

# Characterization of Soil Moisture Level for Rice and Maize Crops using GSM Shield and Arduino Microcontroller

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**Abstract.** Soil serves a medium for plants growth. One factor that affects soil moisture is drought. Drought has been a major cause of agricultural disaster. Agricultural drought is said to occur when soil moisture is insufficient to meet crop water requirements, resulting in yield losses. In this research, it aimed to characterize soil moisture level for Rice and Maize Crops using Arduino and applying fuzzy logic. System architecture for soil moisture sensor and water pump were the basis in developing the equipment. The data gathered was characterized by applying fuzzy logic. Based on the results, applying fuzzy logic in validating the characterization of soil moisture level for Rice and Maize crops is accurate as attested by the experts. This will help the farmers in monitoring the soil moisture level of the Rice and Maize crops.

## 1. Introduction

Soil serves as a medium for plants growth. It absorbs water, keeps moisture and holds the roots of the plants. To irrigate crops, one method commonly used is to follow soil moisture depletion. As a plant grows, it uses the water within the soil profile of its root zone. As the water is being used by the plants, the moisture in the soil reaches a level at which irrigation is required or the plant will experience stress. If water is not applied, the plant will continue to use what little water is left until it finally uses all of the available water in the soil and dies [1]. One factor that affects the soil moisture is drought. Drought has been a major cause of agricultural disaster [2]. Agricultural drought is said to occur when soil moisture is insufficient to meet crop water requirements, resulting in yield losses [3].

To avoid yield losses, a device was developed in India to detect the soil moisture level. The device is placed in the field and works under three conditions wet, normal and dry conditions. If Wet and Normal Condition the device remains constant. If the soil moisture is Dry condition, then the water pump is turned on until it reaches the normal condition [4]. Wireless sensor network is another technology developed in India. It is use in automated irrigation system to enhance the use of water for agricultural crops. It is consists of a soil moisture sensor and temperature sensor placed under the soil where plants roots are reached [5].

Drought is affecting also the large tracts of the main Rice-producing areas of Asia. The Ministry of Environment in Cambodia estimated that between 1996 and 2000 drought-related Rice losses were approximately 20 percent of potential national production. Severe drought in 2004 affected 300,000 hectares of paddy Rice leading to an 82 percent loss of the potential harvest. And in 2009 another severe



drought was recorded and the government issued a USD 12 million rescue package [6]. In the United States, export pRices for corn soared nearly 128 percent above the 20-year historical average. Export pRices also hit the highest level since the import and export pRice index series began in December 1984.

Further, In North Dacota, they used “check-book method to solve the problems in reduced yields. This method uses daily crop water use values and soil water holding capacities to predict the time and amount of water needed to replenish what has been removed from the root zone. Rain and irrigation amounts are deposits for storage in the root zone, and crop water use is a withdrawal of water from that storage [7].

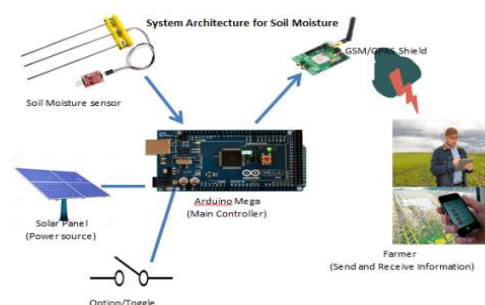
Moreover, the farmers in the Philippines await the coming of rains before planting the season’s crop. A good cropping is highly dependent on sustained rainfall, especially during the critical stages of crop development. The farmers water their plants using irrigation and water pump. Most farmers used “Counting Method” to determine when to water the plants. This process sometimes is not accurate because of the climatic irregularities could spell disaster [8] which leads to crop failure.

