

Smart Solar-Powered Irrigation System For Promoting Agriculture In Nigeria

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1. ABSTRACT

Nigeria has 70.8 million hectares of agricultural acreage, with maize, cassava, grain sorghum, yam beans, millet and rice being the key crops. Nigeria's rice production rose from 3.7 million metric tons in 2017 to 4.0 million metric tons in 2018. Agriculture in Nigerian states can be a branch of the Nigerian economy, providing employment for about thirty-fifth of the population as of 2020, as reported by the Food and Agriculture Organization [2]. Agriculture remains the backbone of the Nigerian economy, despite the presence of oil within the country. For farmers in Nigeria, irrigation farming is extraordinarily troublesome, whereas others realize it is not possible to do for a variety of reasons. In this paper, an automatic smart solar-powered irrigation system to facilitate farming after the rainy season is projected. The device is capable of watering the farm land once the sand is dry. Once the sand gets enough water, the device can stop the watering automatically. Farmers will resolve the case on their own farm, merely and simply. This project would facilitate the interaction of countless Nigerians into irrigation farming, as nowadays, only around 1% of Nigeria's farmers are able to farm after the rainy season. This, in turn, results in acute financial conditions and food insecurity within the country.

Keywords: *Agriculture, Automatic, Crops, Irrigation, Smart, Solar.*

2 INTRODUCTION

A Smart Solar-Powered automatic irrigation system is an electrical and electronic or mechanical device or system that is used for watering, spraying, and lots of work to ease farming powered by Sun Energy. Such devices are useful, particularly after the rainy season. Since the Internet of Things (IoT) is the dominant technology for devices in an exceedingly easier and handier way, the proposed Smart Solar-powered automatic irrigation in this project is controlled based on a webpage, application or SMS messages.

Irrigation practices in Nigeria can be traced back to 700 AD [19], but they became more prominent in 1970 [20]. Irrigation is outlined as adding water to the soil on the far side of the water obtained from rain, increasing plant growth and yield, and in some cases, strengthening yields of leaves and other plant elements. Additionally, by pumping water from groundwater, you'll be able to either pump surface water or divert surface water from one landscape location to another.

In particular, the redoubled use of irrigation techniques in Nigerian states is a crucial necessity for raising Nigeria's agricultural productivity [13]. However, despite government efforts to expand irrigated areas through giant public irrigation systems, a lot of Nigeria's irrigated space is the result of tiny personal irrigation farms. To emphasize, personal irrigation systems measure a lot more than public irrigation systems throughout Nigeria, as farmers plan systems that meet numerous desires in their agro-ecological and socio-economic surroundings. These variations embody the power to access water and distribute it to parcels. [14]

With increasing energy demand, constant depletion of existing fuel sources, and growing issues regarding environmental pollution, humans can discover new non-conventional renewable energy sources for power generation like the sun, wind, etc. [01]

Because totally different states of Nigeria are all exposed to the sun's light for twelve months of the year. Therefore, victimization it in numerous areas may be a nice and wise plan. Solar power is one of the most stylish and best sources of energy in the world. Photovoltaics is a good approach to harnessing solar power. The PV pump system (PVP) is simple to put in any place and doubtless needs less maintenance every 5–10 years, reducing the overall maintenance fee.

When calculating the initial cost of capital, only the cost of solar cells and other necessary equipment is considered. [10] The price of solar panels has been unendingly decreasing, which encourages their usage in numerous sectors. One in every one of the applications of this technology is employed in irrigation systems for farming. Solar-powered irrigation systems may be acceptable to different farmers within the current state of energy crisis in Nigeria.

The cost of solar panels is steadily declining, and they are used in numerous areas and are being promoted. One of the uses of this system is agricultural irrigation systems. In the current state of the Nigerian energy crisis, irrigation systems might be a decent alternative for farmers. Beans, rice, sesame, cashews, casaba, cocoa beans, peanuts, Arabic gum, cola nuts, corn, melon, millet, palm grains, palm oil, obaco, rice, rubber, sesame, soybeans, bananas, and sweet potatoes are the most common crops in Nigeria. [17]

Nigeria was far-famed for commerce in peanut and nut oil in the past. However, over the years, the export rate of those products has declined. Many years ago, some native Nigerian corporations began trading peanuts, cashew crackers, Sesamum indicum seeds, Moringa seeds, ginger, and cocoa. [16]

Nigerian agricultural products can be divided into two major groups: food crops created for self-consumption and cash crops that are oversubscribed fruitfully and exported abroad. The country was self-sustaining before the civil war. However, it has sharply since 1973. Foreign stocks have replaced domestic crops as the most cost-effective staple food. [12] Between 1980 and 2016, yam production redoubled from five million tons to forty-four million tons. [18]

Tons produced in	1980	2000	2016
Maize	612,000	4,107,000	764,678
Millet	2,824,000	5,814,000	1,468,668
Guinea corn	3,690,000	7,711,000	6,939,335
Yam	5,250,000	26,210,000	44,109,615
Cassava	11,500,000	32,697,000	57,134,478
Rice, paddy	1,090,000	3,298,000	6,070,813

Melon seed	94,000	345,000	569,398
Cocoyam	208,000	3,886,000	3,175,842
Sesame seed	15,000	72,000	

Table 1: Food crops produced by Nigeria in Tons from 1980 to 2016

Source: Wikipedia.

