Comparison of Crisp and Fuzzy Logics on the Location of a Gauging Station

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Abstract

The traditional logic (crisp) is based on the dichotomy of true and false, what is not true is false and what is not false is true. Half term does not exist. However, the real world presents some situations where the answers true and false are not enough to represent the reality. Using this idea, it was applied, in this paper, the logics crisp and fuzzy to a problem of choose of place for the implantation of a gauge station in a watershed. COPPETEC-COSENZA model for crisp logic and operation with triangular numbers in electronic spread sheet (fuzzy) were adopted. The same results had been presented with regard to the adequateness to the implantation of the gauge station.

Index terms— fuzzy logic, crisp logic, gauging station, hydrology.

1 Introduction

he traditional logic, called Aristotelian logic or Boolean, assumes a reality there only exists true and false, yes and no, [1]. However, humans function in a vague manner, using as often as possible words such as: warm, not so much, perhaps, more or less, and other words that belong to the infinite universe located among true and false, yes and no, [2]. To this logic, which treats the cloudiness present in many of the processes of daily life, it is given the name of fuzzy logic. With that in mind, we tried to address in this paper the application of crisp and fuzzy logic to a problem of locating a gauging site in a given river basin. Regarding the application of the crisp logic it was applied the COPPETEC-COSENZA model, [3]. Regarding the fuzzy logic, it was applied the operation with triangular numbers in an electronic worksheet.

2 II.

3 How it works

The human operators control very complex processes, based on inaccurate or approximate information or about what is being regarded. The manner how the human brain works in processing this information is also of imprecise nature and, in general, is able to be expressed in linguistic terms. The fuzzy logic, as its sets and its theories, can be used to translate imprecise information into mathematical terms expressed by a set of linguistic rules, [4].

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The fuzzy logic, as its sets and its theories, can be used to translate imprecise information into mathematical terms expressed by a set of linguistic rules, [4].

In this case, the variable is a linguistic variable. In order to illustrate, the values of the fuzzy temperature variable could be expressed as high, not high, quite high, very high, not very high, high but not too high. In this context, the temperature variable is a linguistic variable.

The main function of the linguistic variables is to provide a systematic manner to an approximate characterization of complex phenomena or badly defined. In essence, the use of the type of linguistic description taken on by humans, and not quantified variables, allows the treatment of very complex systems to be analyzed through conventional mathematical terms, [2].

4 III.

5 Application to a Gauging Site

The implementation of a gauging site consists on the installation of a stage gauge or a water-level recorder that enables the knowledge of the water levels. Figure 1 presents a photo of a stage gauge installed on the Guandu river bank, located in Rio de Janeiro State, Brazil. It is necessary to know the water levels and flow rates associated to support the management of water resources, highlighting the activities of planning, uses, reservoirs operation, navigation, recreation, flood risks, land use and occupation, erosion and environmental protection. Data on water levels, combined with the results of measurements of flow, allow the establishment of a relation called rating curve. Thus, the rating curve is a graphic representation of this relation, which involves geometric and hydraulic characteristics of the measuring sections and the considered section of the river.

For the present paper, a hypothetical basin was defined, as shown in Figure 2, where three river sections were selected with the following characteristics: It was assumed the same hydrometric team responsible for gauging site. IV.

6 Simulation through Electronic Worksheet

The triangular fuzzy numbers representing each attribute of demand and offer are presented in Tables 1 and 2 and their graphical representations in Figures 3 and 4. Demand L M R Gt 2 3 3 G 1 2 3 R 0 1 2 W 0 0 1

Note that the letters L, M and R represent the left, medium and right values of the fuzzy triangle. The resulting matrix was obtained by considering two calculation criteria. The first, called Crisp-Fuzzy (CF) admits that the matrix of demand is represented by a crisp number equal to the sum of the medium value of the triangular fuzzy number. The second criterion, named Fuzzy-Fuzzy (FF) admits that the matrix of demand is represented by the triangular fuzzy numbers.

The weighed equation adopted is given by:? ? ? = i i i K a b a i (**1**)

Where i k is the support value; a i the demand matrix and b i the offer matrix.

