Integration of Atmospheric Parameters for Soil Moisture Estimation and Irrigation Control in Agriculture

Dr.A.Rajkumar[1] **A.Ezhilarasi** [2]**J.Sharmila Jessie ignatia**[3]

PG & Research Department of Mathematics

Annai Vailankanni Arts and Science College Thanjavur, Tamil Nadu, India.

(Affiliated to Bharathidasan University, Thiruchirappalli-24, Tamil Nadu, India.)

Abstract:

Soil moisture analysis is a crucial aspect of soil science and agricultural practices. It involves measuring the amount of water in soil, which is essential for understanding plant growth, irrigation scheduling, and assessing soil health. The problem about agriculture that we found is the environment is not support for the plant, like we can't control the moisture in the ground and temperature in the air. In this research demonstrate that it is possible to estimate soil moisture from the evolution of atmospheric parameters near the surface like temperature and relative humidity is a realistic surface transfer model is available. To identify Maximum soil water deficit (MSWD) we can use MATLAB to simulate fuzzy for find maximum soil water deficit (MSWD) to control level of sprinkle that spread the water for agriculture.

Key words: Maximum Soil Water Deficit (MSWD), Soil Moisture, Environmental Relative Humidity, Environmental Temperature, MATLAB.

Introduction:

Soil is a precious resource that sustains life on Earth and supports numerous ecosystem functions. Protecting and conserving soil is essential for maintaining biodiversity, food security, and ecosystem resilience. Soil plays a foundational role in agriculture, serving as the medium in which plants grow and thrive. Soil provides essential nutrients like nitrogen(N), Phosphorus(P), Potassium(K), and various micronutrients that plants need for growth. For effective food production, soil quality is very important [1]. Surface soil moisture content is an essential ecohydrological natural resource that controls crucial land surface activities [2]. There are enormous potential societal benefits from accurately estimating soil moisture since it is universally acknowledged as a critical parameter in the mass and energy balance between the land surface and the atmosphere [3]. The major objective of this study is to show that, supposing an accurate surface transfer model is available, soil moisture may be computed from the change of air factors at the surface (temperature and relative humidity) [4].

Implementation steps:

Step 1: Identify and declare the inputs and outputs.
Step 2: Identify the control surfaces
Step 3: Behavior of control surfaces
Step 4: Fuzzy Inference system and decision making

Step 5: Defuzzification
In this project we use fuzzy logic to set the level of sprinkle to spray the water to plant, to control the moisture of the ground.

Identification and Declaration of inputs and Output

Here we take three types of variables for soil moisture analysis it called an input variable there are

i) Soil Moisture
ii) Environment Temperature
iii) Environment Relative Humidity

Fuzzy logic introduction:

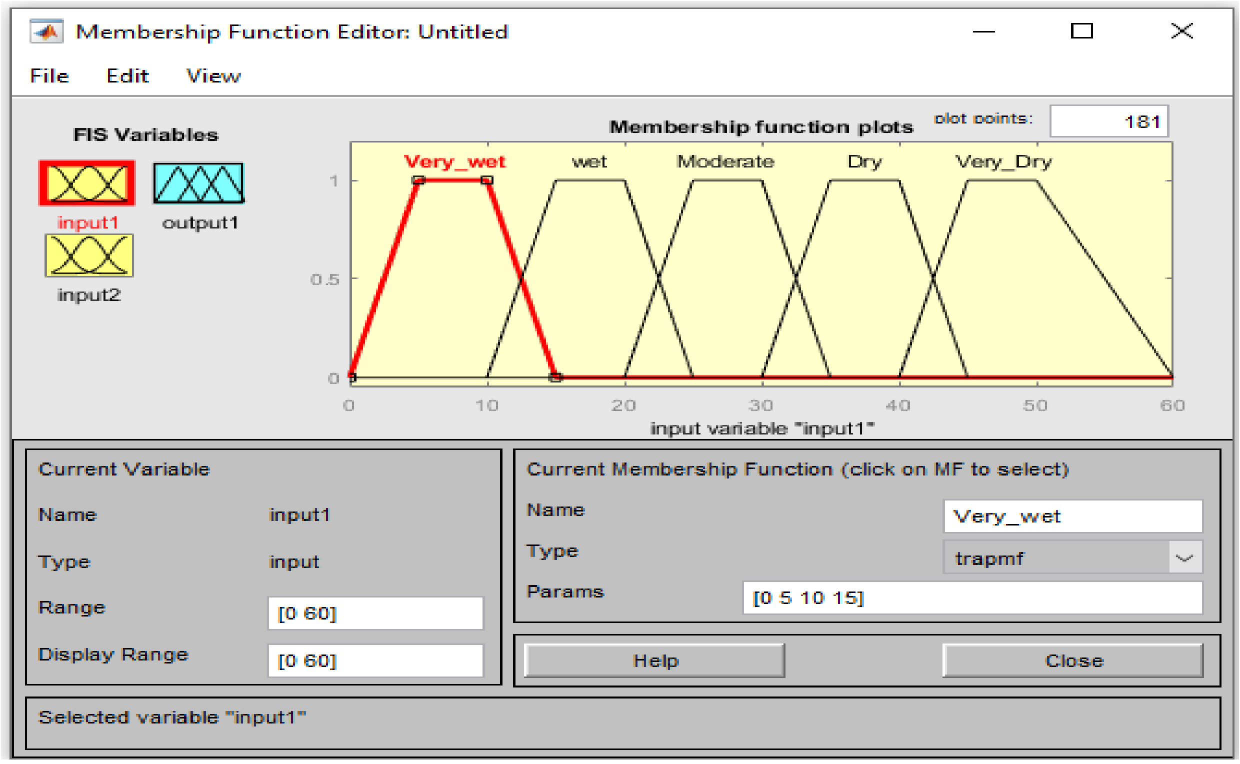
Fuzzy logic was initiated in 1965, by lot. A. Zadeh, professor for computer science at the University of California in Berkeley. Basically, fuzzy logic (FL) is a multivalve logic that allows intermediated values to be defined between conventional evaluations like true/false, yes/no, high/low etc. Fuzzy logic is a form of logic that deals with reasoning that is approximate rather than fixed and exact. Unlike traditional binary logic, where variables can only be true or false, fuzzy logic allows for degrees of truth, represented by values between 0 and 1. This makes it suitable for handling concepts that are inherently vague or imprecise.

Reading obtained from the soil moisture sensor:

Table 1: Soil moisture content in Centibars Reading Obtained from the soil Moisture Sensor

The first experiment involves determining the maximum soil water deficit using a soil moisture sensor measurement. We use five linguistic variables to determine the soil moisture level in centibars, which a soil moisture sensor measure. The linguistic variables are Very wet, wet, Moderate. We calculate the range using the trapezoidal value.

Sensor Moisture Sensor Reading	**Soil Moisture level (Centibars)**	**Linguistic Variable**	**Range**
Field sensor Moisture Sensor Reading	10	Very Wet	[0 5 10 15]
	20	Wet	[10 15 20 25]
	30	Moderate	[20 25 30 35]
	40	Dry	[30 35 40 45]
	50	Very Dry	[40 45 50 60]