The financial institutions of Nigeria started the Anchors-Borrow application to inspire the cultivation of bound crops, specifically rice. The Nigerian government has closed its land borders in numerous ways in order to scale back rice imports and encourage native production [07].

Location	Irrigated	Area
I. Niger Province		2467
a. Wuya edozhigi	1093	
b. Badeggi	1012	
c. Toroko	200	
d. Oguma	162	
II. Ilorin Province (Duku)		458
III. Sokoto Province		405
IV. Kano Province		
a. Tomas	20	
b. Mokodas (Windmill)	B	
	Total	33888 HA

Table 2: Area Reported to be under Irrigation in 1960

(250 mcm), and Amla Otukpo Dam (1.5 mcm). 0.3 mcm; and 2.3 mcm for the Kaduna Dam. [11]

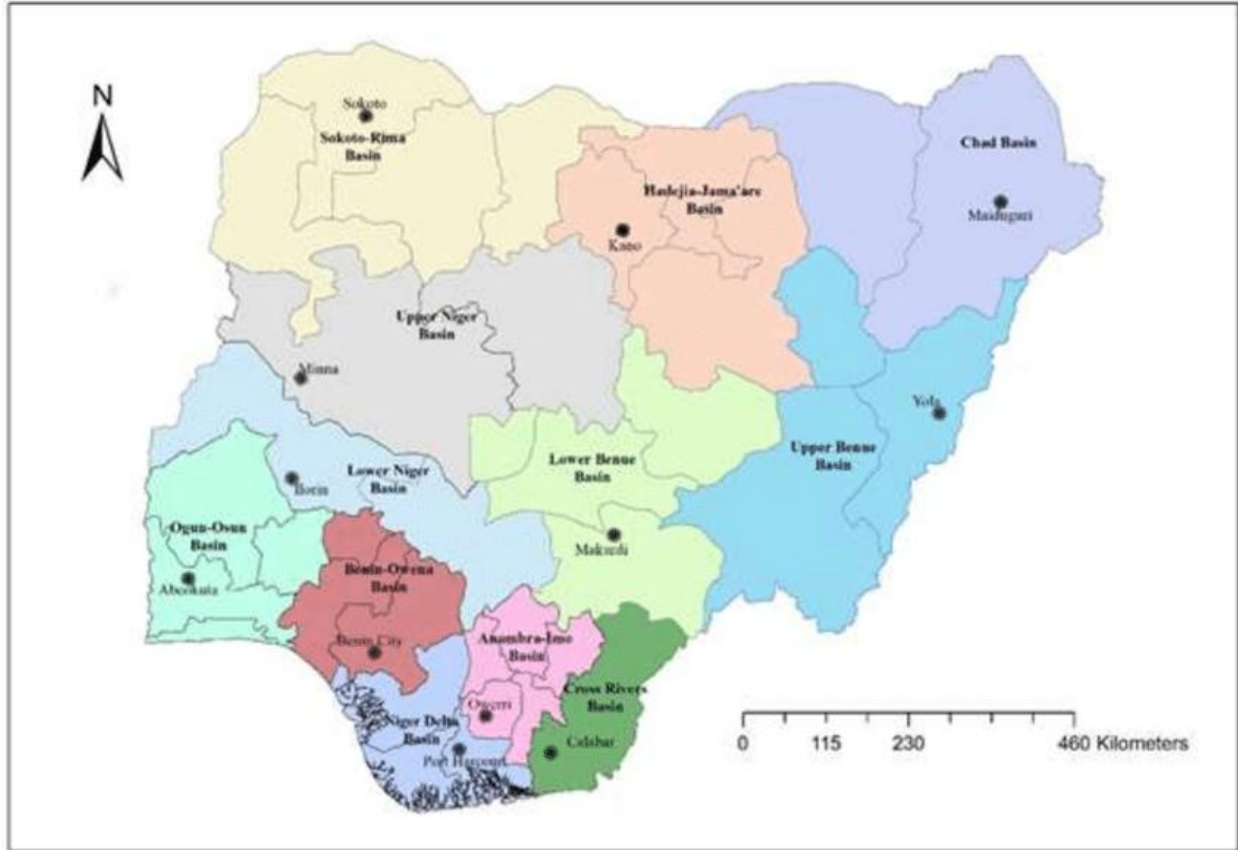


Figure 2: Map of Nigeria sorting River Basins

This project (Smart Solar-Powered Irrigation System) for farming of beans, rice, sesame, cashew crackers, cassava, cocoa beans, groundnuts, gum Arabic, kolanut, maize, melon, millet (corn), palm kernels, palm oil, plantains, rice, rubber, sorghum, soybeans, bananas, yams, and different crops) would promote farming in Nigerian farmlands by an awfully nice proportion. On the other hand, this can alter Nigerian farmers' ability to be engaged in farming even during the rainy season.

