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Fuzzy Logic Model Approaches for Water Saving in Irrigation Systems

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Abstract:

Fuzzy logic model will made using MATLAB to validate the various irrigation systems and reported it, the Air temperature, wind, humidity and rainfall will be a membership's function to result the efficiency of irrigation performance before the irrigation process, the fuzzy information system consists of fuzzy rules which are derived by information of experts or from input-output learning of system. Rules mimics human reasoning**. Mamdani** method is generally used in fuzzy inference technique, The generalized bell function used for both of temperature and wind where the triangular function used for humidity and rainfall, the rules were put based on the last experiments and personal experiences, and the Output will change into crisp value from this procedure of defuzzification. There are many different methods to do defuzzification can be done by but most common technique is centroid method, the resulted surface graphic are enough to monitor, validate and report the irrigation systems efficiency to exact and schedule the irrigation practices managements.

Keywords: Fuzzy, irrigation, efficiency, rainfall, wind, temperature, humidity.

1. Introduction

Soft computing technology is an interdisciplinary research field in computational sciences. At present, various techniques of soft computing, such as statistics, machine learning, neural network, and fuzzy data analysis, are being used for exploratory data analysis.

Proposed a fuzzy set theory in which the set boundaries were not precisely defined; but, boundaries were in fact gradational. Such a set was characterized by the continuum of grades of membership (characteristic) function which assigned a grade of membership ranging between zero and one to each object. The central concept of fuzzy set theory is a membership function, which numerically represents the degree to which an element belongs to a set. In fuzzy set theory, an element can be a member of a particular set and, at the same time, a member of a different set to a certain degree. In fuzzy rule-based systems, knowledge are represented by an if–then rules. [1].

Fuzzy rules consist of two parts: an antecedent part, which states conditions on the input variable (s), and a consequent part, which describes the corresponding values of the output variable. [2] **and** [3]**.** Fuzzy application areas include estimation, prediction, control, approximate reasoning, intelligent system design, machine learning, image processing, machine vision, pattern recognition, in medical computing, robotics, optimization, civil, chemical and industrial engineering, but fuzzy applications in hydrology and meteorology, are relatively less common. [4]**.**

An automated irrigation system not only allows a better water use efficiency, but it also provides all the necessary information to generate detailed water usage reports which are critical to assess and improve irrigation performance. An automated irrigation system resolves one of the most difficult irrigation problems: when and how much water to apply to ensure thorough wetting of the root zone without loss of water past the roots. The flow front of the irrigation water

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can easily be detected with soil, water sensors buried in the ground at the required depth. [5].

Agriculture plays a vital role in economy of countries throughout the globe providing raw material to industries and fulfilling the increasing needs of immensely growing population pressure. However, in spite of great agricultural importance, productivity is not up to the mark and farmer's gains are substantial. Several issues are anticipated responsible like high cost of production, inflation, poverty, agricultural risks, inadequate access to finance, inadequate availability of inputs and the most noteworthy climate change; putting huge threat to the water availability, which is prime source of irrigation in agriculture sector. [6].

Once the soil has reached desired moisture content, the sensors send a signal to a controller to turns off the power to a solenoid valve or a pump which controls irrigation. As a result, the automated irrigation system prevents water escaping past the root zone and therefore, improves the efficiency of water use. [7].

The main goal of this investigation is produce a intelligence model using MATALB and Fuzzy logic system to monitoring, validate and reported the irrigation systems efficiency to correct the irrigation practices managements.

Table 1: List of acronyms and nomenclature

TEMP	= Temperature membership function,
WIND	= Wind membership function,
HUM	= Humidity membership function,
RAIN	= Rain fall membership function,
IE	= efficiency of irrigation performance membership outputs,
MF	= Membership function, and
FIS	= Fuzzy information system.

1. Materials and Methods

1.1. SOFTWARE:

The software which used to achieve the model is MATALAB Ve, based fuzzy control system for irrigation efficiency is shown in Fig 3 to 7**.** These Figs regroup the following functionalities: (TEMP, WIND, HUM and RAIN), acquirement and data logging; display and treatment of information in real-time; and command of actuators. This interface encompasses at the same time reliability, flexibility of use, interactivity and processing capability in real-time of the whole data.

1.2. Identification of Control Surfaces:

Linguistic variables are recognized and membership values for each variable are calculated in this step. Figs 3, 4, 5 and 6.

1.3. Behavior of Control Surfaces:

In this step fuzzy rules are constructed for different inputs to perform different actions. Fuzzy inputs associate with fuzzy output by fuzzy rules. Fig 9.

1.4. Fuzzy Inference System and Decision Making:

The Fuzzy information system (FIS) consists of fuzzy rules which are derived by information of experts or from input-output learning of system. Rules mimics" human reasoning .**Mamdani** method is generally used in fuzzy inference technique. Fuzzy inference system used rules to generate fuzzy outputs, in this system there are 4 inputs against each input there is fuzzy linguistic variables as shown in Fig 9.

1.5. Defuzzification:

Defuzzification is a process of conversion from a fuzzy set to a crisp number. For crisp input value, there are fuzzy membership for input variables, and each variable cause different fuzzy outputs cells that will used to activate or to be fired. Output will change into crisp value from this procedure of defuzzification. Defuzzification can be done by different methods but most common technique is centroid method. [8]. Fig 10.