With the above scenario, there is a felt need to integrate technology in determining the soil moisture level to improve the Rice and corn production. This will also help the farmers to manage their crop properly and to avoid loss of crop production. Thus, the objective of the study is to characterize the level of soil moisture level for Rice and Maize crops using Arduino with Fuzzy Logic. Arduino Mega is a microcontroller which has a number of facilities that communicates with other microcontroller, sensors and computer. Fuzzy Logic Algorithm was used to characterize the values gathered from the Arduino Mega.

## 2. System Architecture

Figure 1 shows the Arduino Mega as the main controller of the entire system. All other components are directly connected to the controller. The soil moisture sensor rod is directly planted to the soil as the i2c is connected to the controller. The sensor detects the moisture level of the soil and gives the information to the controller. A text message containing the soil moisture value and the action to be taken will be send immediately to the farmer thru GSM Shield. The sensor is also capable of switching to different crop such as Rice and Maize using toggle switch. The GSM Shield will carry all SMS send and receive by the farmer. The solar panel serves as the power source of the different components.

Figure 2 shows the System Architecture for Water Pump. The Water Pump is connected to the Arduino Mega via switching relay as plugged to 220v AC. When the soil gets dry, a SMS will be sent automatically to the farmer and the farmer has the option to turn on or off by sending SMS “ON” or “OFF”, respectively. The switching relay is triggered when the farmer send SMS to the GSM Shield to turn on the water pump as the water pump already plug to the AC.



**Figure 1.** System Architecture for Soil Moisture Sensor



**Figure 2.** System Architecture for Water Pump

### 3. Methodology

This study used descriptive and developmental type of research design. Descriptive research is significant as surveys abound in educational research and are utilized by many researchers as an investigative tool to collect data in order to address educational questions [9]. Developmental research design seeks to create knowledge grounded in data systematically derived from practice. It is a way to establish new procedures, techniques, and tools based upon a methodical analysis of specific cases [10].

The researchers designed system architecture for soil moisture sensor and water pump. Fuzzy logic was integrated in characterizing soil moisture level for Rice and Maize crops. As proven in the study of [11], fuzzy logic has been used in: process control, management and decision making, operations research, economics and engineering. Fuzzy logic is more stable to use and estimation of soil moisture is more balance, thus, this study will be using fuzzy logic for characterizing soil moisture level for Rice and Maize.

Purposive sampling was used in determining the experts. The experts who were available at the testing period validated the characterization of the soil moisture value detected by the soil moisture sensor. For example, for Rice crops soil moisture value, if the device detected 270, the experts characterized it as Wet. This means that the soil moisture level of the Rice crops is still wet and do not need to be watered. And if the device detected 435, the experts characterized it as Dry. This means that the soil moisture level is dry so it needs to be watered.

#### 3.1. Hardware Components

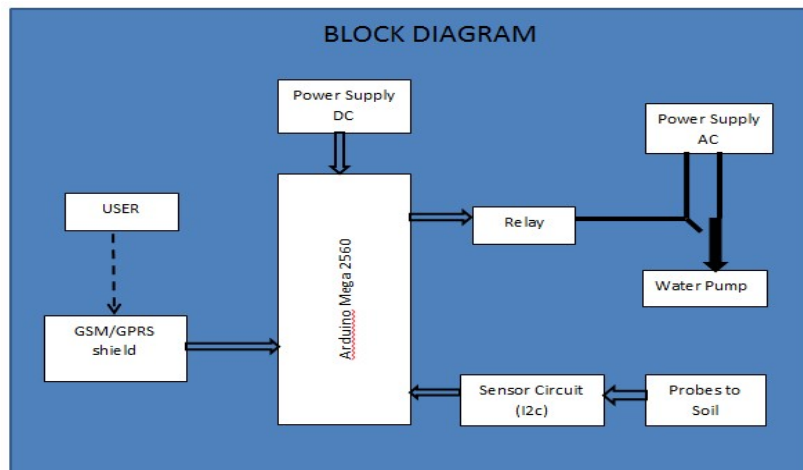
The following hardware components below were used in the study.