In this paper, I propose a sensible solar-powered irrigation system utilizing solar panels that drive water pumps to pump water from a borehole or well to a tank, and therefore the outlet valve of the tank is automatically regulated using Arduino UNO, moisture and humidity sensors to regulate the rate of water from the tank to the irrigation field, which optimizes the employment of water.

2 Overview of the Literature

Currently, the country's total land is calculable to be approximately 34.6 million hectares.

However, only about four hundredth of that is cultivated, and of that, five hundredth is irrigated [25]. The country has huge irrigation potential in dams scattered throughout the country.

However, most government-invested dams are underutilized or abandoned for irrigation [26].

Despite a quick growing economy, one of the nation's biggest reserves of coal, oil, and gas, and therefore the country's standing as Nigeria's prime oil producer, The Nigerian power business continues to fail, thanks to the approaching solar electricity offer to residential families and industrial producers. Solely forty-five percent (45%) of Nigeria's population is presently connected to the electrical grid, and power outages are common (approximately eighty-five percent) and nearly non-existent in some areas. [30]

Nigeria's power reforms have focused on privatizing generation and distributor assets, as well as stimulating company investment within the business. The government maintains management over transmission assets while creating moderate progress toward establishing a restrictive framework that draws foreign investors.

Non-solar-powered smart irrigation systems emit greenhouse gases into the atmosphere, like greenhouse emissions, methane, hydrochlorofluorocarbons (HCFCs), hydrofluorocarbons (HFCs), and other gases within the lower atmosphere. Gases, on the other hand, have an impact on Earth's living organisms.

For these reasons, I'll propose a smart solar-powered irrigation system which will curb the loss and promote agriculture in the Nigerian States; one that is zero-hazard and easy. Solar power is free of charge. Therefore, you do not have to pay cash before using a sun light. Since it's free, I am proposing a solar-powered smart irrigation system that will promote agriculture in Nigeria.

The system can be controlled over the web, through applications or through SMS messages. Using the GSM module, which stands for Global System for Mobile, with the help of GPRS (General Packet Radio Service), you have the ability to send and receive SMS or connect with the web. As the value records from the moisture sensor and humidity sensors are transmitted to

the THINKSPEAK Channel. THINKSPEAK is an open information platform that allows one to gather, store, analyze, visualize, and work on actuators.

2.1 Overview of the Smart Solar-Powered Irrigation System

The Smart Solar-Powered Irrigation System is an associated automatic watering device that detects the correct time to water the plants within the farmland. The device can find the quantity of water or wetness, the temperature, and therefore the wetness of the land. Once the land is wet, the device can detect it, then it'll stop automatically and display the soil property on the liquid crystal display (LCD display).

An ultrasonic sensor has the power to find the quantity of water remaining within the storage tank or instrumentality with the help of ultrasonic sensing. As long as the tank desires more water, it'll activate the water buster. As soon as the tank is full, it'll flip the buster off automatically by employing a relay module. No more wasting of water.

The device can be controlled automatically, over a mobile application or using the web. Utilizing the web mode permits it to operate wherever a farmer is round the globe, as long as there's a network within the farmer's location.

2.2 Purpose of the Paper

The aim of planning a smart solar-powered irrigation system is to form a less complicated, easiest, and most profitable device for farmers to use while farming in and after the rainy season. As said earlier, the device is designed to be a solar base (to work with solar panels). A device which will be controlled from any location a farmer is in so as to market healthy crops and curb the absence of watering plants on time and overwatering the plants.

3 Discussion

The agricultural sector is projected to interchange the country's future economic property [22]. However, development plans can't be realized while not addressing the challenges facing irrigation systems. The availability of water resources for irrigation plays a crucial role in the agricultural and economic process [23]. As a result of agriculture and irrigation measure tangled,

every agricultural set up is very important, particularly in countries like Nigeria, where there are massive spatiotemporal fluctuations in national downfall [24].

The device can be automatically controlled via mobile applications (Android phone applications, IOS applications, Windows Phone applications, etc.). Sometimes, because of some drawback, the farmer can miss a day or two going to his farm in order to water the plants. The difficulty can be because of the death of his relatives, children, etc. Until then, he was unable to go to his farm. In some cases, this might result in something else. As I said before, once there is a network, you'll be able to manage your devices over the net.

