the grid requirements a static rectifier-inverter was installed on board in order to have, no matter the turbine speed, always the same electrical output in terms of voltage and frequency, and always in phase with the national grid.

The platform is moored to the seabed by four mooring lines, each made of a textile rope connected to a chain that is connected to a mooring block at the sea bottom. The 4 mooring blocks are made of concrete weighs 35 t each.

The site where the plant is positioned (Figure 2.2) is very closed to Ganzirri, in the Strait of Messina, by the Sicilian coast, distant from the shore about 150 – 200 m. The depth varies from 15 to 35 m and the maximum current speed is around 2 ms^{-1}.

The moorings, due to the weight of the lines, work like non-linear, exponential springs, following the catenary's law. This means that if the displacement of any line is a little more than the others, the force of this line will be much greater than the others, thus the mooring lines work only one at a time, especially at high thrusts.

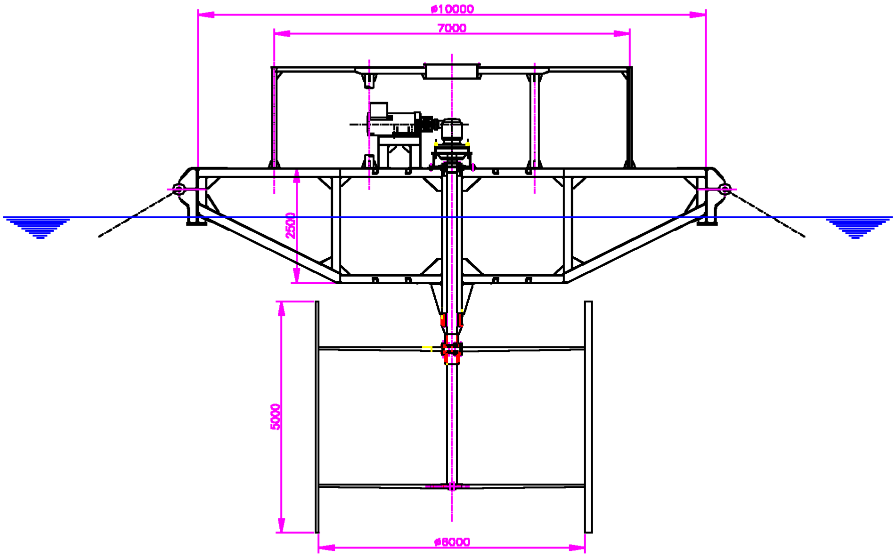

Figure 2.1. Kobold platform: hull floating and the turbine

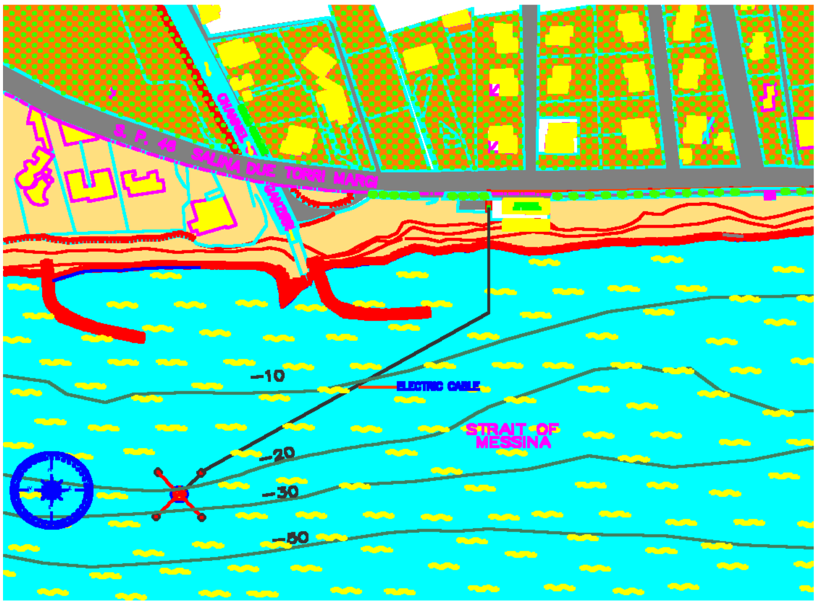

Figure 2.2. Mooring site of the Kobold platform in Ganzirri, Strait of Messina

3. THE METHODOLOGY OF EVALUATION

It is quite clear that when plans to evaluate the landscape impact of a project, or as in our case of a prototype, the object in question is not the design/prototype itself, but the design/prototype which participates in a landscape, or the ratio, the relationship between the design/prototype and the landscape context.

