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Smart Village

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Abstract

A village is a clustered human settlement or community, larger than a hamlet but smaller than a town. A Smart Village is a concept where the present standards of living of village residents, livelihood, agricultural practices, energy production and consumption, education, etc., are all improved by adapting smart technologies from various engineering fields leading towards the smart village concept. Many projects have been proposed for the development of villages but, most of the projects aggregate a large number of units under the same system, which requires more hardware components and is more complex. This project report focuses mainly on three major sectors viz., Street Light Management (SLM), Automatic Irrigation System (AIS), and Water Management System (WMS). The main objective of this project study is to implement all the above-proposed components in creating a sustainable smart village environment. The overall benefits of this project study are reduced energy consumption, efficient water management, farming flexibility, and water quality control.

Keywords — *Smart technology, Streetlight management system, automatic irrigation system, water management system, overall benefits*

I. INTRODUCTION

In INDIA, approximately there are 6,38,588 villages, and 68.84% of the total nation's population reside in rural areas as per the Census report on 2011. The village sector contributes to 75% of the country's Gross Domestic Product (GDP). The government and private sectors have already initiated various programs encouraging improved (smart) village concept, where PradhanaMantri Gram SadakYojana (PMGSY) is one of the popular and leading rural development programs in our country concentrating on various improved village aspects such as providing electricity, streetlight facility, water management, solar pumps, education, better lifestyle, etc., to name a few. Punsari, a village with a 5500 population in the Sabarkantha district of Gujarat state, is the first smart village of India framed under the guidelines of PMGSY. Each village is unique and poses a diverse set of problems and situations; hence it is necessary to focus on fulfilling common fields such as electricity, streetlight, water management, etc.

Smart village concept focuses on viz., sustainability, empowerment, water management system, accessibility to sustainable energy, economic growth, etc. Here in this project, the main focus aims to accomplish three major village requirements viz., SLM, AIS, and WMS forwarding towards Village 3.O.

The traditional streetlight management system was all about switching lights ON and OFF automatically. Similarly, in the case of an automatic irrigation system, the goal was to make the water pump ON and OFF automatically, and finally, in the water management system, it was just concerned about checking the primary basic water quality parameters such as pH, turbidity and pathogen content of water through laboratory chemical methods. Any upgrade to these systems was not successfully implemented to its potential level because of lack of knowledge on utilization of Information Technology (IT) tools and also due to improper strategy, unfocused planning, and above all, execution and monitoring of these activities.

A. Street Light Management (SLM): an overview

Studies have shown that darkness results in many crashes and fatalities, especially those involving pedestrians; pedestrian fatalities are 3 to 6.75 times more likely to occur in the dark than in daylight. The SLM system adopted in this project study comprises of IR sensor, LDR sensor, 4-channel relay module, and ESP8266 WIFI module**.** All the sensors and relay

module are connected to the Arduino 2560 microcontroller and is programmed under ArduinoIDE by C/C++ language. A fault signal is sent out by the fault detection unit comprising the ESP8266 WIFI module with cloud storage present in the SLM system to the required authorized concerned personnel in the base station, confirming the exact fault site. The SLM system also helps in overall energy consumption reduction. The automated system and fault detection unit adopted results in lower manpower and easy monitoring of the SLM system.

B. Automatic Irrigation System (AIS): an overview

The conventional irrigation system has some major drawbacks, viz., water loss, soil erosion, leaching of nutrients, and plant decay due to excess moisture, etc., hence controlled usage of water in an irrigation system is necessary to prevent the drawbacks mentioned above. To account for the above problems posed by conventional irrigation systems, AIS is a feasible solution. The AIS comprises of Arduino Mega 2560 microcontroller programmed under Arduino IDE with C/C++ language with the inclusion of a single-channel relay to interrupt and transfer the signals. All the above components are interfaced with the microcontroller. The SMS and DHT11 sensor examine the moisture content and temperature of the soil of the agricultural land. A fault signal is sent out by the fault detection unit comprising the ESP8266 WiFi module with cloud storage present in the AIS system to the required authorized concerned personnel in the base station, confirming the exact fault site. The benefits of the inclusion of SAIS in the agricultural practices are, viz., reduced water loss, farming flexibility, reduced energy consumption for a pumping system, conservation of soil nutrients, fault alert, etc.