The calculation worksheets by the two criteria are shown in Tables 3 and 4, and the graphic representation of the fuzzy numbers in Figure 5. L M R L M R L M R L M R A 0 1 2 0 0 1 2 3 3 0 0 1 LO 1 2**3**L M R L M R L M R L M R A 0 1 2 0 0 2 0 3 6 0 0 2 LO 1 2**3**

7 Simulation through COPPETEC-Cosenza location model

The success expected with respect to the COPPETEC COSENZA location model concerns: (a) careful conceptualization of the attributes that will be considered in each case of study, and (b) mechanisms to evaluate the level in each attribute will be offered or demanded [5]. According to the model, the specific factors are those essential to the establishment of an industry: the absence of any of these factors implies the impracticability of this industry on the evaluated site. Being n the number of general and specific factors:a) n ? C > n ? PC + n ? I b) n ? PC > n ? I c)

If there is a critical factor or an insufficient amount, the region should be disregarded in the process of decision making.

From the classifications made, offer matrices are constructed of specific and general factors of each elementary area to be analyzed and demand ones for these same factors of industries to be evaluated. Priority Matrix in Relation to General and Specific Factors Consider P = [p ik] mxr = C?C*, such that the special sum operation meets the following matrix:c ik c* ik > 0 0 0 0 0 > 0 c* ik + c ik c* ik

The elements of P represent the location advantages with respect to the general and specific factors. One may observe that the impossibility of location in relation to the specific factors automatically annuls the location advantage, however, if the project does not depend on the specific factor the operation must be: The critical and conditioning factors have been adopted as being equal to 1, i.e., important, therefore the little conditioning and irrelevant factors are equal to 0, i.e. not significant. Thus, the demand matrix for the general factors can be completed as Table 5. Following the same procedure, the demand matrix for specific factors can be completed as Table 6. For the construction of the offer matrix, it was considered that the general and specific factors will assume 0 and 1 values, in case of absence and presence, respectively, in the considered sections. Thus, the offer matrix of general factors in the considered sections can be completed as Table 7. A 0 0 1 LO 0 1 1 M 1 1 1 BM 1 0 1

The offer matrix of specific factors in the considered sections can be completed as Table 8. The priority matrix resulting from the decision making in relation to the general factors is shown in Table 9. The priority matrix resulting from decision making in relation to the specific factors is shown in Table 10. The priority matrix resulting from decision making in relation to the general and specific factors is shown in Table 11. The final results to the gauging site by the three sections are shown in Table 12.

8 Conclusion

The results of the simulations performed with the use of the electronic worksheet and displayed in Figure 5 allows to deduce that in the Crisp-Fuzzy criterion, the triangles resulting from the operation of fuzzy numbers are not superimposed, sequentially following, in ascending order of section 1 to 3, with respect to the suitability for the gauging site. With respect to the Fuzzy-Fuzzy criterion, section 3 remains to be the best candidate for the gauging site, but the resulting triangles of sections 1 and 2 are superimposed, indicating certain "cloudiness" about the hierarchy between them.

The simulations carried out using the COPPETEC-COSENZA model allowed to infer that, with respect to the general factors section 3 showed superior results compared to the other sections. With respect to the specific factors, sections 1 and 3 presented result equal and superior to that of section 2. In conclusion, section 3 is the most suitable for the implantation of the gauging site and section 2 is not appropriate for such. Based on the above, section 3 is the one that provides the best conditions for meeting the factors of general and specific demand of the project in question.

1

Figure 1: Fig. 1 :