3.1 The Advantages of a Solar-Powered Smart Irrigation System

- ✓ Solar power is pollution-free and emits no greenhouse gases when installed.
- ✓ It reduces reliance on oil and fossil fuels.
- ✓ Renewable, clean energy that's offered year-round, even on overcast days.
- ✓ Unlike paying electricity prices, there's a return on investment.
- ✓ Solar panels last for over thirty years with virtually no maintenance.
- ✓ Helps the economy by creating jobs by supporting solar battery manufacturers, installers, and others.
- ✓ Excess electricity may be transferred back to the biggest company if the grid is interconnected.
- ✓ Can be put in virtually any place, from a field to a building.
- ✓ Square batteries are being used to store additional electricity for use in the dark.
- ✓ The ability to measure off the grid if all energy generated is comfortable for the farm or structure.
- ✓ It is also erected in virtually any place, from a field to a structure.
- ✓ Batteries can be used to store excess energy for later use.
- ✓ Solar will then be able to boil water, leverage farms and buildings, and even power a lot of machines on the farm.
- ✓ More secure than ordinary electrical phenomena
- ✓ Efficiency is usually high enough that the same size solar batteries offered nowadays are a lot more economical.

- ✓ Aesthetics: square measure up, using the sun is a lot more versatile than older models; as an example, printing, flexible, solar, and so on.
- ✓ Federal subsidies, tax breaks, and compensation programs are available to help with the initial costs.

3.2 Challenges

First, Nigeria's irrigation development has faced inconsistent and unstable policies and inadequate restrictive frameworks for several years. Water and agriculture, though separate entities, are regarded as irrigation farming across the country [21].

- ✓ Expensive small irrigation: Most of the time, those who are able to adopt measures, both wealthier farmers and poor farmers, face some problems in buying farming machines. However, it may be resolved by coming up with and constructing a low-cost irrigation system.
- ✓ Delays in completion of projects: As expressed above, on the second of Jan of the year 2020, the Nigerian government completed 10 projects concerning irrigation farming. These projects take a long time to complete before they are implemented.
- ✓ Energy Crisis because of power shortages and special interruptions across rural and urban Nigeria. Because of this immense drawback, the device is going to be a solar-primarily based smart irrigation system. It'll use solar power to convert it to electricity with the help of an inverting circuit.

4 Methodology

The method followed during this analysis involves data collection. Analysis was done using completely different books, encyclopedias, journals, and alternative open sources. The research was primarily based in Kano State.

4.1 Required Equipment

- Arduino UNO
- GSM GPRS SIM900A Modem

- Vero Board,
- Relay Module
- DC Water Pump,
- LCD Display 16*2
- Jumper Wires
- Humidity Sensor (DHT11),
- Soil Moisture Sensor,
- Battery,
- Solar Panels.

Arduino: Arduino UNO is a tunable ASCII text file board which will be utilized in a wide range of easy and complicated projects. This board features a microcontroller that is associated with using ATMEGA328P, which is designed to program and execute the commands. The Arduino will act with a variety of outputs, together with LEDs, motors, and displays, via sensors and inputs.

Microcontroller	ATMega 328P
Operating Voltage	5V
Input Voltage	7 to 12 volts
Input voltage limit	5 volts
Digital I/O Pins	14
PWM Input Pins	6
Analog Input Pins	6
DC Current Per I/O Pin	20 mA
DC Current Fore 3.3 Volts	50 mA
Flash Memory	32 KB
SRAM	2 KB
EEPROM	1 KB
Clock Speed	16 MHz
LED Build-in	13
Length	68.6 mm

Width	53.4 mm
Weight	25 g

Table 3: Description of Arduino UNO

Source: *Arduino.cc*

Solar Panel: For the operation of any system, electricity is needed [27]. PV cells form the basis of a solar panel. Whenever the PV cell transforms lightweight energy into electricity, the energy is held on to in association. It aids in the operation of the system [28].

The solar panel's cells are hit by the sun's rays. The excitation of the cells causes the thermal energy and terminals to extend. Engineered into the vanguard of the sustaining structure, it transports and transforms the obtained heat. Lightweight energy is reborn into electricity, which is then transmitted through the wires and held on outwardly.

When a solar panel is exposed to daylight for sixteen hours, it produces 5.5 hours of energy, with eightieth of the energy being usable without loss [29].

Battery: The battery is employed to avoid wasting electricity obtained from the solar battery for this project. The battery specifications are:

- VOLTAGE: 12V
- CAPACITY: 100Ah
- CHARGING CURRENT RANGE: 10-15A
- TYPE: TUBULAR

Humidity Sensor: A Humidity Sensor is a device that has the power to observe the wetness and temperature of the atmosphere.