C. Water Management System (WMS): an overview

The water management system in a tropical country like INDIA is an important aspect since rainfall is unpredictable, and the present water storage systems and water quality management pose a lot of issues. To overcome these problems, big-scale manpower and system modulations confirming higher costs are required; hence the implementation of WMS is a tactical approach to overcome the issues present in the conventional water management system. The WMS comprises of Arduino Mega 2560 microcontroller programmed under ArduinoIDE with C/C++ language with the inclusion of water level sensor, temperature sensor, pH sensor, and turbidity sensor. All the components are interfaced with the microcontroller.

A fault signal is sent out by the fault detection unit comprising the ESP8266 WIFI module with cloud storage present in the WMS system to the required authorized concerned personnel in the base station confirming the exact fault site. The benefits of WMS are an effectively controlled distribution of water, better water quality control, easy fault detection, operation flexibility, and ease of maintenance.

The proposed model aims at making optimal and sustainable use of all primary resources while maintaining an appropriate balance between social, environmental, and economic aspects.

II. Related Work

Boyu Sun et al. [1] have proposed a street light management method that evaluates the performance by verifying the stability, usability, high efficiency of the terminal service node, data interaction, and the usability of permissions management, which proves the reliability of the overall system architecture.

FathimaDheena PP et al. [2] have proposed the automated streetlight management system that aims at conservation of energy to reduce the wastage of electricity and manpower. Energy wastage prevention can be brought in by switching off the lights automatically.

Juvy Amor Galindo [3] develops an energy management methodology applied in the streetlights of a school campus. Here the streetlight has a dimming capability that minimizes the cost of energy consumption. Raspberry Pi and Raspberry camera modules are used to controlling the dimming of the LED lights. This is brought in by using the computer vision technique.

Akanshakaul, Tina Chaudhary [4] has proposed a smart LED street light system that controls the intensity of light during rain and fog. The method is implemented using Arduino, LED lights, and an LED dimming control PWM circuit. The merits of the proposed system are that it is cost-sensitive and is very simple in its design part when compared to network-based wireless sensor systems.

Sanguk Park, ByeongkwanKang [5] has proposed a method that examines the problems related to the integrated ESS (Energy Storage System) in a smart grid, which results in high installation costs and low management efficiency. The initial installation costs can be reduced by applying this system by using micro-distributed ESS and IoT-based intelligent energy management.

U N V P Rajendranath [6] has proposed an automated irrigation system based on the sensors which are interfaced to the microcontroller unit using the Arduino board is being developed. Sensors being used in the system are the temperature and humidity DHT11 sensor and Soil moisture sensor VH400.

Janani P [7] has proposed a method in which the main objective is to optimize the use of water effectively, and the motor is driven based upon the texture of the leaf. The system presents information about the suitable soil for cultivating the plants such as banana, paddy, wheat, etc. The proposed system results in cost-effectiveness for utilizing the water resources for agricultural production, and also it helps in biomass production.

A Sumalatha [8] has proposed an automatic smart irrigation system that uses solar power for irrigation purposes. Based on different soil parameters like moisture and temperature, a solar-powered water pump operates automatically. The system ensures efficient irrigation since it uses solar energy simultaneously whenever a power failure occurs.

Sanjay Kumawat [9] has proposed a method to provide an automatic irrigation system, thereby saving the time, money, and power of the farmer. Automated technology of irrigation minimizes human intervention.

P.Suganya [10] has proposed a Smart agriculture system, which is an automated and directed information technology implemented with IoT, and this is achieved using remote sensing, microprocessors, IoT, DBMS. The major objective of the system is to get real-time data and reduce the water that is lost in the irrigation process and the time spent in the field.

ChandaRajurkar [11] develops a system that mainly focuses on monitoring the use of water by considering one block of the house in a flat system that is at the partition of the pipeline from where the water gets diverted to various parts of a block. The sensors will sense the flow of water to each pipe, which ultimately tells the usage of water at one block ideally.

SreekanthNarendran [12] has proposed a method that mainly focuses on the sustainable water management system based on the Internet of things (IoT) that automates the water distribution, storage, and regulation of water wastage. An IoT system designed for sustainable water management is proposed for the Gudipadu Cheruvu village.