The first membership function input is temperature and the second is wind, they are under the *generalized* bell membership function. The *generalized* bell - membership function is specified by three parameters and has the function name G*bell*-MF. G*bell* MF formula is next:

$$F(x; a, b, c) = 1/(1 + |(x-c)/b|^{20}).$$

Figs (1, 3 and 4)

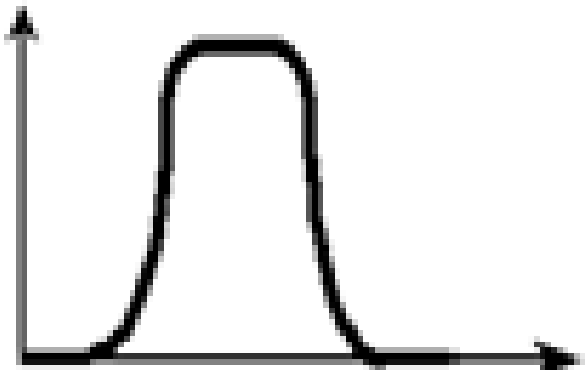


Fig 1: The generalized bell function.

The third membership function is humidity and the fourth is rainfall, beside, they are under triangular function. The simplest membership functions are formed using straight lines. Of these, the simplest is the *triangular* membership function, and it has the function name triMF. It's nothing more than a collection of three points forming a triangle. Figs: (2, 5 and 6).

The data values of temperatures are ranged from zero to 40 Celsius, where the data values of wind MF are ranged from zero to 6 Km/h, and then the data values of humidity are ranged from zero to 80 %, finally the data values of rainfall are ranged from zero to 1000 mm/day.

The triangular function formula is next:

(x; a, b, c) = max (min ((x-a) / (b-a).(c-x)/(c-b)),0)

Fig 2: The triangular function.

A membership function associated with a given fuzzy set maps an input value to its appropriate membership value.

1.6. Fuzzy rules

The basic fuzzy rules were needed to describe a useful relationship between the four inputs and the final output (Efficiency of irrigation performance). The fuzzy rules are given based on published experiments and personal experiences. Fig 9.

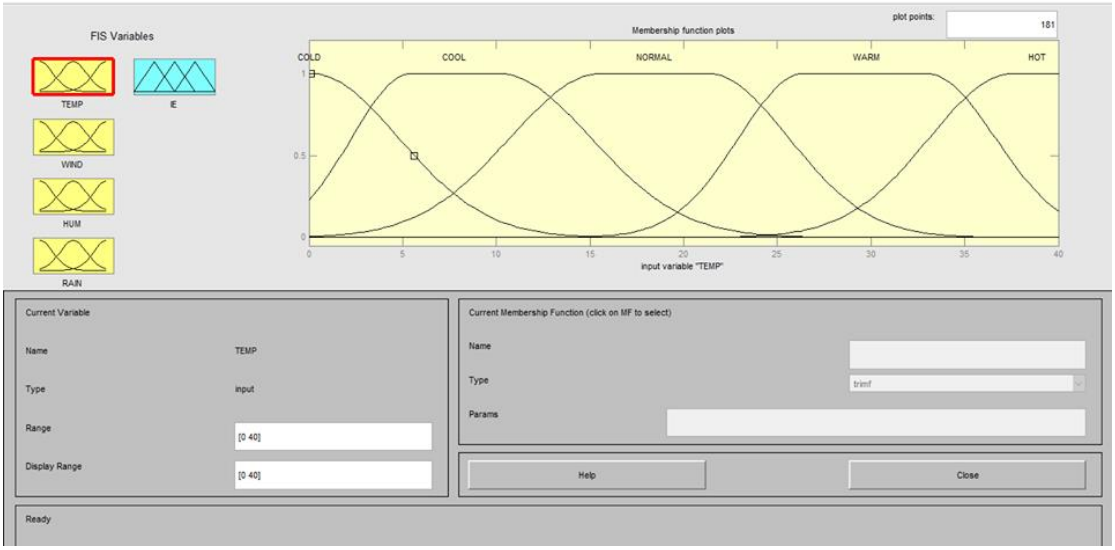


Fig 3: The membership functions for temperature input.

