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SOLAR POWERED AUTOMATED IRRIGATION SYSTEM WITH ADVANCED SOLAR TRACKING

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***Abstract* - In present times, the most biggest issue is the spoilage of food materials due to huge wastage and inefficient usage of water in the field of agriculture. The extraction of underground water without any limitation is leading many land areas to become unsuitable for agriculture. To resolve these issues, we have made an automatic irrigation system which will sense the soil moisture level and will distribute the right amount of water to the plants so that there would not be any unwanted wastage of water. As we know, the whole operation of this system needs a massive amount of power, so we will be using solar energy to power this system. In present world, solar panels are widely recognized for being cost effective and are also very efficient. It is obvious that if the solar panels are fixed at a definite position, then it would limit the generation of energy as the sun changes its position while moving from east to west each day. To break this limitation, we have come up with a unique design of solar tracking system consisting of servo motor which will move the solar panels to change its angular position to track sunlight from sunrise to sunset. This system has been tested in real world conditions. It also demonstrates higher efficiency while consuming low power than existing systems.**

Keywords- *Solar Tracking, Smart Irrigation, Solar Panel, Sensors.*

I. INTRODUCTION

Solar energy is the most important renewable resource. Sun is the primary source of energy for our planet earth. For enhancing the method of capturing solar energy, solar tracking systems are implemented which will change the orientation of solar panels to maintain a perpendicular angle with the sun rays. The perpendicular position will allow the solar panels to absorb the maximum amount of energy throughout the day. The main objective of the project is to increase the output energy from the solar panels with the help of automatic solar tracking system. This will ensure maximum absorption of solar energy using an automated system which will adjust the solar panel's orientation to track the maximum sunlight.

Our system has an automatic water pumping system which is powered by a battery pack. The battery pack is charged by the solar panels. The soil moisture sensor controls the water pump. The water pump would automatically turned on when the soil moisture sensor would detect dryness in the soil. The angular orientation of the solar panels depends on the values of the resistances of the light dependent resistor (LDR) sensors used. The main components of logger consists of a microcontroller and LDR sensors which would offer a very cost-effective solution. This system will offer maximum utilization of solar energy in the agricultural sector. The generated power from the system would give power to both water pump and solar tracking system which will ensure adequate water supply to plants at desired time in regions with irregular power supply particularly in remote regions.[9]

This mechanism not only enhances the energy utilization process but also beats the obstacles of water scarcity in areas with frequent power cut. This automated solar tracking and water pump system also reduces the need for manual labour and helps in sustainable water management. The battery bank ensures smooth working of the system even during the time of low sunlight or after sunset. This would result in a reliable supply of water anytime when required. This project underscores the potential of merging renewable energy technologies with smart automation to tackle challenges related to energy and resource management. Successfully implementation of this system could set a precedent for enhancing resources availability and energy efficiency in off grid and remote areas.

II. EXPRIMENTAL SETUP

Materials And Methodology

Materials

- 6V DC solar panel - 2
- LDR sensor - 2
- Servo SG90-1
- 5V Relay-1
- Soil moisture sensing module - 1
- 5V DC Pump-1
- Arduino UNO-1
- Arduino NANO-1
- Resistors-2 (100k ohm), Jumpers, Wires
- 3.3 volts lithium battery - 3

Fig 1. Materials Required

Methodology

Implementation of LDR Sensor with Arduino

- Light Dependent Resistor (LDR) or Light resistors are the resistors whose resistance changes when light intensity changes. Its working is based upon the principles of photoconductivity.
- When high intensity light is incident on the sensor, the photosensitive material present in the sensor gets activated resulting in lowering of resistance and increase in conductivity.
- When there is no light incident on the sensor its resistance becomes highest resulting in no conductivity.
- For the implementation of LDR sensor with Arduino, one terminal of LDR sensor is connected to 5V pin of Arduino. The other terminal is connected to the analog pin A0 of Arduino.
- A 100k ohm resistor is connected to the terminal of the LDR sensor which is connected with the analog pin A0 of Arduino. [1]

Implementation of Servo Motors with Arduino

- A servo motor is a dc motor that uses a position feedback mechanism to provide precise control of its shaft. The server motor operates by sending pulse series (one pulse in every 20ms) through the signal wire of servo motor.
- Pulse length determines the position of the servomotor.
  A. Short pulse (<=1ms) will position the servo at 0 degrees.
  B. Pulse of 1.5ms will position the servo perpendicularly.
  C. Pulse (>= 2ms) will make the servo rotate to 180 degrees.
- For the implementation of a servo motor with Arduino, the red wire of the motor is connected to the 5V pin of Arduino, the brown wire is connected to the ground and the signal wire (orange) is connected to analog PWM enabled pin of Arduino.