Parameters	Conditions	Minimum	Typical	Maximum
Humidity				
Resolution		1%RH	1%RH	1%RH
			8 Bit	
Repeatability			± 1%RH	
Accuracy	25 °C		± 4%RH	
	0-50 °C			± 5%RH
Interchangeability	Fully Interchangeable			
Measurement Range	0 °C	30%RH		90%RH
	25 °C	20%RH		90%RH
	50 °C	20%RH		80%RH
Response Time (Seconds)	1/e(63%)25 °C , 1m/s Air	6 S	10 S	15 S
Hysteresis			± 1%RH	
Long-Term Stability	Typical		± 1%RH/year	
Temperature				
Resolution		1 °C	1 °C	1 °C
		8 Bit	8 Bit	8 Bit
Repeatability			± 1 °C	
Accuracy		± 1 °C		± 2 °C
Measurement Range		0 °C		50 °C
Response Time (Seconds)	1/e(63%)	6 S		30 S

Figure 3: DHT 11 specification and description

LCD Display 16*2: This is a 16*2 screen which will show sixteen (16) characters in 2 columns. The information obtained from the moisture and humidity sensors is displayed on the LCD display screen.



Figure 4: Arduino UNO Board

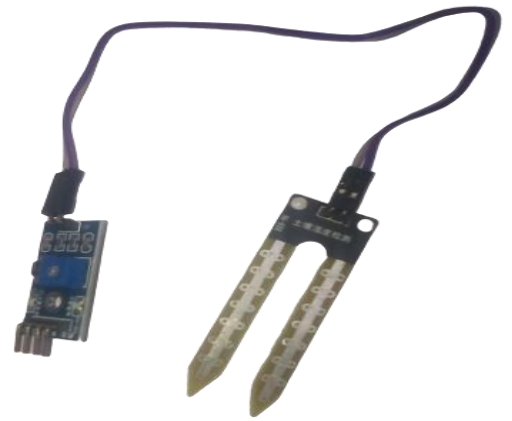


Figure 5: Arduino Moisture Sensor

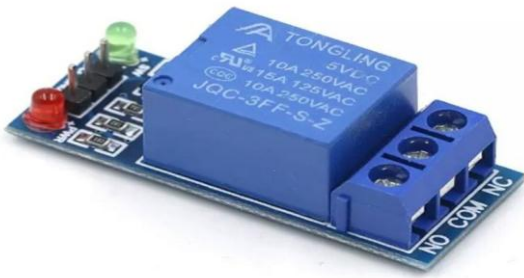


Figure 6: Arduino Relay Module

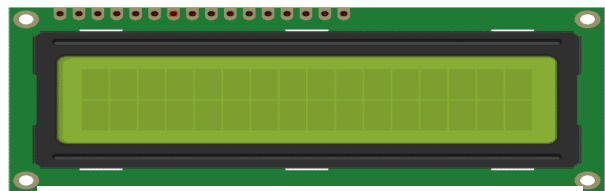


Figure 7: Arduino LCD Display 16*2



Figure 9: 12V Solar Panel



Figure 8: Vero-Board



Figure 10: Humidity Sensor

4.2 Procedure Used

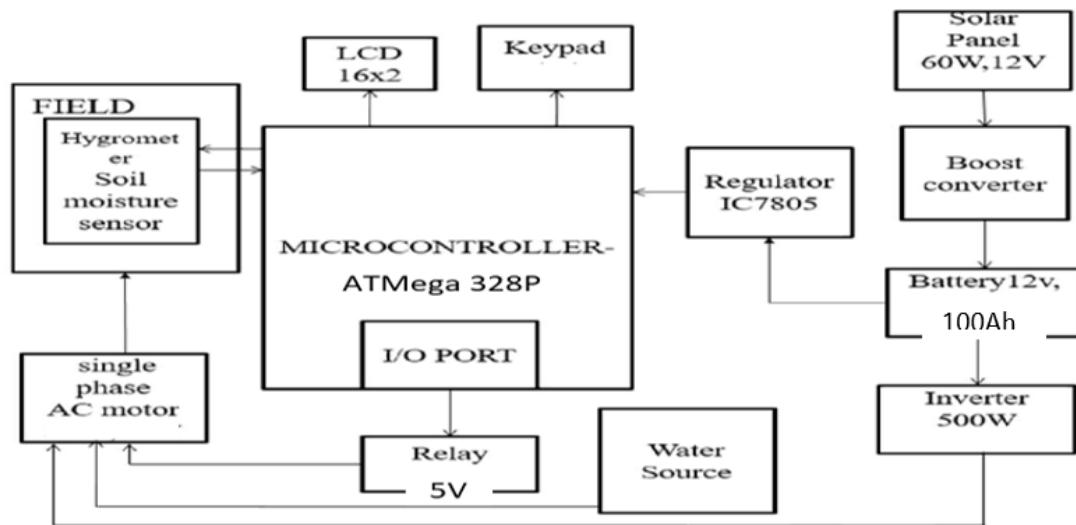


Figure 11: Block diagram of Proposed Solar based Smart Irrigation System

4.2.1 GSM GPRS SIM900A Modem

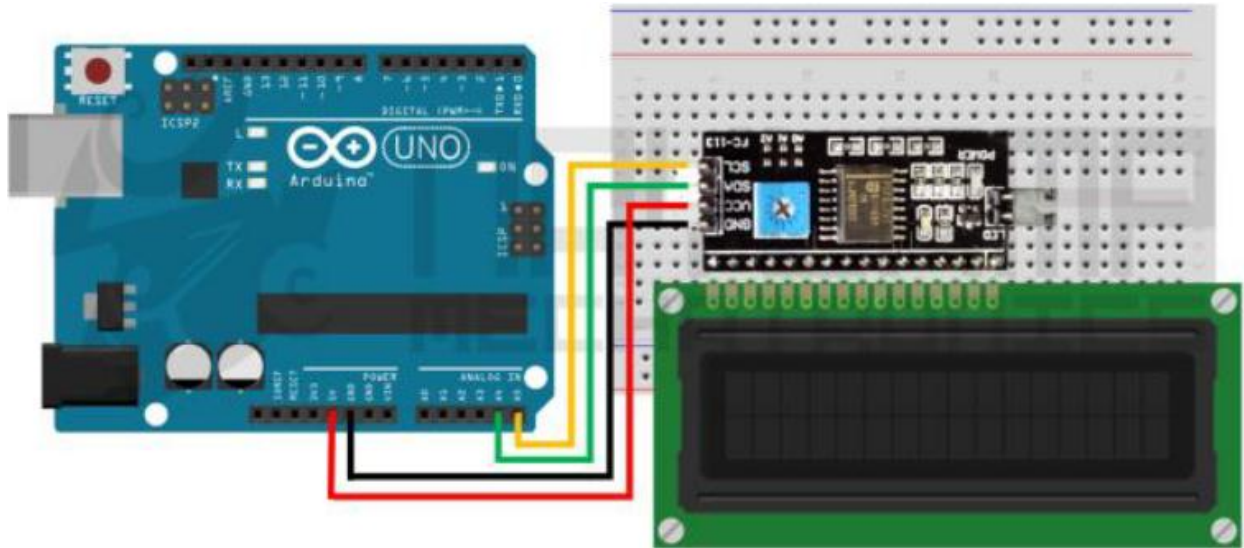