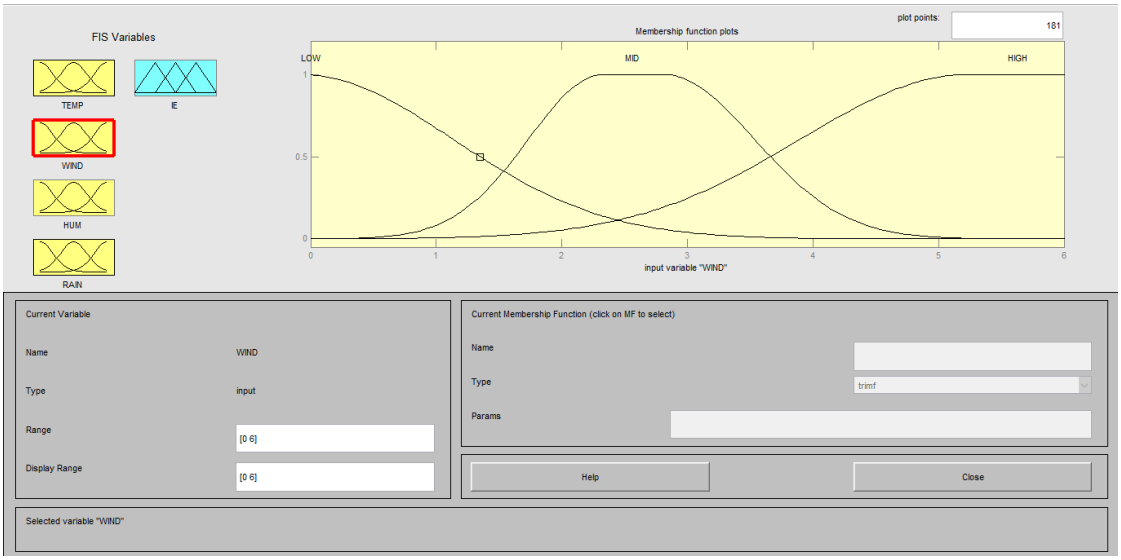


Fig 4: The membership functions for wind input.

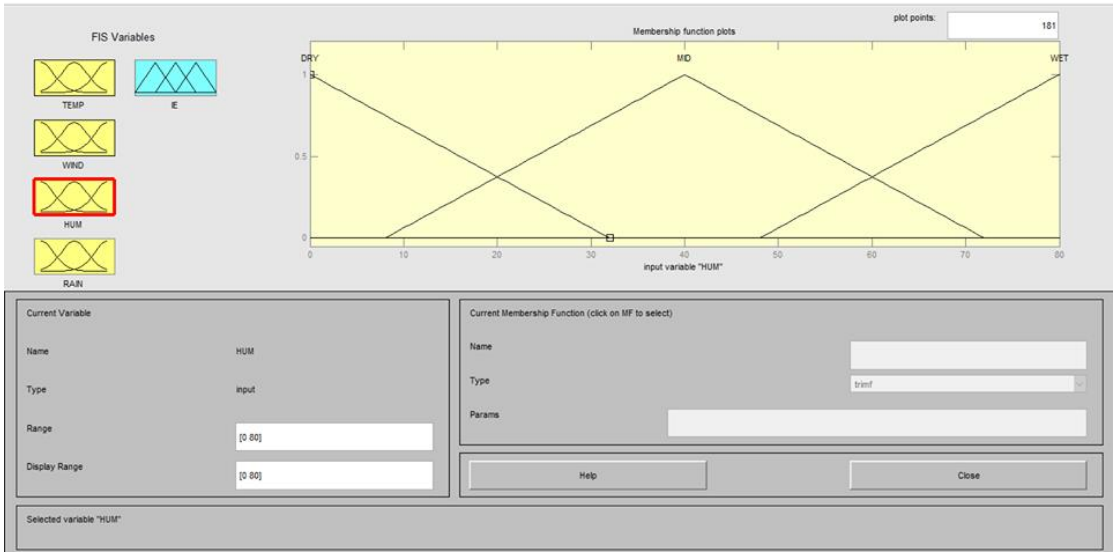


Fig 5: The membership functions for humidity input.

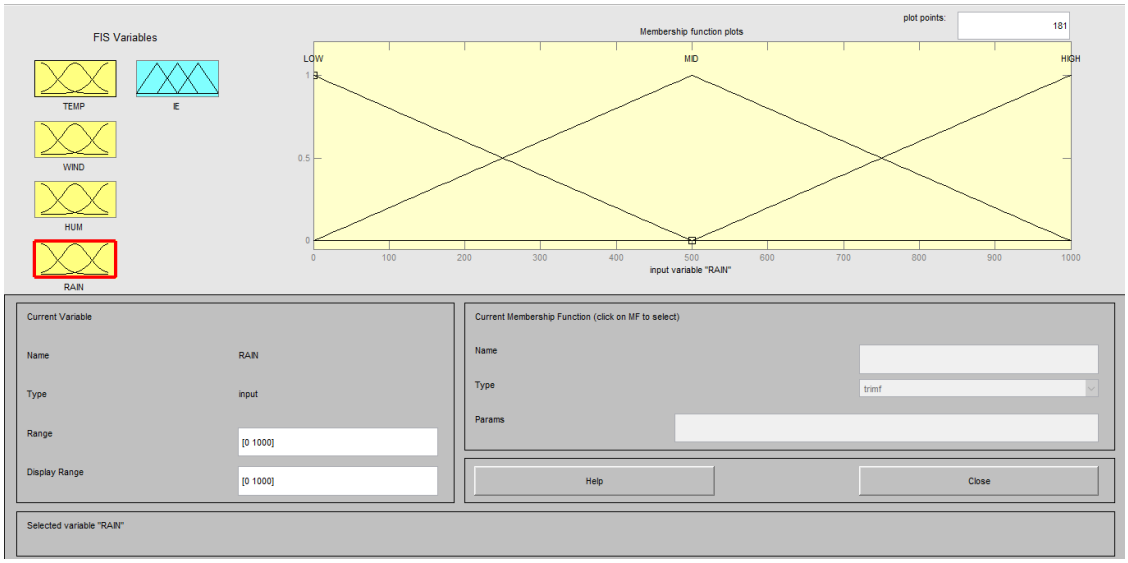


Fig 6: The membership functions for rainfall input.