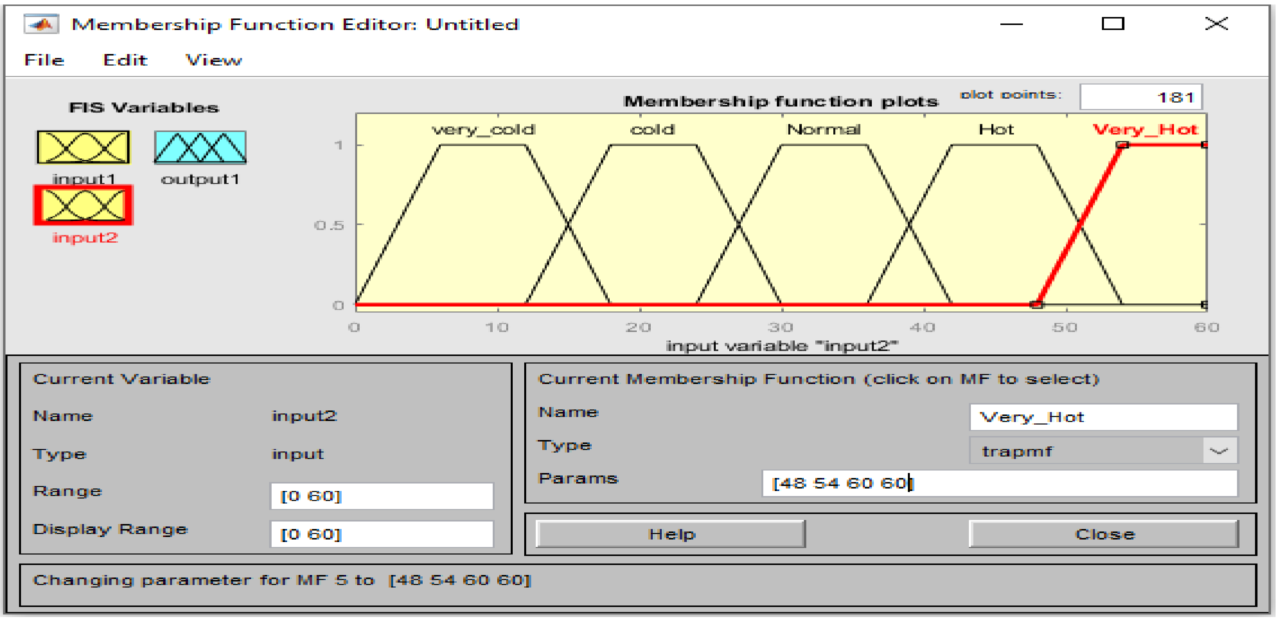


Reading obtained from the Temperature sensor:

In the second experiment involves determine the Temperature from environment using Temperature sensor analysis. In this experiment we used the linguistic variable to find the Environment temperature they are Very cold, cold Normal, Hot, Very Hot. We calculate the range using trapezoidal rule.

Table 2: Environmental Temperature in Degree centigrade Obtained from Temperature Sensor

TemperatureSensor Reading	Environment Temperature (Degree Centigrade)	Linguistic Variable	Range
Environment Temperature in Degree Centigrade obtained from Temperature sensor	10	Very cold	[0 6 12 18]
	20	cold	[12 18 24 30]
	30	Normal	[24 30 36 42]
	40	Hot	[36 42 48 54]
	50	Very Hot	[48 54 60 60]