III. Hardware and SoftwareDescription

A. Hardware description

1) Arduino Mega2560:

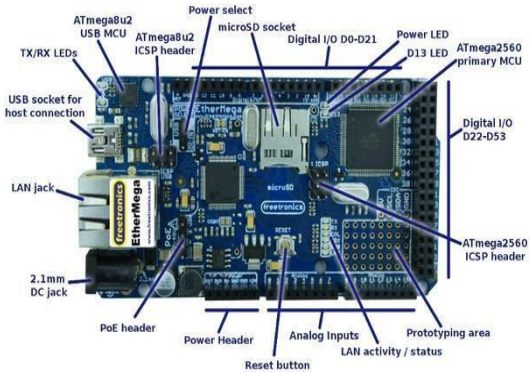

Fig 1: Arduino mega 2560

The Arduino Mega is a microcontroller board based on the AT mega 2560. The microcontroller has 54 digital input or output pins, of which 14 can be used as PWM outputs. There are 16 analog inputs, 4 UART's, a 16MHz crystal oscillator, a power jack, a USB connection, an ICSP header, and a reset button.

2) Light Dependent Sensor (LDR) 5mm Through Hole:

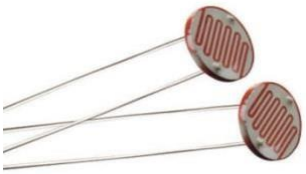

Fig 2: LDR Sensor

The Light-Dependent Sensor (LDR) is a component used in light sensing circuits with variable resistance that varies with the light intensity that falls upon it. The LDR is also given various names, viz., photo-resistor, photo-conductor, and cadmium sulfide cell (CdS). The resistance value of conventional LDR decreases as the light intensity falling upon it increases. LDR has daylight and dark resistance values of 5000 Ω and 20000000 Ωrespectively.

LDR are generally made out of semiconductor materials to enable them to have light-sensitive properties.

3) LM393 Photosensitive Light-Dependent Control Sensor Module:

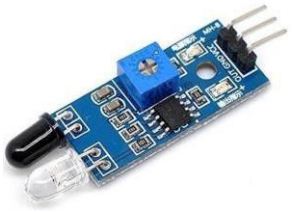

Fig 3: Digital LDR Sensor Module

A digital LDR module is an interface used to measure the light intensity falling upon it. The output of the module goes high as the light intensity increases and becomes low as light intensity decreases.

4) RKI-3141 Infrared (IR) Sensor:

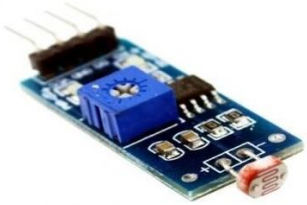

Fig 4: RKI-3141 IRSensor

An Infrared (IR) sensor is a device that detects and measures the infrared radiations present in the surrounding environment. As the IR magnitude changes, the resistances and the output voltages of the photodiode under IR light emission also changes concerning the change in magnitude.

5) 3 in 1 Soil Tester Meter for Garden Lawn Plant Pot moisture Light pH Sensor:

Fig 5: pH Sensor

A pH sensor is a device that uses a measuring electrode and a reference electrode. The measuring electrode detects any change in pH value, and the reference electrode provides a stable signal. The pH sensor measures whether the water is alkaline or acidic. The pH scale varies from 0 to 14, where 7 indicates a neutral pH value.

The water is said to be acidic if its pH value falls between 0 to 6.9, and it is said to be basic if the pH value falls between 7.1 to 14. The pH is one of the primary and important water quality parameters.

6) RKI-2350 Water Level Sensor :

Fig 6: RKI-2350 Water Level Sensor

As the name indicates, the water level in lakes, ponds, tanks, open channels, canals, etc., is measured by the water level sensor. The water level sensor also detects the powdered solid substances present in the water or any fluids. A conductive sensor is used in this project study, where this sensor includes a source of low voltage power and at least two electrodes.

7) YL- 83 RainSensor:

Fig 7: YL-83 Rain Sensor

A rain sensor is a device that gets activated when rainfall falls on it. Rain sensors are effective tools as conservation devices where the sensors automatically shut off the irrigation system when they sense a rainfall event. Rain sensor measures rain moisture through analog output pins and provides a digital output when a preset critical moisture content value is

exceeded.

8) DHT11 temperature and humidity sensor:

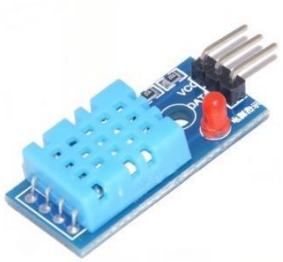

Fig 8: DHT11 T&H Sensor

The DHT11 is a low-cost, basic model sensor that measures the temperature and humidity of the surrounding environment. The DTH11 sensor is composed of a moisture-holding substrate topped by electrodes at the surface, and other components include a thermistor and an Integrated Circuit (IC). The DHT11 measures the humidity of the surrounding by measuring the electrical resistance between two electrodes. The change in the resistance depicts the relative humidity of the surrounding environment.