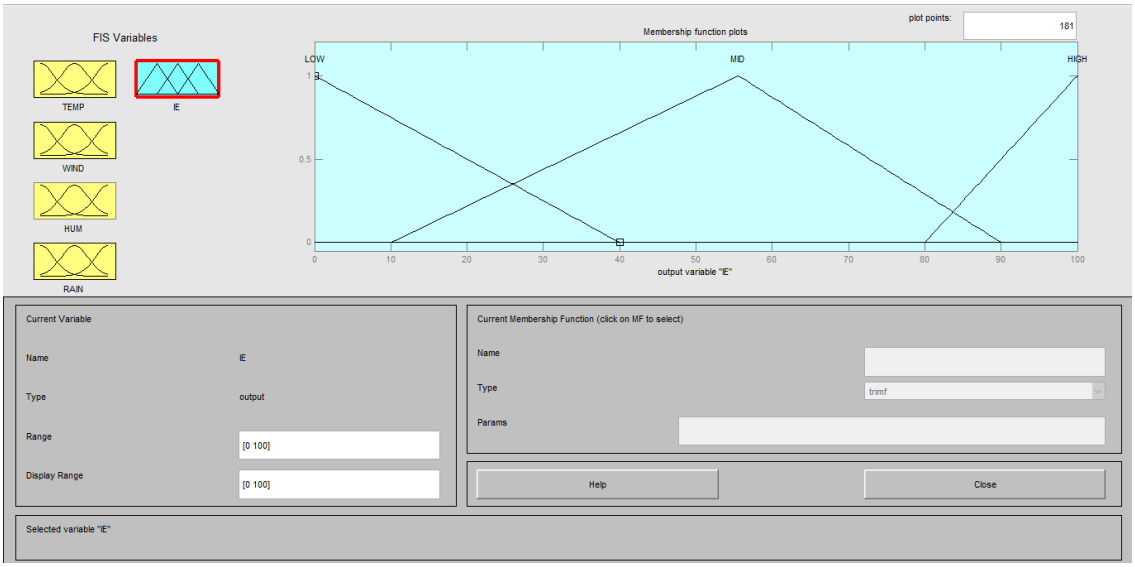


Fig 7: The membership functions for efficiency of irrigation performance output.