Figure 2: T

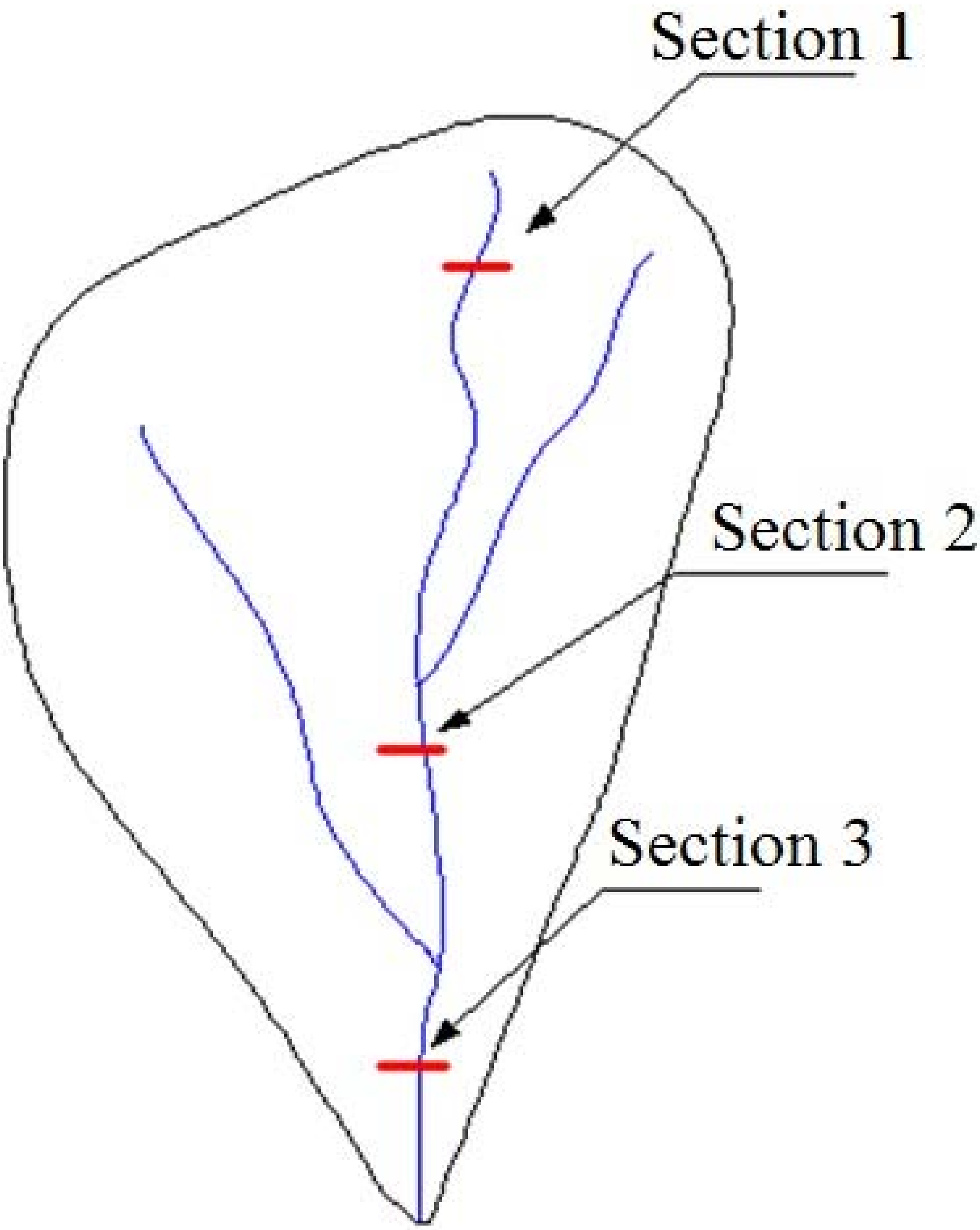

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