GSM GPRS SIM900A is an electronic device. It operates at 900 and 1800 megacycles. These 2 bands can be looked up automatically by SIM900A. AT Commands may be used to set the frequency bands. Through the AT command, the band may be adjusted between 1200-115200. The built-in TCP/IP stack of the GSM/GPRS electronic equipment permits you to attach to the GSM-based net. The wireless module SIM900A is implausibly tiny and dependable. [31]



Figure 12: GSM GPRS SIM900A Modem

4.2.2 Connecting Arduino UNO with LCD Display

The LCD Display's 16*2 pinouts are connected to the Arduino Uno Board, as shown in the figure below:



*Figure 13: Connecting Arduino with I2C LCD Display 16*2*

Then humidity, relay, and soil moisture sensors are connected to the Arduino UNO board. And lastly, the programmed code is uploaded into the Arduino UNO ATMEGA328P chip to execute the program. The Arduino IDE is employed in writing the program.

4.2.3 Connecting Arduino UNO with GSM900A Modem

The GSM900A modem is connected to the Arduino UNO board. GSM900A is a wireless module that allows us to send and receive data from far away. We are using the serial pins of the Arduino, which are Rx and Tx, to connect the GSM900A Module. We start by connecting the Tx pin of the GSM module to the Rx pin of the Arduino UNO, and the Rx pin of the GSM module to the Tx of the Arduino UNO. Finally, connect the GSM900A module's ground pin to the Arduino UNO's ground pin. Below is how the two boards are connected.