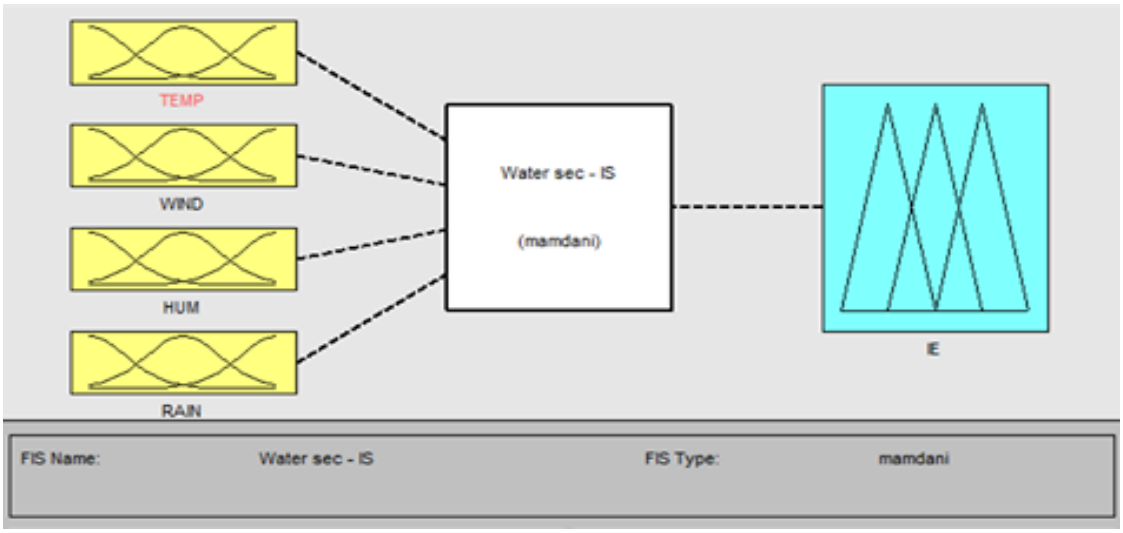


Fig 8: The Fuzzy Logic Tool Box uses simple Mamdani system

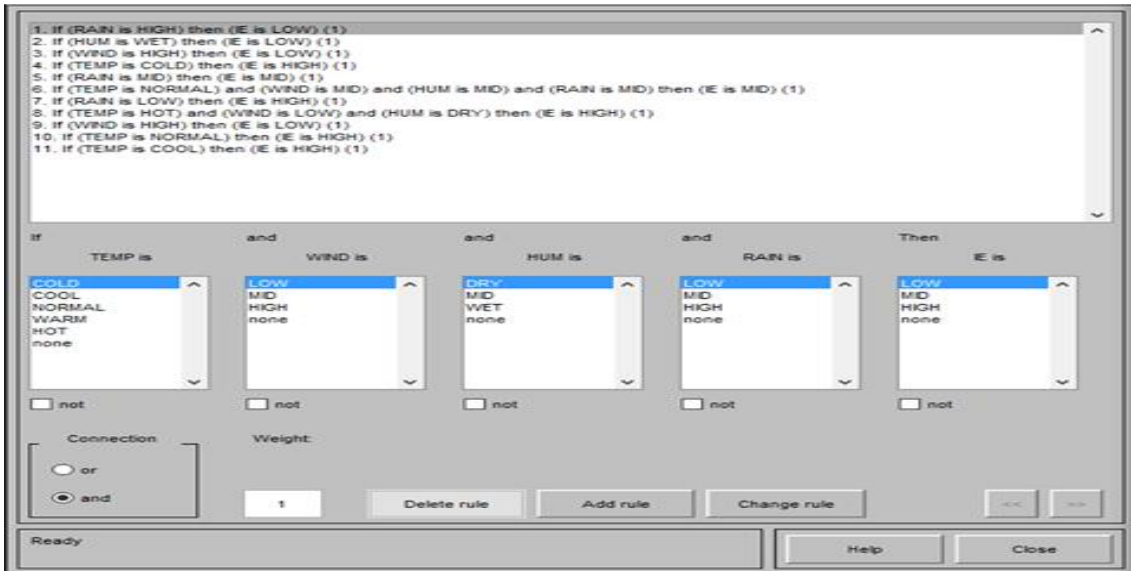


Fig 9: The fuzzy defined rules for irrigation performance

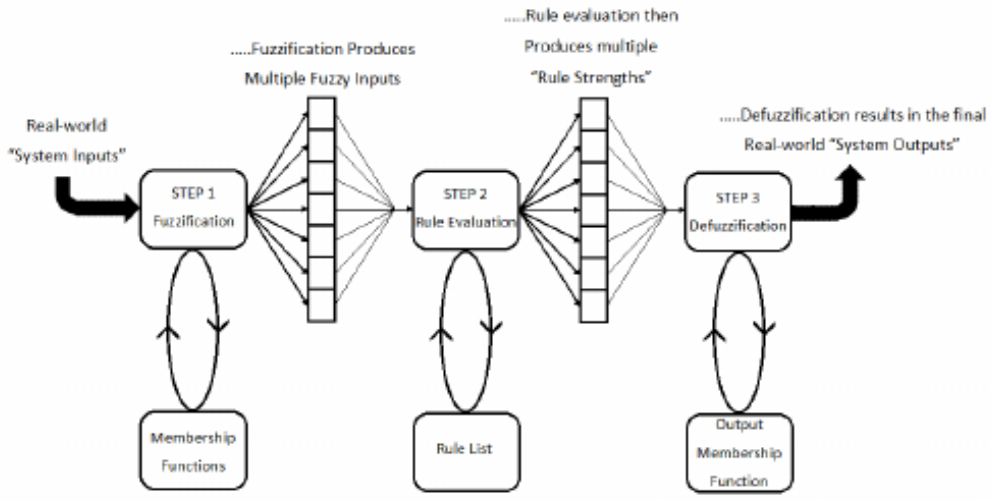


Fig 10: Steps involved in Fuzzy Logic

2. Results

2.1. Air Temperature:

Fuzzy surface graph of temperature shows the defuzzification relationship of temperature and other membership function such as humidity, rainfall and wind, beside the irrigation performance, the increasing of temperature is followed by evaporation and transpiration of both of soil and plant, the soil evaporation causes the water losses specially in the highest temperatures degrees and reduces the efficiency of irrigation performance and efficiency, As a consequence, there will be a salt stress on the plant according to the soil salt concentration increasing as a result of water losses by evaporation. Figs 11 (A, B, C, D, G and K).

2.2. Air humidity:

The humidity degree ranged from 0 to 80 % according the climatology of Hungary beside the green wild area of forest and fields.

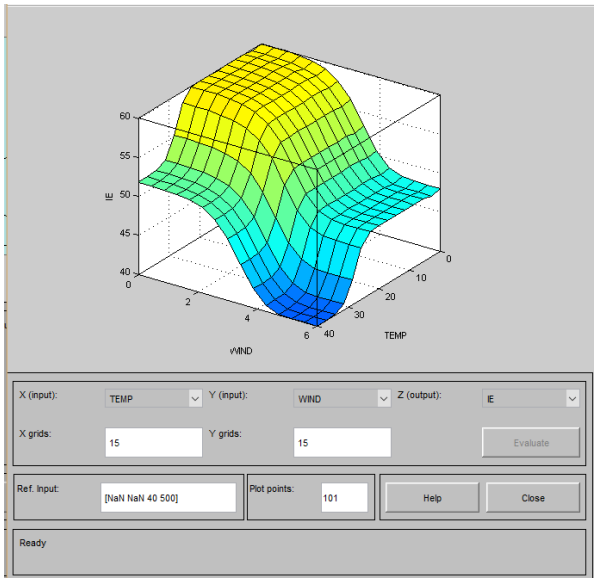
The air humidity is important factor of irrigation performances and influences indirectly on the efficiency of irrigation performance and by the same token on the plant productivity and quality. When the humidity degree increased may be caused a lot of fungus disease so the efficiency of irrigation performance will reduce specially, the irrigation systems which apply water on the plant surface like sprinkler system, beside the high humidity degree influence negatively on the transpiration process. Figs 11 (B, E, G, H, J and M)