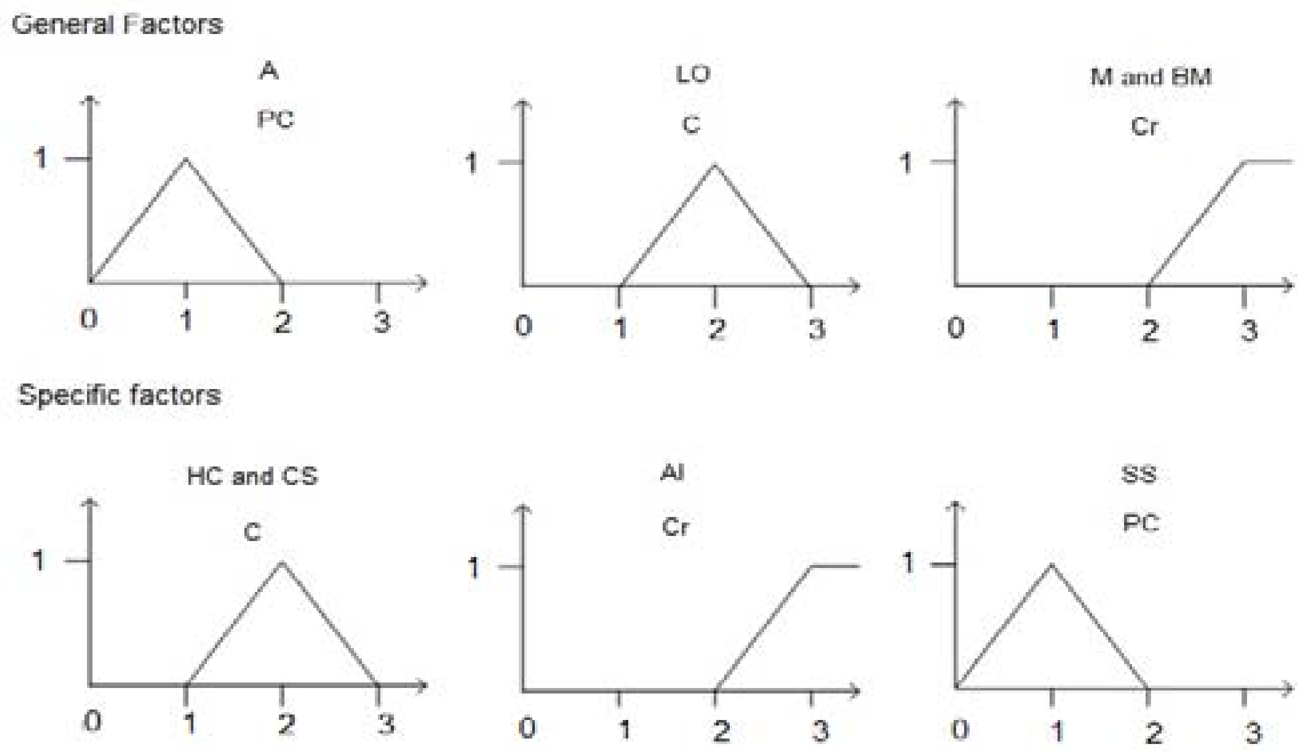
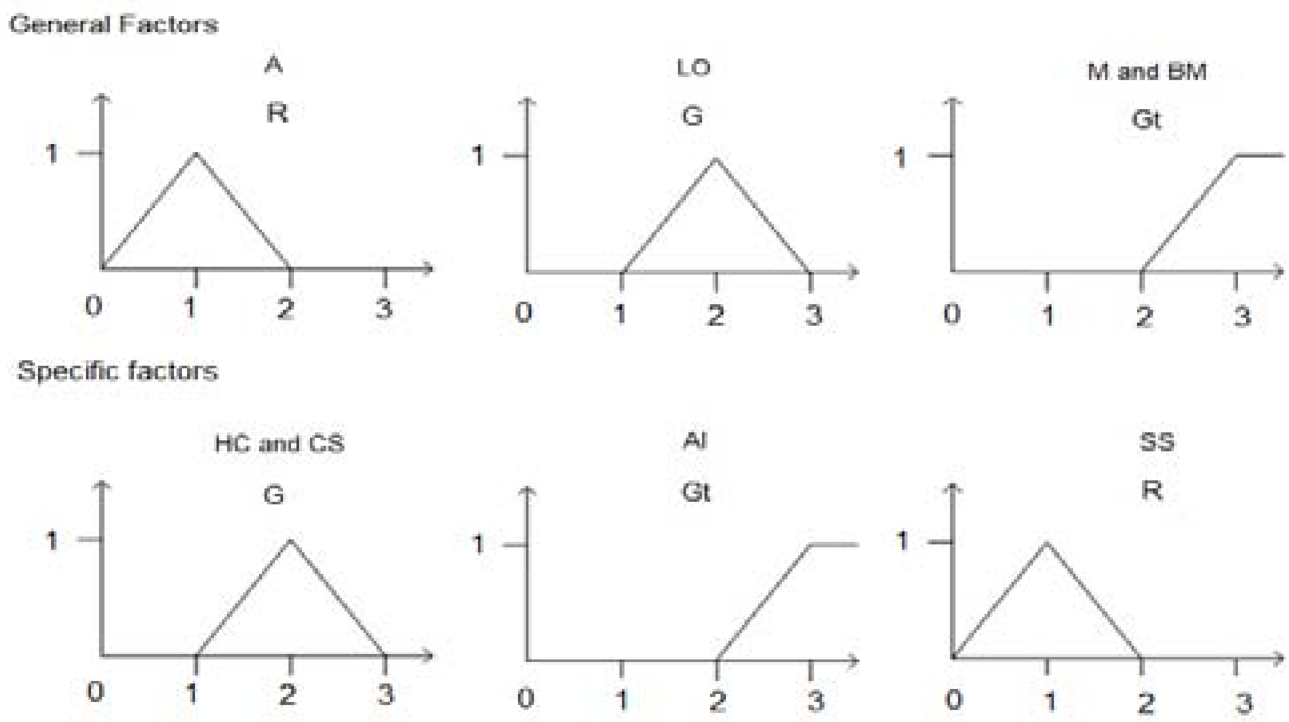
Figure 3: Section 1 ? 2 ? 3 ?