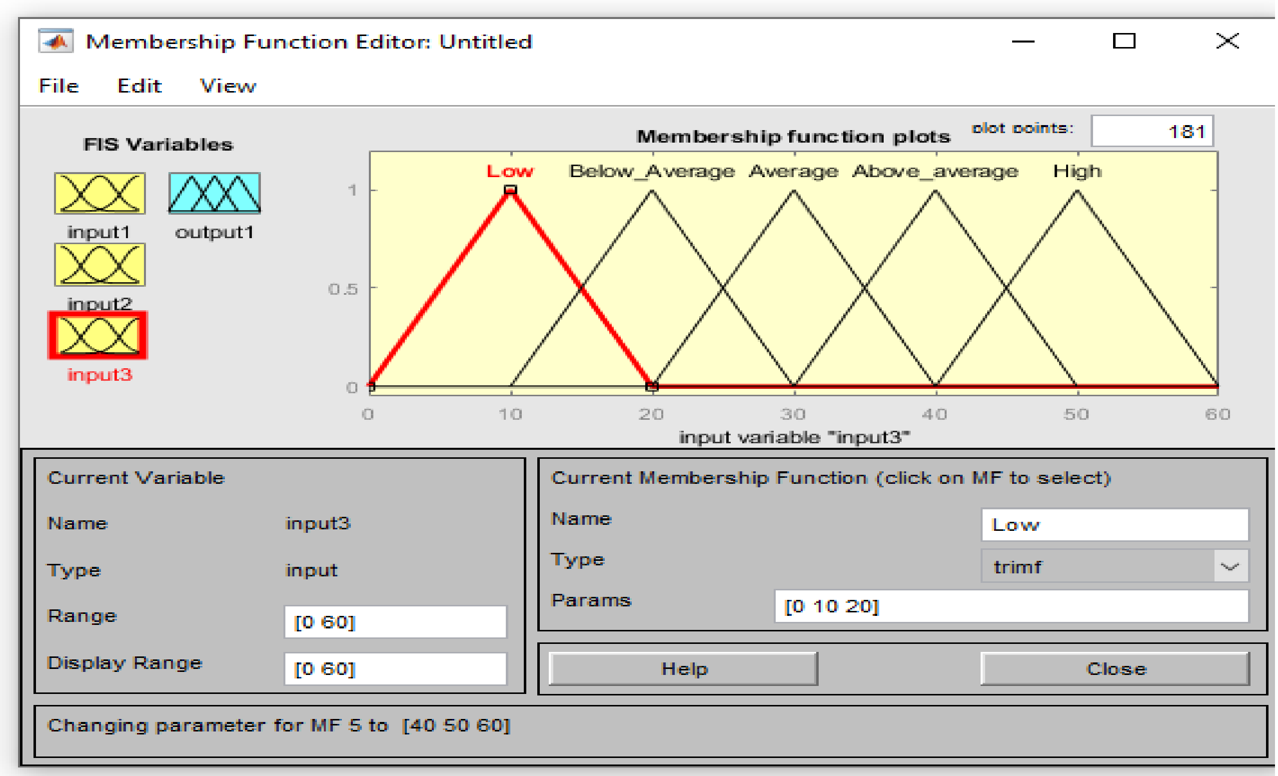


Reading obtained from the Humidity sensor:

Table 3: Environmental Relative Humidity in Degree centigrade Obtained from Temperature Sensor

In the third experiment involves determine the Environmental relative humidity using Temperature sensor. In this experiment we used the linguistic variable to find the Environment relative humidity they are low, below average, average, above average, high. We calculate the range of linguistic variable using triangular rule.

Relative Humidity Sensor Reading	Relative Humidity level from (Degree Centigrade)	Linguistic Variable	Range
Environment Temperature in Degree Centigrade obtained from Temperature sensor	10	Low	[0 10 20]
	20	Below average	[10 20 30]
	30	Average	[203040]
	40	Above average	[30 40 50]
	50	High	[40 50 60]



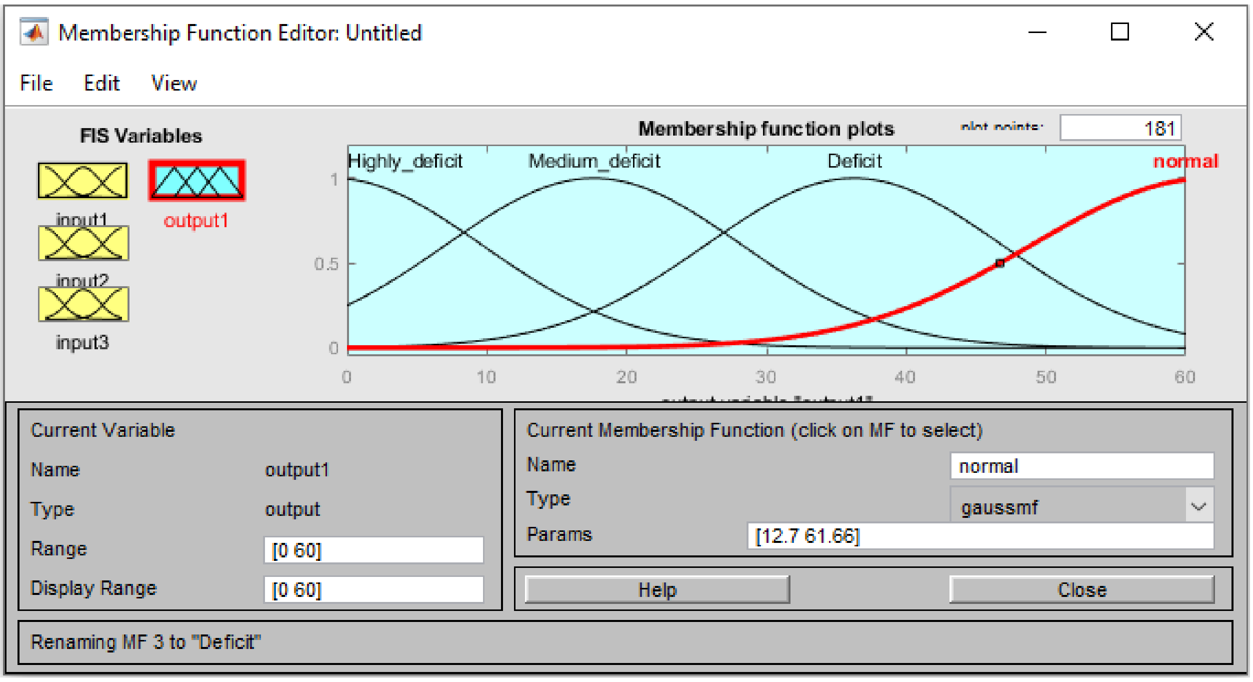
Result and Discussion:

Fuzzy Relation:

- If temperature Very cold and relative humidity is low and soil moisture is very dry then MSWD is highly deficit.
- If temperature is cold and relative humidity is below average and soil moisture is dry then MSWD is Medium Deficit.
- If temperature is Normal and relative humidity is average and soil moisture Moderate then MSWD is Deficit.
- If temperature is Hot and relative humidity is average and soil moisture wet then MSWD is Normal.
- If temperature is very Hot and relative humidity is above average and soil moisture wet then MSWD is Normal.