9) YL-69 Soil MoistureSensor:

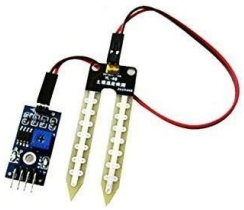

Fig 9: YL-69 Soil Moisture Sensor Module

The soil moisture sensor uses the properties of soil, such as electrical resistance, dielectric constant, etc., to estimate moisture content. And the data is fairly accurate. The sensor consists of two probes that pass the current through the soil and records the resistance value offered by the moisture content present in the soil, indicating the volumetric water content present in the soil. As the moisture content in the soil increases, the conductivity increases, leading to a low resistance value indicating higher moisture content in the considered soil sample.

10) Single or 1 – Channel Relay Module 5V- Interfacing:

Fig 10: Single or 1 – Channel Relay

A single channel relay module is a convenient board primarily used to control high voltage, high current load in solenoids, lamps, motor, and AC load. This relay module is designed to act as an interface with a microcontroller such as PIC, Arduino, etc.

The relay's terminal is brought out as a screw terminal consists of COM, NO, NC and an LED to depict the working status of the relay. The main advantages of a single-channel relay module are good safety, and it has a wide range of controllable voltage.

11) 4-Road/ Channel Relay Module (Light Coupling) 12VInterfacing:

Fig 11: 4 – Channel Relay

The 4 channel relay module is a convenient board primarily used to control high voltage, high current load in solenoids, lamps, motor, and AC load. This relay module is designed to act as an interface with a microcontroller such as PIC, Arduino, etc. The relay's terminal is brought out as a screw terminal consists of COM, NO, NC and an LED to depict the working status of the relay. In this project study, a 4 channel relay control board with opt coupler is adopted.

12) Passive PiezoBuzzerModule:

Fig 12: Buzzer

The buzzer is a component that provides sound features to a system. It is a small, efficient compact 2 pin structure and can be easily and widely adopted in most electronic system applications.

13) Liquid Crystal Display -1602(LCD):

Fig 13: Liquid Crystal Display

The LCD is a flat panel display that uses liquid crystals in its primary form of operations. The LCD most commonly available and used in practical applications is the 16*2 LCD module, displaying 16 characters in one line.

14) ESP8266 WiFiModule:

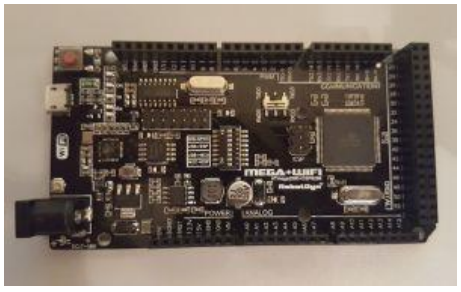

Fig14: ESP8266 WiFi Module

The ESP8266 serial WIFI module is a self-contained SOP with integrated TCP/IP that can give any microcontroller access to the WIFI network. The module has the capability of either hosting an application or offloading all WIFI networking functions from another application processor. The module has a preprogrammed AT command set firmware enabling it to be a powerful onboard processing and storage capability that in turn allows it to be integrated with sensors and other specific devices through its GPIO's with minimal loading duration runtime.

B. SoftwareDescription:

1) Arduino IDE 1.8.12:

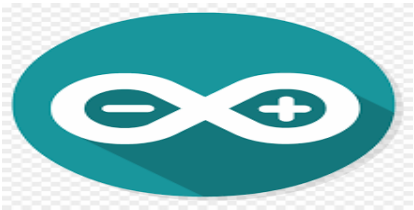

Fig 1: Arduino IDE

The Arduino IDE is an open software source used for writing and compiling the code into the Arduino module. The range of Arduino modules available is Arduino Leonardo, Arduino Mega, Arduino Micro, Arduino Uno. Each of the above modules continues a programmed microcontroller and accepts the information in the form of code. The sketch(main code) created on the IDE platform will ultimately generate the Hex file uploaded in the controller. The IDE contains two primary parts, viz., editor and compiler. The editor is used for writing the code, and the compiler is used to upload the code into the Arduino module. The module supports both C and C++ languages.