2.3. Wind velocity:

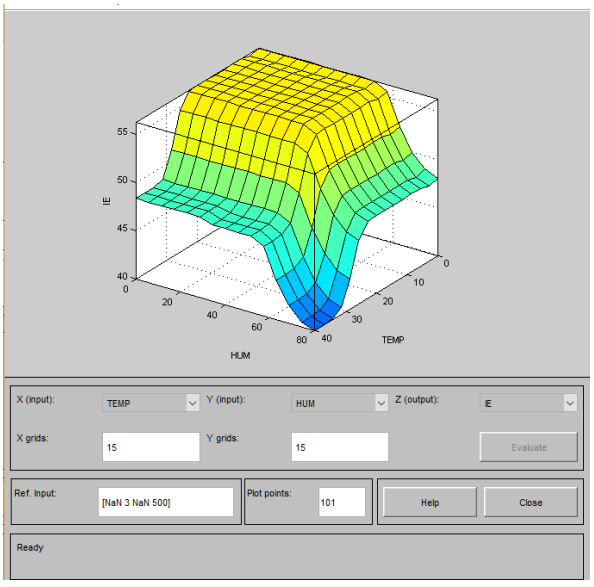
This wind variable shows the effect of air flow on irrigation performance, where there's correlation between both of wind and irrigation performance, when the wind velocity increasing this cause the air moisture movement, by the same token the air need to have a lot of evaporation to replace the Humidity reduction and makes evaporation from both of plant and soil making water and salt stress. According to the relationship of both of wind and efficiency of irrigation performance the suitable function is *The generalized bell function*. Figs 11(A, D, E, F, H and L).

2.4. Rain fall:

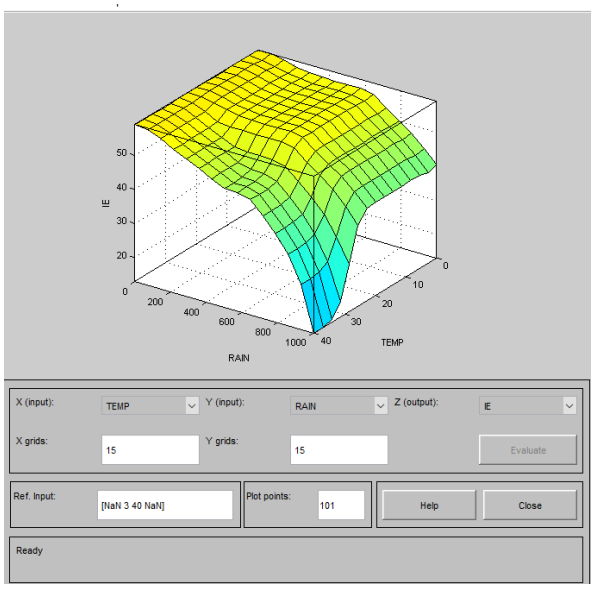
The average annual precipitation across the country is 600 millimetres. The maximum of rain, nearly 1,000 millimetres, so the rainfall is an important factor in irrigation process, beside control of supplemental irrigation on and off, there is a strong correlation relationship between of rainfall and efficiency of efficiency of irrigation performance as shown in the fuzzy defuzzification of rainfall and other factors versus irrigation efficiency. Figs 11(C, f, J, K, L and M).



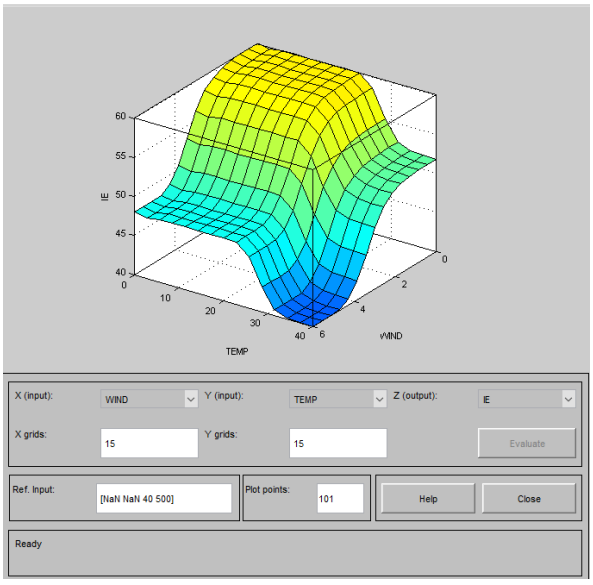
A: Fuzzy surface graph of TEMP and WIND versus IE.