Output:

Soil Moisture	**Relative Humidity**	**Temperature**	**MSWD**
Very Dry	Low	Very cold	Highly Deficit
Dry	Below Average	cold	Medium Deficit
Moderate	Average	Normal	Deficit
Wet	Above average	Hot	Normal
Very wet	High	Very Hot	Normal



Numerical Example:

The problem here is to determine the initial conditions at the beginning of an analysis period so that the corresponding evolution best fits the data. The primary goal is to determine the maximum soil water deficit level utilizing atmospheric parameters like as temperature, soil moisture, and relative humidity. In this study, provide a distinction between the data and the model variables.

Fig 1 Shows that If weput temp =24.2, humidity = 27.1, moisture= 27.8 MSWD will equal to 31.1 and the plot point value is 101.

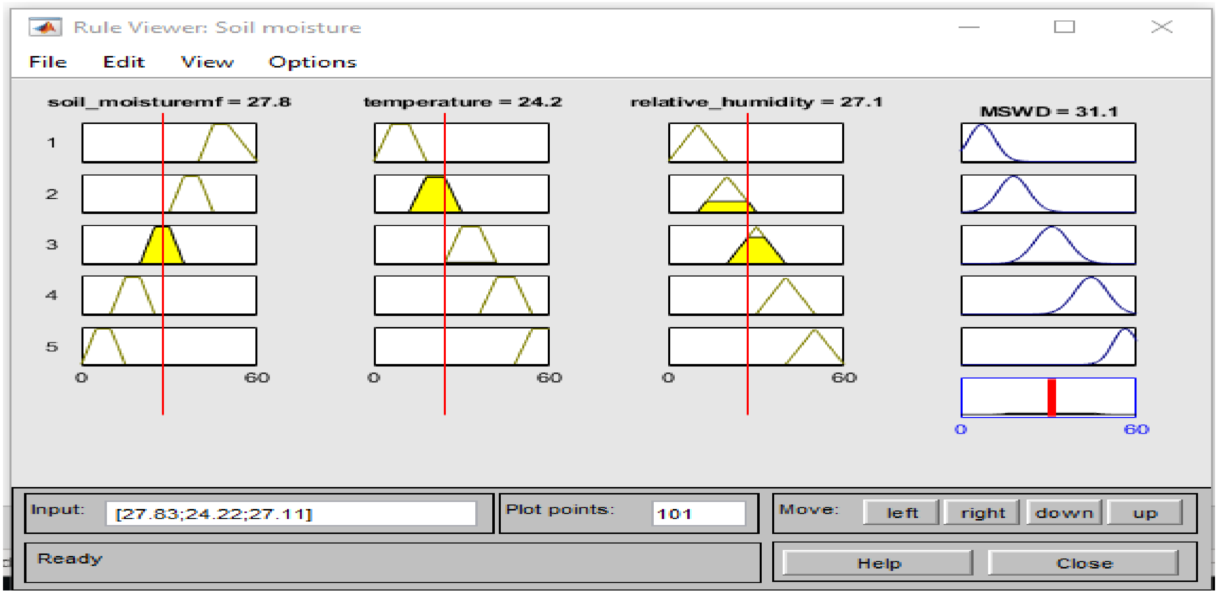


Fig 2 Shows that the surface from Temperature and soil moisture level. If we put Temp=26 and Soil moisture =28 and the ref. input is [NaN NaN 30]