2

Figure 4: Fig. 2 :?



3

Figure 5: Fig. 3 :

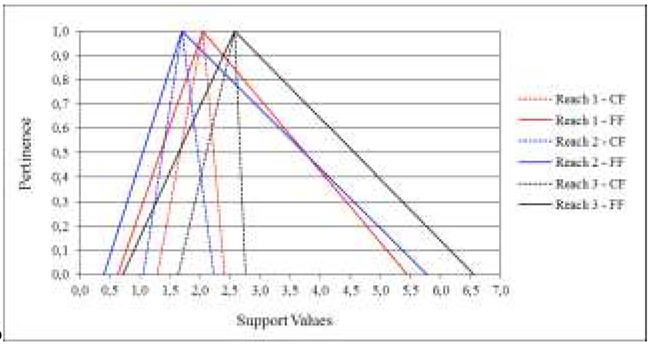
5 

Figure 6: Fig. 5 :

1

Attribute	L	Demand M	R
Cr	2	3	3
C	1	2	3
PC	0	1	2
I	0	0	1

Figure 7: Table 1 :

2

Figure 8: Table 2 :

3

Factors	Demand	Section 1	Weighted Offer Section 2	Section 3

Figure 9: Table 3 :

4

Factors	Demand	Section 1	Weighted Offer Section 2	Section 3

Figure 10: Table 4 :

5

General factors	Variable Linguistics Numerical	
A	PC	0
LO	C	1
M	Cr	1
BM	Cr	1

Figure 11: Table 5 :

6

Specific factors	Variable Linguistics Numerical	
HC	C	1
CS	C	1
AI	Cr	1
SS	PC	0

Figure 12: Table 6 :

7

General		Section	
factors	1	2	3

Figure 13: Table 7 :

8

Specific		Section	
factors	1	2	3
HC	0	0	1
CS	1	1	0
AI	1	0	1
SS	0	1	1

Figure 14: Table 8 :

9

Gauging Site	Section 1	Section 2	Section 3	Sum
A	0.04	0.25	0.04	0.33
LO	0.00	1.00	1.00	2.00
M	1.00	1.00	1.00	3.00
BM	1.00	0.00	1.00	2.00
Sum	2.04	2.25	3.04	

Figure 15: Table 9 :

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Gauging Site	Section 1	Section 2	Section 3	Sum
HC	0.00	0.00	1.00	1.00
CS	1.00	1.00	0.00	2.00
AI	1.00	0.00	1.00	2.00
SS	0.00	0.00	0.00	0.00
Sum	2.00	1.00	2.00	

Figure 16: Table 10 :

11

General and specific factors	Gauging Site
HC	1
CS	1
AI	1
SS	0
A	0
LO	1
M	1
BM	1

Figure 17: Table 11 :

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Figure 18: Table 12 :

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