Any intervention can be considered as a perturbation of the state of affairs, whose noticeably is certainly proportional to the clear recognition and characterization of the landscape where they work (Regione Lombardia, 2002). In the conceptual approximation described above we can define the landscape impact I as:

$$I = S \times i$$

Where S denotes the sensitivity of the site and i shows the impact of the project/prototype, i.e. the perceptual measurement of disturbance produced.

To identify the sensitivity of a place and the impact of a project/prototype we refer to the methodology described in the aforementioned Guidelines of the Regione Lombardia.

Opinion is widely shared by scientist that the landscape marked by the most recent transformations are usually characterized, as compared to those of the past, from a loss of readability of the relationships between natural factors and human endeavour, as loss of linguistic consistency and organic (in the sense of complexity) space. For this reason, in estimating the sensitivity of a site you should review the membership of the site in recognizable landscapes and readable as structural systems (natural and anthropogenic), strongly related and also featured from common linguistic and formal characters.

This is not the only level of evaluation of the sensitivity of a place because, of course you must consider the conditions of co-visibility between the site and seen around.

Finally, to characterize the sensitivity of a place, you must consider anthropic and social issues related to values that society attaches to areas of interest, in relation to the symbolic values associated with them (celebration of literature, painting, history, local legends, etc.).

Ultimately, the overall assessment of the sensitivity of the landscape, in the model used here, considers three different modes of assessment:

- Morphological-structural
- Visual
- Symbolic

Each mode of assessment will be applied to different levels of reading: supra-local (wide area) and local (site of the intervention in the strict sense).

The following table summarizes and explicates the grids and the reading levels for the assessment of the sensitivity landscape of a place.

Evaluation criteria	Supra-local level	Local level
Systemic	Participation in landscape system of supra-local interest in geo-morphology, natural, historical settlements, archaeological, cultural and formal	Membership/contiguous landscape system of local interest in geo-morphology, natural, historical settlements, archaeological, cultural and formal
Visual	Perceptibility of a large territorial area - interference with scenic routes of supra-local interest	Interference/proximity to points of view on a small scale - Interference/proximity to locations of landscape-environmental use - Interference with perceptual significant relationships between local elements
Symbolic	Belonging to areas subject to large celebrations literary, artistic or historical - belonging to areas of high repute	Interference/proximity to places marked with a status of representation in the local culture

In a similar way we can proceed to build an evaluation grid of the impact of the project/prototype of places:

Evaluation criteria	Supra-local level	Local level
Morphological impact	Consistency, conflict or indifference of the project / prototype compared to natural forms, systems of natural interest, rules of composition and morphology of the landscape	Preservation or alteration of the morphological features of the place - preservation or alteration of the continuity of the relationship between art historical and natural elements
Linguistic impact	Consistency, conflict or indifference of the project/prototype with respect to linguistic ways	Consistency, conflict or indifference of the project/prototype with respect to linguistic ways

	(colours, styles, materials) typical of the vast area	(colours, styles, materials), typical of the context, understood as the immediate surrounding
Visual impact	Visual clutter - colour contrast - profiles and sky-line alterations	Visual clutter on low scale - concealment of relevant visual
Environmental impact	Alteration of the ability to use general sensory (auditory, olfactory) of the landscape-environmental context	
Symbolic impact	Adequacy of project/prototype compared to the symbolic and celebratory values of the vast area	Image design capabilities to relate properly with symbolic values attributed by local communities to the site

To exit from the absolute subjectivity, albeit governed by the evaluation grids explained above, from the renunciation of repeatable measurable impact landscaping and the conflict of interest that often links the designer (the scientist) at the outcome of impact assessment, we introduce a methodology, absolutely innovative, which we can define experimental-statistical-quantitative and uses fuzzy logic as a mathematical reference. For a theoretical review see Zadeh (1965), Klir and Yuan (1995), and Bonarini (2003).

To define what is a fuzzy set, consider first the concept of a traditional set, later called crisp set. A set is composed of all elements of the universe that satisfy a given membership function. For a crisp set membership function is Boolean, that is associates with each element x of the universe a value “true” or “false”, depending on x “belong” or “not belonging” to set.