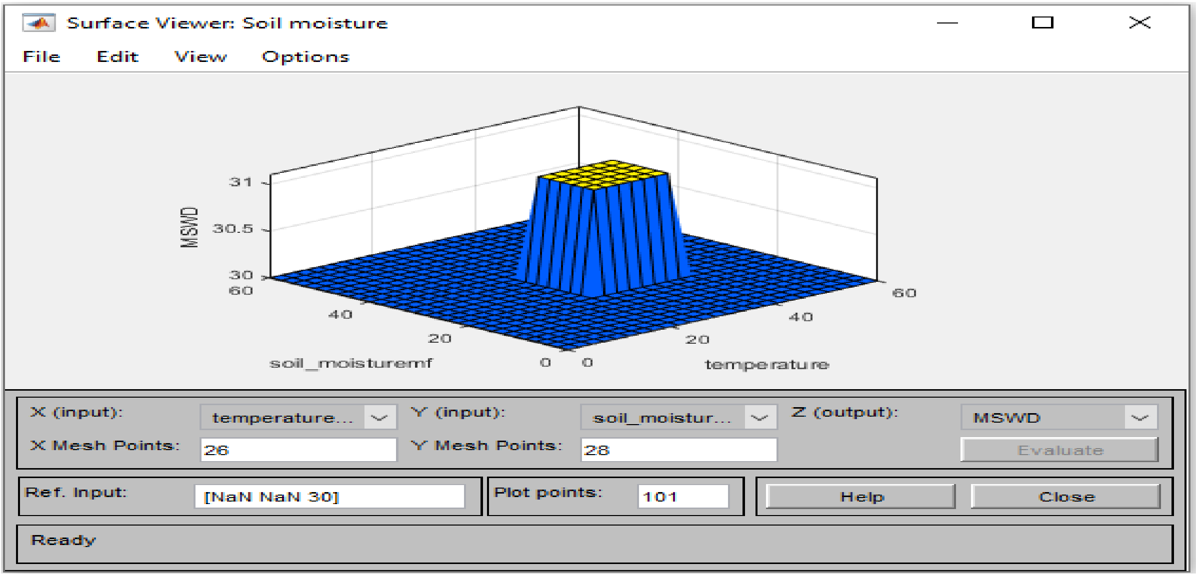


Fig 2: Surface from Temperature and Soil moisture

Fig 3 Shows that the surface from Temperature and relative humidity level. If we put Temp =26 and relative humidity = 27and the ref. input is [30 NaN NaN]

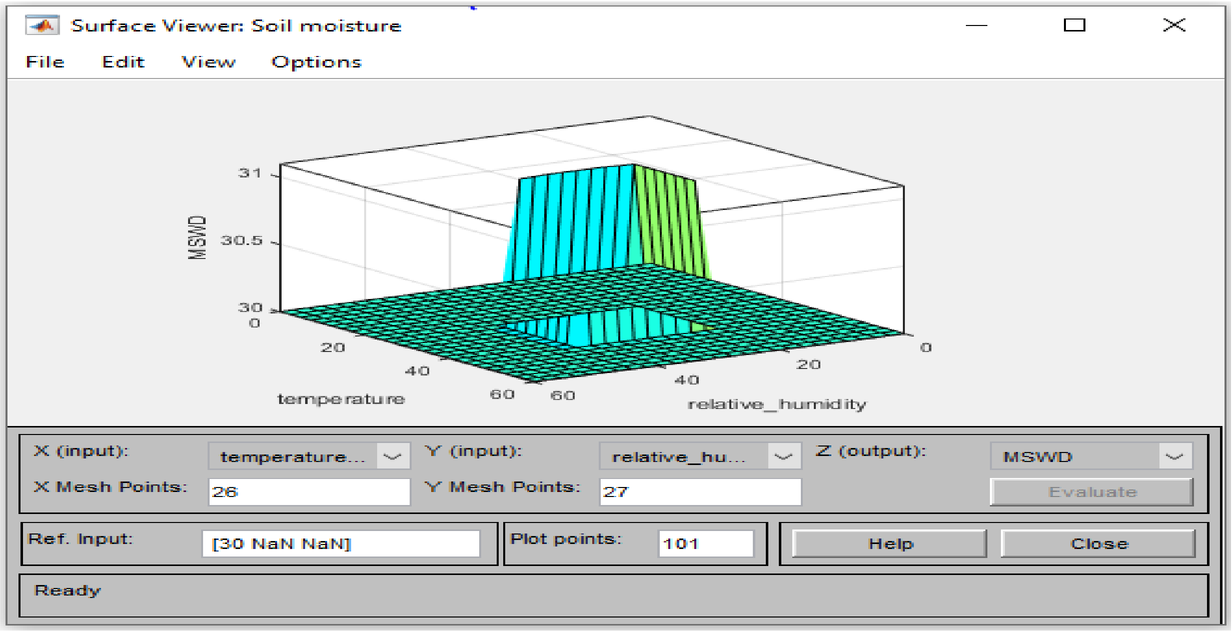


Fig 3: Surface from temperature and relative humidity

Fig 3: Shows that the surface from soil moisture and relative humidity level. If we put Temp =26 and relative humidity = 27 and the ref. input is [NaN 30 NaN]