- Arduino Mega - The Arduino Mega is the main controller of all the components in the circuit.
- Soil Moisture Sensor - The Soil Moisture Sensor will be used to check the condition of the soil.
- Solar Panel - The solar panel is the source of electricity.
- GSM Shield - The GSM Shield is used to establish communication between a user and microcontroller. It requires a SIM (Subscriber Identity Module) card just like mobile phones to activate communication with the network. The purpose of the component to the project is to wirelessly alert the farmers about the condition of the soil.
- Mobile Phones - The farmers will use mobile phone to receive notification from the GSM Shield about the condition of the soil. This helps a lot in determining when to water the plants using the water pump. As mentioned in the study of [12], that GSM Shield Technology is suitable for modern days and improved the old method of collecting data in the farming areas.

#### 3.2. Working Principle

Soil Moisture sensor checks the level of moisture content. The sensor probes are directly planted to the soil and detect the soil moisture value. The sensor value will be the input for the arduino board and process it. After this, Arduino board reads the moisture condition from soil moisture sensor. If it detects normal, wet and too wet conditions the system will not send a message to the farmer. But if it detects dry and too dry conditions then a text message will be sent to the mobile phone of the farmer informing of the soil moisture value, the condition of the soil and the action to be taken. The farmer then will turn

on the water pump to water the plants via SMS. The farmer will send “ON” message to the system to water the plant. Otherwise, “OFF” message to turn off the water pump. Figure 3 shows the block diagram of the developed device for the whole system.



**Figure 3.** Block Diagram of the developed device

#### 4. Results and Discussion

The Table below shows the values detected during the testing of the equipment in the field at Tagudin, Ilocos Sur, Bangar and Sudipen, La Union. It was validated by five Rice farmers and seven Maize farmers since they are the farmers that are available and doing the watering and checking of the soil condition when the proponents did the testing of the equipment. Too Wet, Wet, Normal, Dry, Too Dry are the characterization used to better understand the soil moisture values.

Based on the gathered data during the testing of the equipment, as shown in the table below from when the Rice was transferred until 80% of growth, it requires plenty of water. But when the Rice plant reaches 81% growth, the farmer's start to reduce the amount of water going to the Rice plants until it will be harvested. Like in the Rice, for example under the Wet, the sensor detected the value 270 to 383 during 0 to 80% growth of Rice and 360–405 during the 81% until it is ready to be harvested. This implies that the value is lesser if the growth stage is 81%, thus, the amount of water needed for Rice is lesser if it reaches 81% growth and until it will be harvested.

On the other hand, Maize plants needs plenty of water from 0 to 80% growth stage compared to when it reaches 81% growth; the required water will start to reduce. Like under Wet, the sensor detected the value 281 to 369 under 0-80% growth, and 351-395 under 81% -100%. This implies that the more water is needed when the growth stage is from 0-80% growth compared to when the Maize crops reaches 81% of the growth stage.

**Table 1.** Characterization of Soil Moisture Level for Rice and Maize Crops with Fuzzy logic

Growth Crops	Soil Moisture Level Values									
	Too Wet		Wet		Normal		Dry		Too Dry	
	0-80%	81-100%	0-80%	81-100%	0-80%	81-100%	0-80%	81-100%	0-80%	81-100%
<b>Rice</b>										
Max	269	359	383	405	434	418	450	430	1023	1023
Min	0	0	270	360	384	405	435	419	451	431
<b>Maize</b>										
Max	280	350	369	395	440	460	470	461	1023	1023
Min	0	0	281	351	370	396	441	489	471	490

## 5. Conclusion

The current work aimed to characterize the soil moisture level for Rice and Maize crops using Arduino with fuzzy logic. Based from the obtained result, the proponent concluded that the Soil Moisture Level gathered using the Arduino Mega was accurate based from the validation made by the experts. Also, it was found out that Rice and Maize needs more water if the growth stage is from 0 to 80%. This characterization will help the farmers in determining the required amount of water for Rice and Maize in specific growth stage.

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