But there are more qualitative concepts or where there are irreducible complexity of positions, of views for which it makes sense to define membership functions for a set, that returns intermediate values in the range 0 “false” - 1 “true”. This allows to define “how” it is considered an element of universe that belongs to the set, and thus allows to give an intermediate degree of membership between the Boolean true or false. Given a universal set U, a subset of A is fuzzy if the elements $x \in U$ that compose it, belong it to a certain degree $\mu(x)$, expressed with a number between [0, 1]; if the membership is complete $\mu(x)$ will be 1, if any $\mu(x)$ will be 0, but in general will be $0 < \mu(x) < 1$.

Consequently, the term fuzzy number (Figure 3.1) means a number characterized by a certain membership function as opposed to crisp numbers (Figure 3.2):

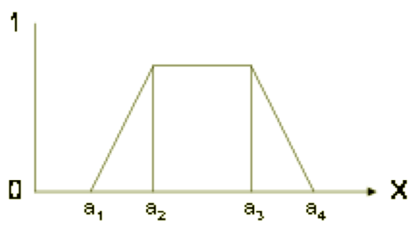

Figure 3.1. Typical fuzzy number

Figure 3.2. Typical crisp number

A fuzzy number, depending on its shape, can be identified by a vector of numbers. For example, the trapezoidal variable represented in Figure 3.1 can be identified by the array (a_1, a_2, a_3, a_4, a_5).

Now consider two generic fuzzy numbers A = (a_1, a_2,…, a_i), and B = (b_1, b_2,…, b_i). Under the so-called extension principle we can define:

$$A\ (+)\ B = (a_1, a_2,\dots, a_i)\ (+)\ (b_1, b_2,\dots, b_i) = (a_1 + b_1, a_2 + b_2,\dots, a_i + b_i)$$

$$A\ (-)\ B = (a_1, a_2,\dots,a_i)\ (+)\ (b_1, b_2,\dots,b_i) = (a_1 - b_1, a_2 - b_2,\dots,a_i - b_i)$$

$$\lambda\ (x)\ A = \lambda(a_1, a_2,\dots,a_i) = (\lambda a_1, \lambda a_2,\dots,\lambda a_i)$$

Operations just defined allow us to calculate the averages of fuzzy variables.

At this point, the objective is to define and calculate the sensitivity class of the site, the degree of impact of the project and therefore the impact I through the variables and operations defined in fuzzy logic, then to check what percentage of the impact I belongs to values set and are below the relevance threshold, between the relevance and tolerance threshold, and over the tolerance threshold.

4. THE MAIN RESULTS

The transition from a single assessor to a valuing statistical universe is the first important conceptual step to overcome the subjectivity and often arbitrariness inherent to traditional impact analysis. The evaluation of the sensitivity of the site is entrusted to a group of people with scientific, institutional and interdisciplinary characteristics, experts of the Strait of Messina in the fields of marine ecology, environmental engineering, architecture and landscape protection, marine archaeology, oceanography physics, literature and visual arts, ethno-anthropology. The impact assessment of the project is evaluated through a field research carried out on an adequate sample size of the population of Torre Faro and Ganzirri, and research objectives.

The tables, above developed, which explain the grids and reading levels for the landscape sensitivity assessment and the degree of impact of the site, so much easier can be transformed into two different closed questionnaires constructed through a series of questions to each of which can answer graded from 1 to 5.

Table 4.1. Table of landscape impact

		Landscape Impact= Sensibility x Incidence				
		Project Incidence Level				
		1	**2**	**3**	**4**	**5**
Sensibillity Class	**1**	1	2	3	4	5
	2	2	4	6	8	10
	3	3	6	9	12	15
	4	4	8	12	16	20
	5	5	10	15	20	25

Landscape impact below Importance threshold

Landscape impact above importance threshold but below tolerance threshold

Landscape impact above tolerance threshold

The two questionnaires were administered: the first, on the sensitivity of the site, to a scientific and institutional sample (as just described); the second, on the impact of the project, to a sample of population randomly selected from the Phone List. The number of extractions (> 200) ensures that the sample is representative of the universe. Although the statistical literature is pointed out that the use of Phone List has a small source of error due to the fact that they are including only telephone subscribers, however, in this case, given the now very large spread of the phone, this error is negligible. The chosen ones have been achieved by the interviewers previously trained. The sample, given the homogeneity of the universe and the amplitude of itself, may be considered appropriate to ensure a high quality of the data[1].

The answers to each question of both questionnaires, giving rise to a distribution scores (note, from 1 to 5) that, properly normalized to 1 in the integral, can be reinterpreted as a fuzzy number, expressed through an array of 5 numbers.