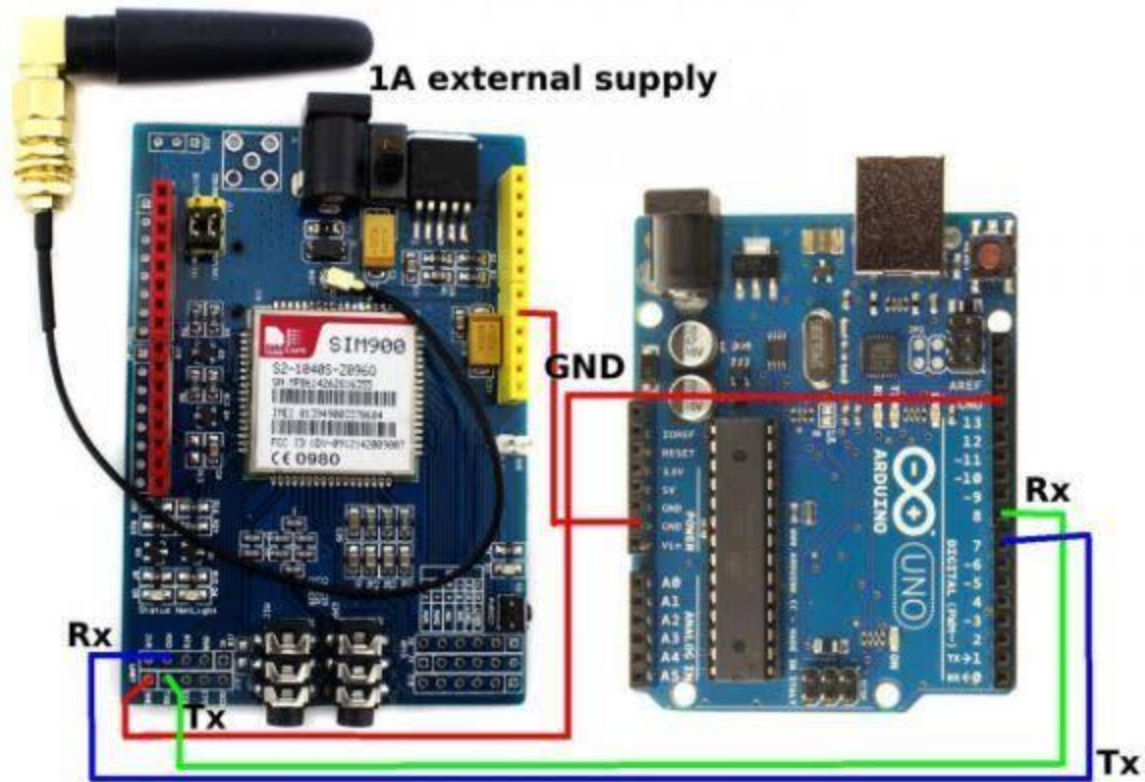


Figure 14: Connecting of Arduino UNO with GSM900A Modem

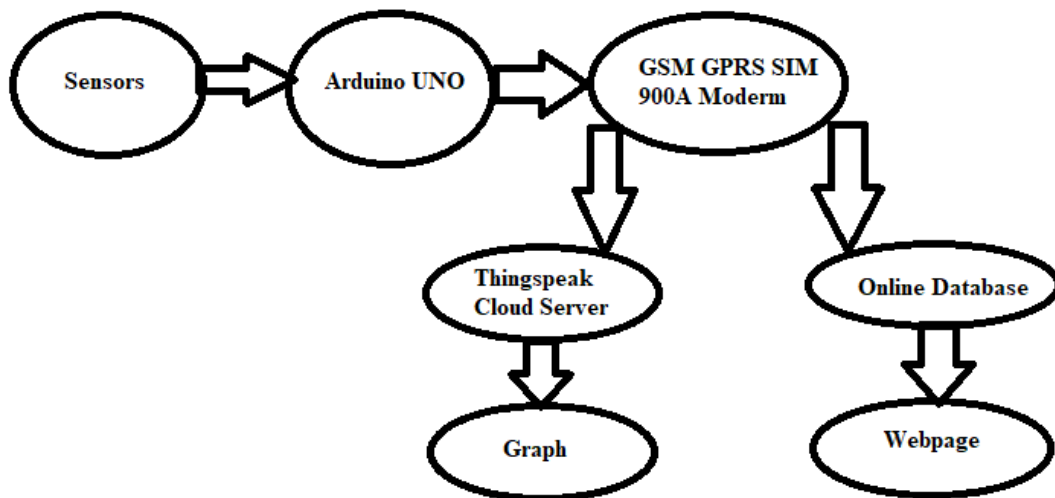


Figure 15:flow chat of the GSM section

4.3 Working Principle

The proposed smart solar-powered irrigation system can be controlled in numerous ways. Either by sending a text message (SMS) to the device to "On" or "Off" itself, using a webpage platform to regulate it or to regulate itself automatically, since its sensors will facilitate the method. The moisture sensing element detects the moisture content of the farmland with 12V power from the inverting circuit. In our project, if the dryness is greater than 450, the pump will automatically activate and begin watering the farmland. If the wet level is a smaller amount than or adequate to the desired value, the pump is turned off and watering of the portion is completed. If you would like to flood plants and fields, you may wish to stop the humidity sensing element at a high level or set the programming value below the previous fastened value. The graph and all values may be read via the webpage. The graph below shows that the motor starts watering at a higher dry point and typically stops at saturation to succeed in a balanced position. The humidity sensor and moisture sensor are connected to the Arduino [15].