IV. ProposedMethod

A Streetlight Management System (SLS) workflow:

The proposed methodology for SLM comprises Arduino Mega 2560 microcontroller, Arduino IDE for programming with C/C++ language, LDR, IR, and a Fault detection unit. The Arduino IDE is used to edit, compile and debug the program. All the above components are interfaced with the microcontroller. The 4 channel relay module is used to interrupt and transfer the signals. The LDR sensor in the street light system recognizes the light rays to indicate whether it is day or nighttime. If the LDR is turned ON, then it indicates it's daytime. As the daytime ends, the LDR sensor gets activated, i.e., ON, and the LED bulb present in the street light turns ON.

The IR sensor detects the oncoming vehicular traffic and increases the intensity of street light illumination. As the vehicular traffic moves away from the street light, the street light illumination intensity decreases to its initial state. If the LDR sensor does not get activated during night time, a fault signal is sent out by the fault detection unit comprising ESP8266 WIFI module with cloud storage present in the SLM system to the required authorized concerned personnel in the base station confirming the exact fault site. The WIFI module also stores all the sensor data in cloud storage and is easily accessible.

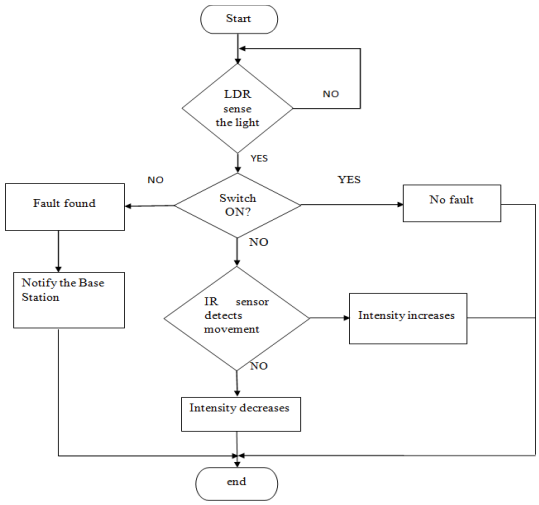

Fig 1: Flowchart for Street Light Management System

B Automatic Irrigation System (AIS) workflow:

The proposed methodology depicts the automatic irrigation system comprising of Arduino Mega 2560 microcontroller programmed under Arduino IDE with C/C++ language with inclusion of single-channel relay to interrupt and transfer the signals. All the above components are interfaced with the microcontroller. The SMS and DHT11 sensor examine the moisture content and temperature of the soil, and if found to be dry or the soil has a moisture content less than the minimum moisture content, WLS gets activated. The WLS checks the water level in the source, and if the water is available, i.e., the water level in the source is greater than the specified minimum amount that is to be maintained at the source, it signals to the water pumping system to turn ON and pump the water to the agricultural field. As the soil reaches the saturated state in its moisture content, the SMS dispatches the signal back to the WLS and turns to the water pumping system to stop the course of pumping action. On the flip side, if the water source does not contain the required amount of water or if the pumping system fails, the fault detection unit sends an electronic alert message to the required concerned personnel to take the necessary required actions. This is achieved by incorporating the WIFI module. The sensors reading are analog, so the ADC component in the microcontroller converts the analog signal into digital format, which is easily accessed by the concerned personnel.

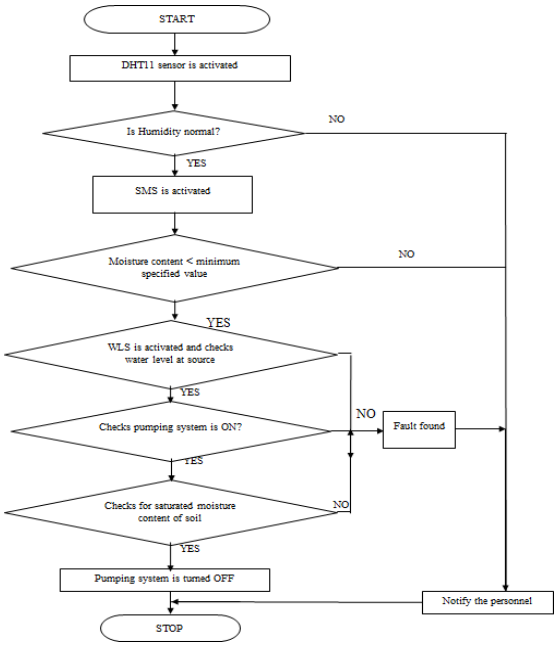

Fig 2: Flowchart for Automatic Irrigation System(AIS)