Here we show in Figure 4.1 the fuzzy number that represents the degree of impact of the project. It was obtained by calculating the mean of fuzzy numbers for each request of a questionnaire.

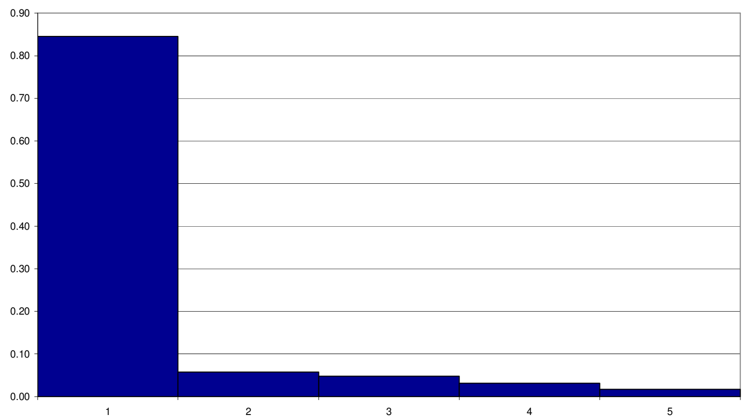

Figure 4.1. Distribution and fuzzy variable of the project/prototype incidence

It seems clear that there opinion is strongly supported by the local population on the low incidence of project/prototype. The fuzzy variable appears in fact as a crisp number, with smooth slow decay, characterized by very low values of its coordinates.

[1] It was not deliberately intended to refer to the concept of significant sample often criticized in the literature. The amplitude was chosen in relation to the type of crosses that were going to do taking care to avoid that, because of non-response and the size of the subgroup, analysis were done on small samples of data (Bailey, "Metodi della ricerca sociale", Il Mulino 1991).

Read less obvious feature is the fuzzy variable characteristic of the site sensitivity, shown in Figure 4.2.

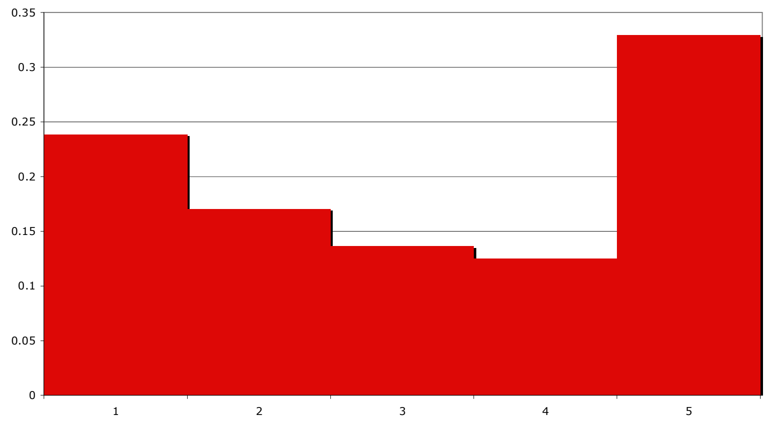

Figure 4.2. Distribution and fuzzy variable of the site sensitivity

In it results the overlap of the different opinions that the scientific-institutional group expresses on the degree of sensitivity of the large area (the Strait of Messina area), and the local level (the site of intervention). To clarify this point, we show separately the fuzzy variables, respectively obtained by calculating the average values for the supra-local and local level:

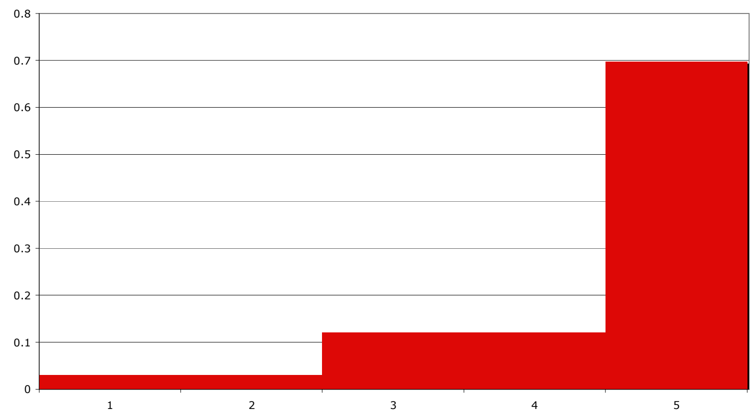

Figure 4.3. Distribution and fuzzy variable of the wide area

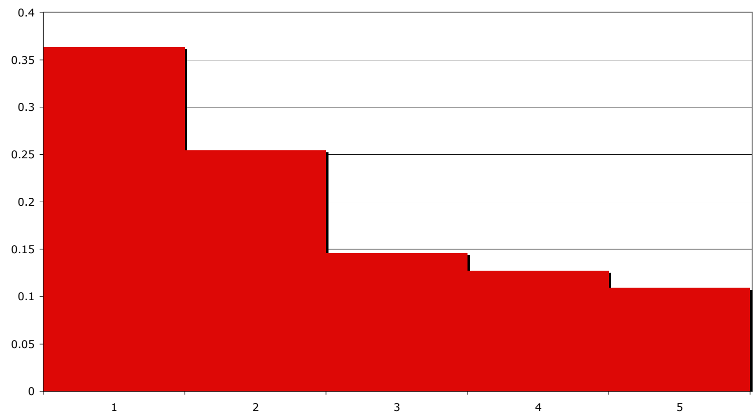

Figure 4.4. Distribution and fuzzy variable of the site of interest

As is clear from the geometrical characteristics of fuzzy variables, the group who received the questionnaire expresses an opinion is strongly supported on the high degree of sensitivity of the Strait, and a medium-low degree of sensitivity of the site concerned by the intervention, although in the local case the function decays very slowly and this means that the experts interviewed have different positions depending on the discipline from which you view the site. This separation clearly explains the overall shape of the fuzzy variable.

At this point we only have to define the impact I as a fuzzy variable represented by three-dimensional array:

$$I_{ij} = S_i \times i_j$$

The following graph (Figure 4.5) shows the impact I obtained, through the display of values in the points ij of the sensitivity/impact plane:

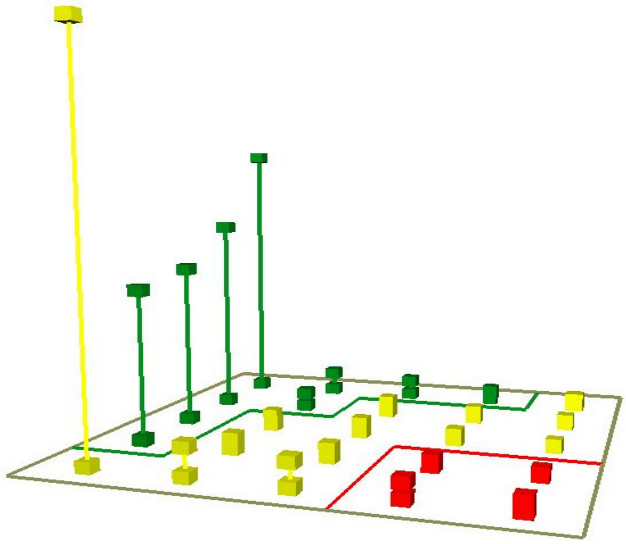

Figure 4.5. Impact in the Sensitivity/Impact plane

The fuzzy variable representing the impact is 61% below the relevance threshold, and 98% below the tolerance threshold.

This result allows us to state that the measure of the impact landscape has been a huge success.

REFERENCES

BONARINI, A. (2003). "Sistemi Fuzzy". *Mondo digitale,* No.1, p. 3-14.

GIL ALUJA; MARINO, D.; MORABITO, F.C. (2004). *Techniques and Methodologies for the Information and Knowledge Economy.* Falzea Editore.

GIUNTA, G.; MARTIGNETTI, L.; SCHÜLTER, R. *et al.*, (2006). *Shortcut – guidelines for a TSR® process*. Mesogea.

KLIR, G.J.; YUAN, B. (1995). *Fuzzy sets and fuzzy logic. Theory and applications*. Prentice Hall, Upper Saddle River, NJ.

MARINO, D. (1999). "Territorial Economic Systems and Artificial Interacting Agents: Models Based on Neural Networks". *International Journal of ChaosTheory and Applications.*

MARINO, D. (2004). *Scelte sociali, decisioni pubbliche e sotenibilità: teorie, metodi politiche*, ESI, Napoli, p. 1-166.

REGIONE LOMBARDIA. (2002). *Linee guida per l'esame paesistico dei progetti*. D.g.r. 8 novembre 2002 N. 7/11045.

ZADEH, L. A. (1965). "Fuzzy sets". *Information and control,* Vol. 8, p. 838-353.