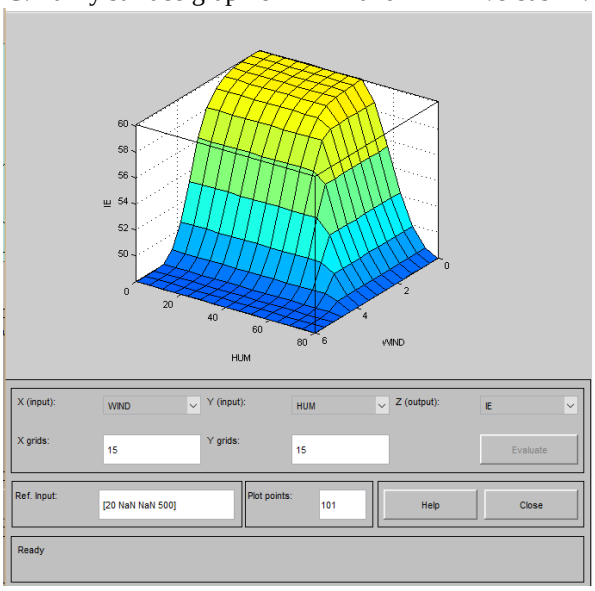
B: Fuzzy surface graph of HUM and TEMP versus IE.



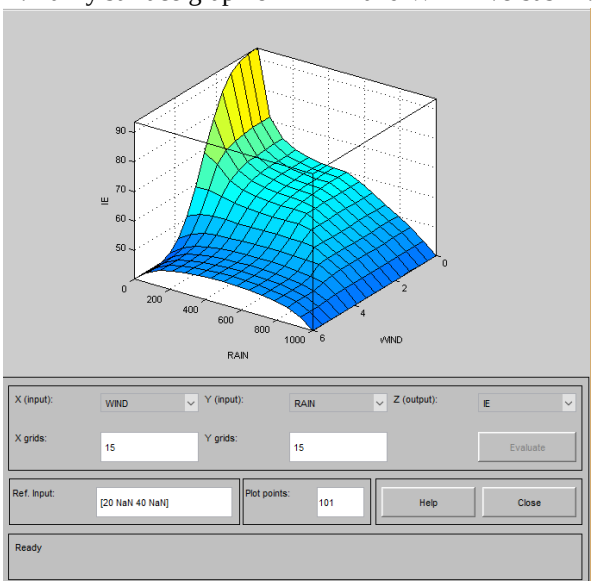
C: Fuzzy surface graph of RAIN and TEMP versus IE.



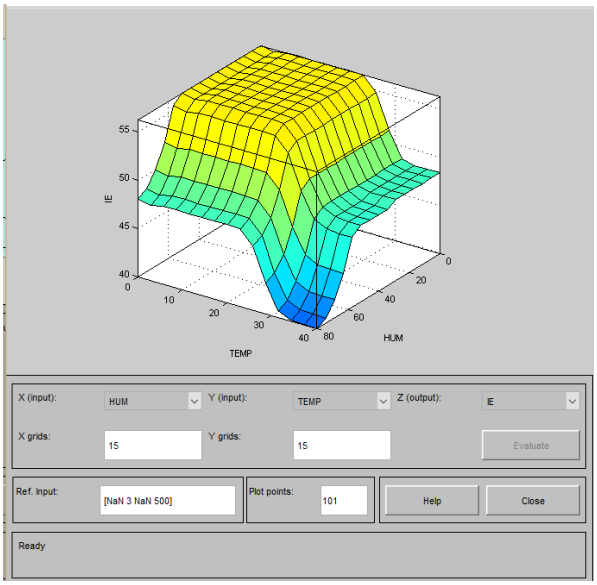
D: Fuzzy surface graph of TEMP and WIND versus IE.



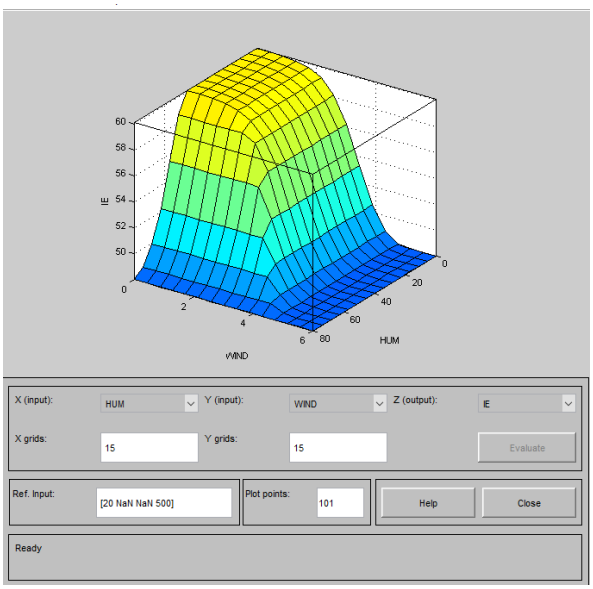
E: Fuzzy surface graph of HUM and WIND versus IE.