C Water Management System (WMS) workflow:

The proposed methodology for WMS consists of an Arduino Mega 2560 microcontroller programmed under Arduino IDE with C/C++ language with the inclusion of water level sensor, temperature sensor, pH sensor, and turbidity sensor. All the components are interfaced with the microcontroller. The WLS is mainly used to estimate the level of water before its release from the source. The sensors like temperature, pH, and turbidity sensors are used to control the quality of water and to determine whether the water is suitable for domestic and agricultural purposes. The data generated from the sensors will be transferred to the cloud storage over the Internet with a WIFI module. This data is easily accessible and analyzable at any point in time.

Once the data is analyzed, if any fault in any area of WMS is found, an alert message is sent to the authorized concerned personnel.

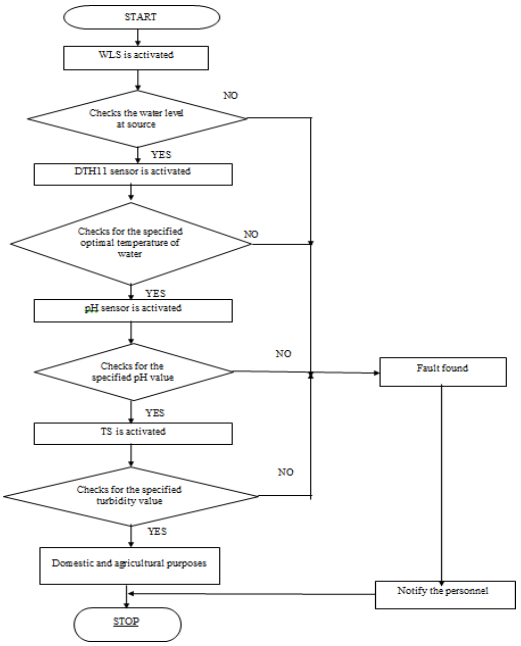

Fig 3: Flowchart for Water Management System (WMS)

V. RESULTS

The developed model of Streetlight management system, Automatic Irrigation System, and water management system is as shown in the figures Fig 1 Fig 2 and Fig 3 respectively below:

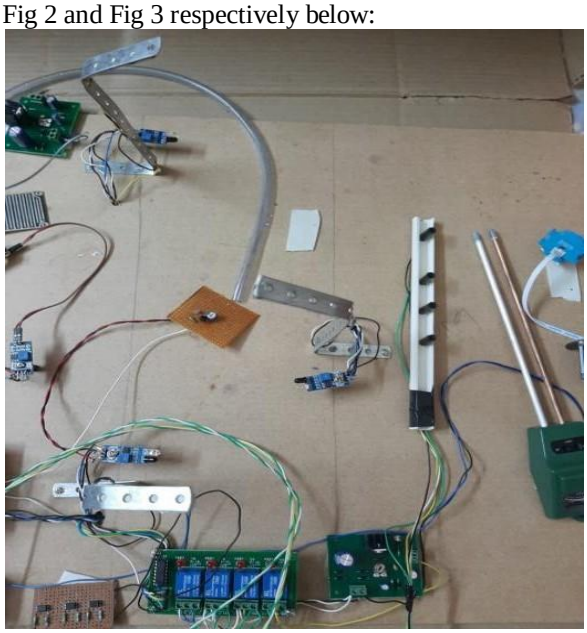

Fig 1: Streetlight management system developed model

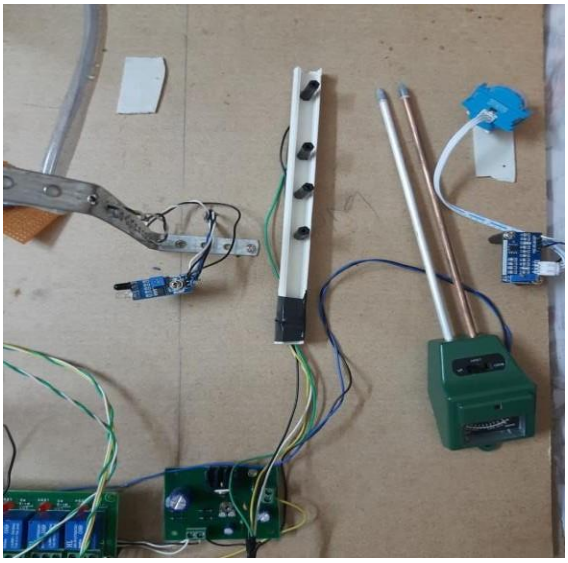

Fig 2: Automatic irrigation system developed model

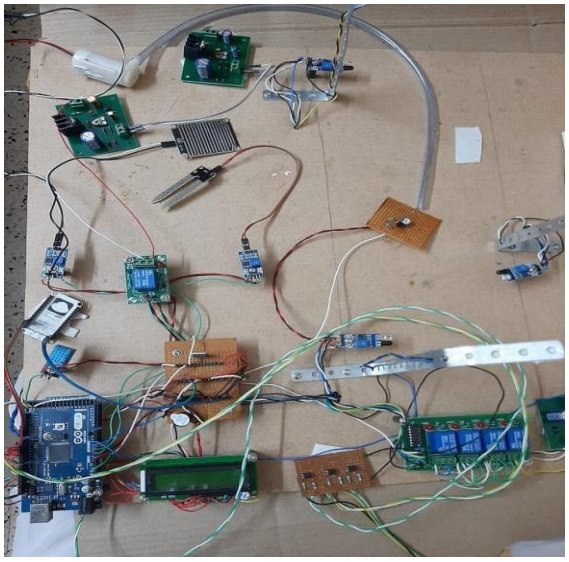

Fig 3: Water management system developed model

The fault detection in the streetlights will be displayed on the LCD and is as given in the figure below :

Fig 4: Fault in Streetlight

The water level in the pump and its content is sent as an SMS via Telegram application and is as shown in the figure below :

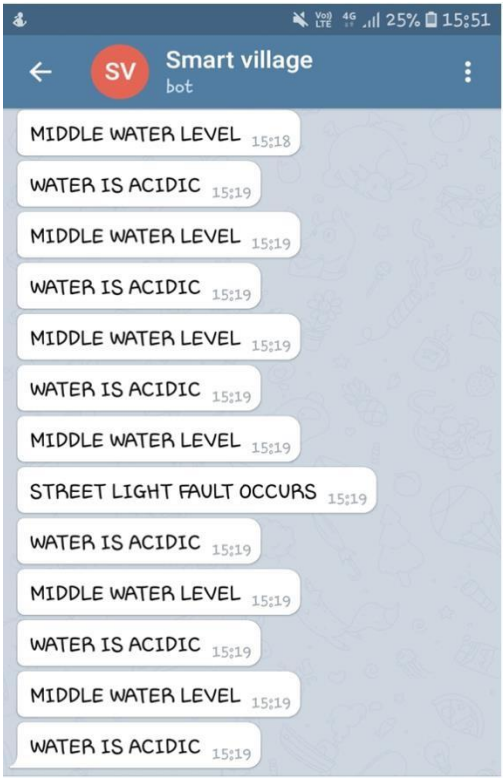

Fig 5: Water level and content of the water in the pump

Fig 6: Pump being driven

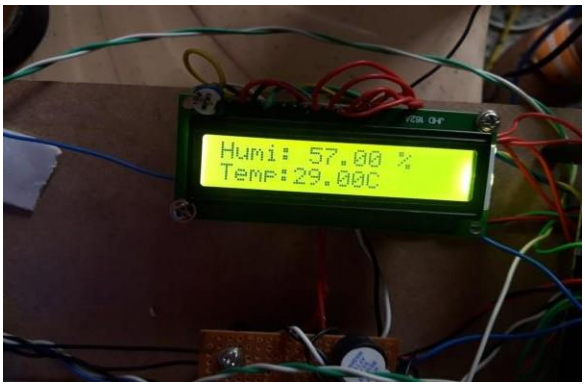

Fig 7 : Humidity and Temperature of the soil

Fig 8: Moisture content of the soil

VI. CONCLUSION

The study presented a design on light street management, automatic irrigation, and water management. The study on street lights proved that the manpower is minimized and power consumption can be reduced. The study on automatic irrigation with several features like automatic switching on and off of the water pump based on the respective sensor's output, which helps in preserving the soil structure and nutrients, conserving water, time, and provides gardening flexibility. The study on water management proved that it helps in avoiding health issues and also it is notified the personnel regarding the level of water ensuring that there is no wastage

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