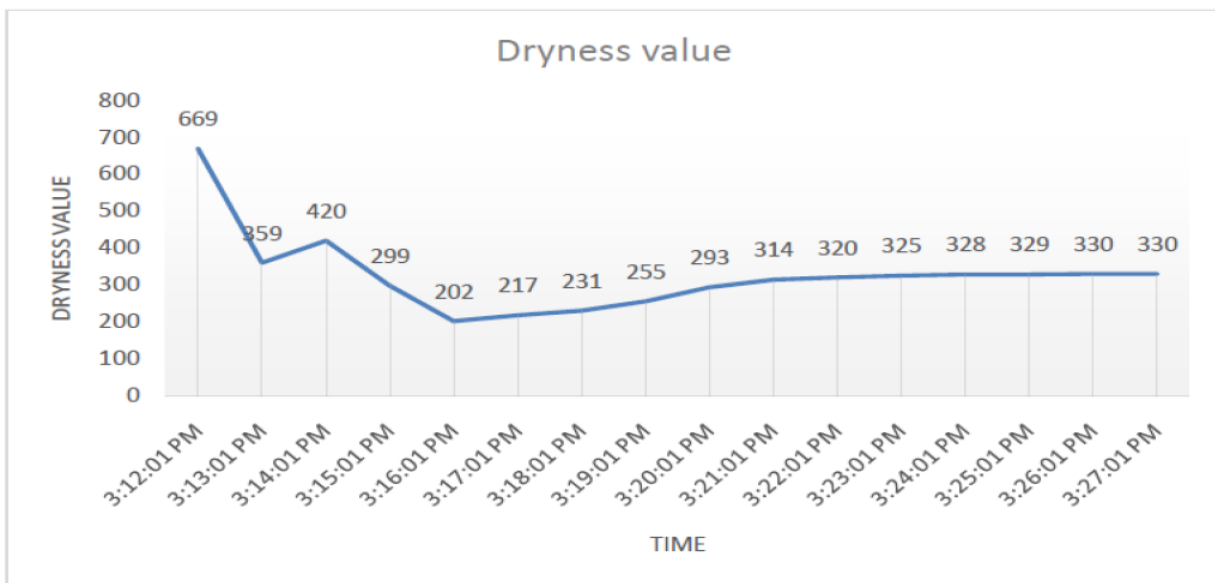


Figure 16: Graphical representation of dryness level of soil for saturation watering

S.No.	Crop	Moisture Level(in %)	Water Requirement(in mm)	Optimum Temperature(in F)
1	Rice	20%	900-2500	77
2	Wheat	12%	450-850	72
3	Maize	18-24%	500-800	77
4	Soybean	13%	450-700	57
5	Sunflower	9.5%	350-500	60
6	Corn	15.5%	500-750	95
7	Tomato	10%	600-800	85
8	Potato	12.5%	500-700	60
9	Onion	11%	350-550	75
10	Bean	16%	300-500	75

Figure 17: Water requirements for crops

5 Conclusion

A solar-based smart irrigation system was proposed and designed for this project. The project is made up of a number of components, like the Arduino UNO, GSM900A electronic equipment, moisture sensor, humidity sensing element, relay, water pump, solar panel, etc. The smart irrigation system is incredibly reliable and friendly to use. The system uses data from the soil detected by moisture and humidity sensing elements to send the signals to the Arduino UNO, then it'll interpret the signal. The data obtained from the farmland is saved in an extremely webpage cloud storage. It makes irrigation easy and it prevents or protects excessive irrigation or insufficient watering. The device uses a 12-volt power supply from a solar panel that converts sun energy to electrical energy. At the heart of this project are the Arduino UNO, the GSM900A device, the soil moisture sensor, and the solar panel. With this, farmers would be able to afford this type of smart solar-powered irrigation system with a simple little amount of money. This project can be self-control (it controls itself without the assistance of human interaction once installed).

6 Recommendation

- ✓ This project may be managed based on the net. So as to be controlled from any location around the globe,
- ✓ It may be upgraded to serve several functions, like serving as a sprayer of weed and bug killer on a farm,
- ✓ This project is useful to Nigerian farmers. As a result, it'll help in providing healthy and clean crops.
- ✓ It can scale back an enormous loss to farmers.

- ✓ Farmers can afford this smart solar-powered irrigation system with a simple amount of money.
- ✓ The project can be self-controlled; it controls itself without the assistance of human interaction once installed.
- ✓ The device can be used in the rainy season.

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