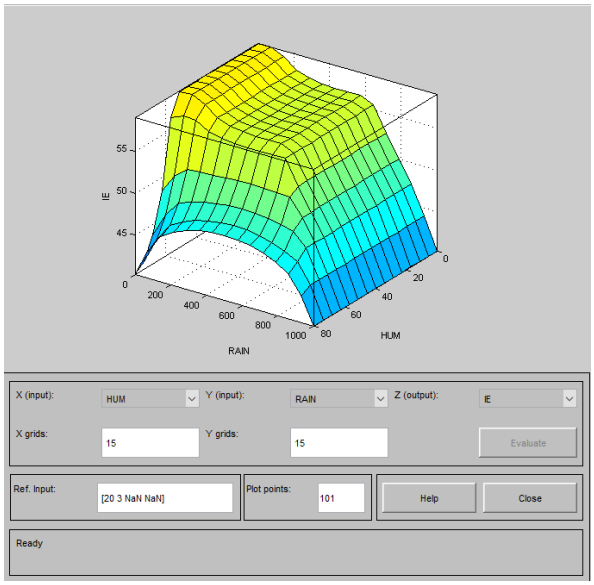
F: Fuzzy surface graph of RAIN and WIND versus IE.



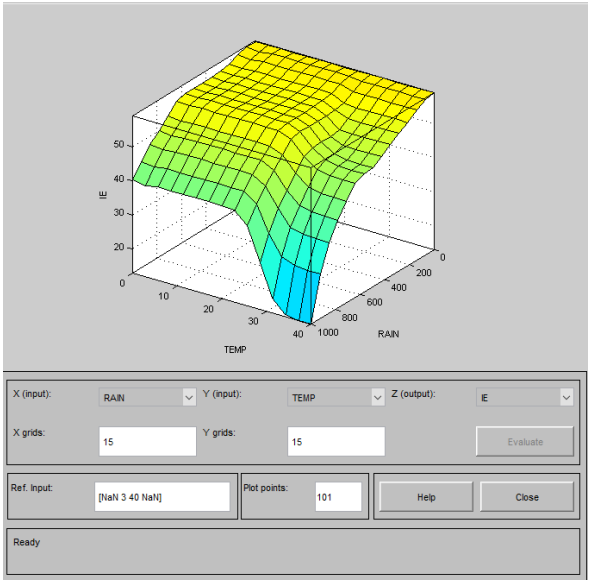
G: Fuzzy surface graph of TEMP and HUM versus IE.



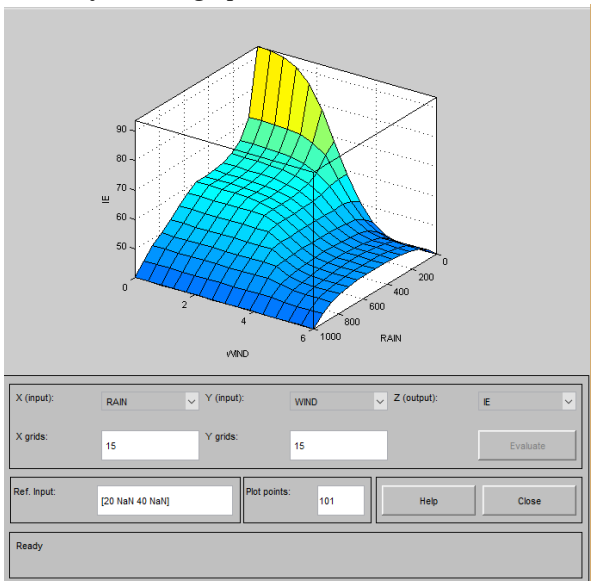
H: Fuzzy surface graph of WIND and HUM versus IE.



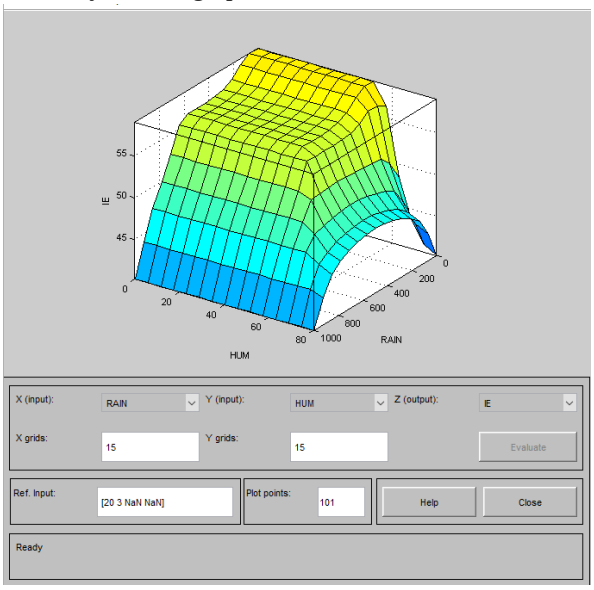
J: Fuzzy surface graph of RAIN and HUM versus IE.



K: Fuzzy surface graph of TEMP and RAIN versus IE.



L: The relationship of WIND and RAIN versus IE.



M: Fuzzy surface graph of HUM and RAIN versus IE.

Fig 11: The Fuzzy surface graph of membership functions versus efficiency of irrigation performance.

5.3. Discussion

Air temperature, wind, humidity and rainfall are basic influence of irrigation efficiency directly, beside the interaction between every factor and the others, and need to monitor and watch irrigation process to report and validate it, the resulted surface graphic are enough to monitor, validate and report the irrigation systems efficiency to exact and schedule the irrigation practices managements

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