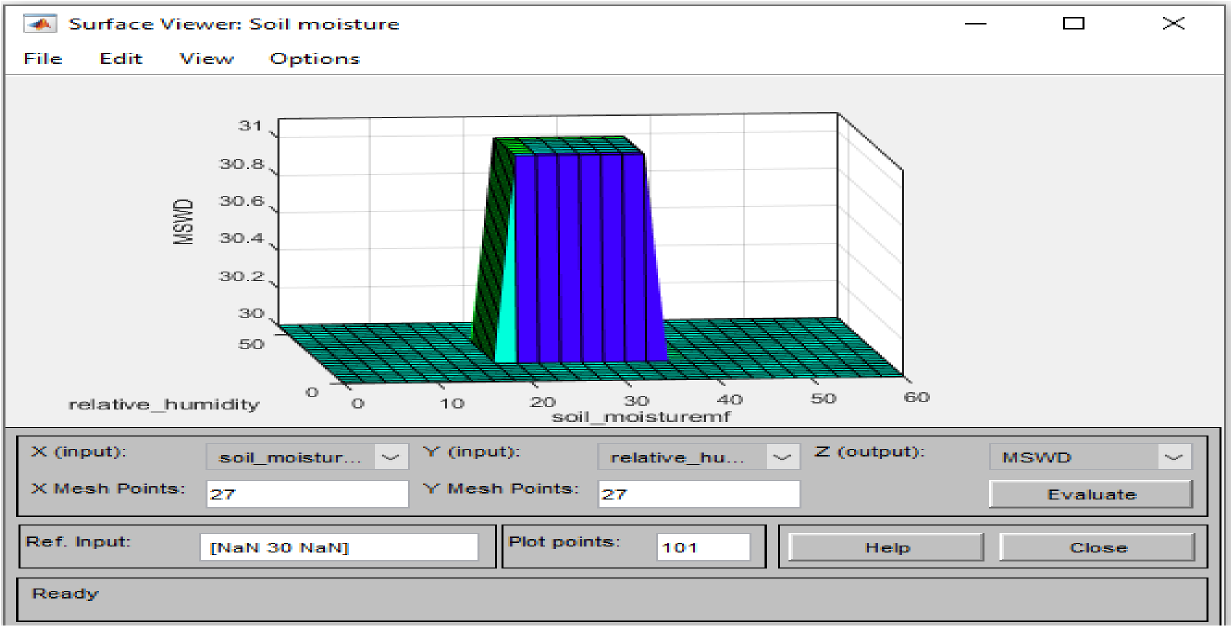


Fig 3:Surface from soil moisture and relative humidity

Conclusion:

From thisstudy we use MATLAB to simulate fuzzy for find Maximum Soil Water Deficit (MSWD) to control level of sprinkle that spread the water for agriculture The sensor senses the input value then the program will calculate and give the output as the result. The program can apply using in agriculture in many ways. From this study will make the agriculture more accurate because some plant needs the special care. And if not take care well enough, there will cause the damage to the plant.

Reference:

[1] Larry Elikplim et.al., Assessment of soil moisture content Measurement Methods: Conventional Laboratory oven versus Halogen Moisture Analyzer. Journal of soil and water science. Vol 4, Issue 1, (2020).

[2] Muhammad Waseem Rasheed et.al. Soil Moisture Measuring Techniques and Factors affecting the Moisture Dynamics: Comprehensive Review. Emerging Agricultural Engineering Sciences, Technologies and Applications. Vol 14, Issue 18, (2022).

[3] Luca Brocca et.al., Soil Moisture for Hydrological Applications: Open Questions and New Opportunities. Advances in Hydro-Meteorological Monitoring. Vol 9, Issue 2, (2017).

[4] Jean-Francois Mahouf Analysis of soil Moisture from Near -Surface Parameters: A Feasibility study. Journal of Applied Meteorology. Vol 30, Pg. No 1534-1547.