Implementation of Soil Moisture Sensor with Arduino

- A soil moisture sensor is a sensor that monitors the moisture content of the soil. The sensor has two exposed conductors whose resistance varies with soil moisture content.
- When the soil moisture content is more the resistance of the two exposed conductors decreases and vice-versa.
- The soil moisture sensor has an electronic module which generates an output voltage based on the resistance of the probe in Analog pin of Arduino. The signal gets processed by LM393 comparator which converts analog signal to digital signal that can be accessed at the digital pin of Arduino.
- The Vcc pin of the sensor module is connected to 5V of Arduino, ground to ground, analog output pin to analog pin of Arduino, digital output pin to digital pin of Arduino. The module has an inbuilt potentiometer for sensitivity adjustment of the digital output.

III. CIRCUIT CONECTIONS

- Arduino needs to be given a power supply, it can be given through many sources like barrel adapter, the USB connector by connecting it to a PC/laptop, batteries greater than 5V supply, using battery shield etc. We used USB connector from Arduino to PC.

- A solar tracker irrigation system integrates renewable energy with automated irrigation, enhancing efficiency and sustainability. This system harnesses solar power to operate irrigation mechanisms and utilizes a tracking system to maximize solar energy capture.

- Different components required are soil moisture sensor, LDR sensor, servo motor, solar panel, 5V relay and few other components including batteries for power source (irrigation) required etc. All these are connected as per the connections.

- We have made our own logger unit named "iFarming" where soil moisture data, pump ON/OFF state and angle of inclination of solar panels are recorded.

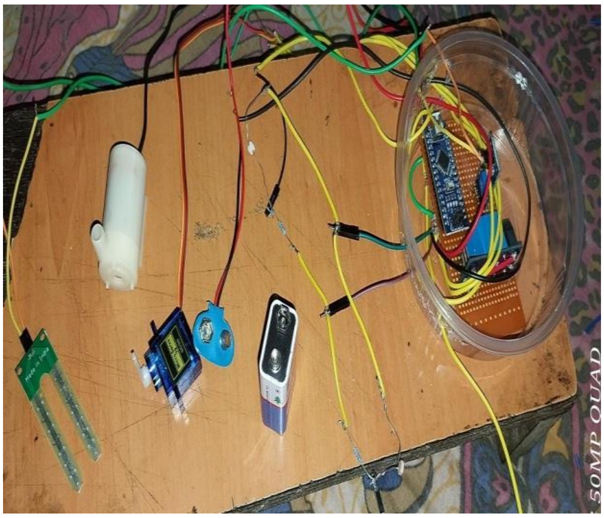

Fig 2. iFarming Logger

IV. FLOWCHART

Solar tracker System

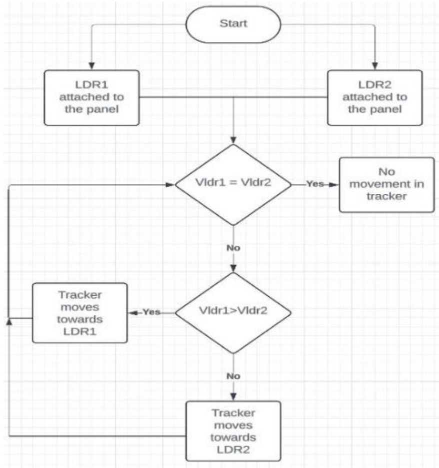

Fig 3. Solar Tracker System [10]

Smart Irrigation System

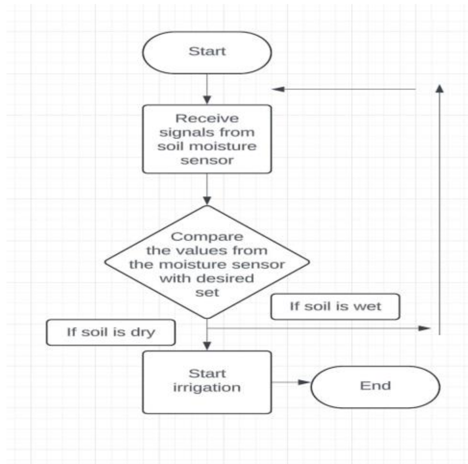

Fig 4. Smart Irrigation System [11]

V. SOLAR TRACKER SYSTEM

In this tracking operation, servo motor fixed to the structure holds the solar panel (12 V DC) and also responsible for the movement of it. Servo motor specifically, is used as it exhibits for accurate control of angular position and the solar panels are embedded with LDR sensors which measures the sunlight intensity as a reference input signal. The imbalance in voltages generated by the LDR sensors generates a voltage difference. The voltage difference produced is proportional to the variation between the sunlight location and the solar panel location. The microcontroller compares the difference in voltage produced by individual LDRs. If any of the LDRs receive more light, the servo motor moves in that particular direction, until the values become same or the voltage difference becomes zero, in turn bringing the panel to face the sun, at every instant of the day. The power generated from this system is used to charge a 11.1 V battery pack which is used as power supply for the smart irrigation system. [5]

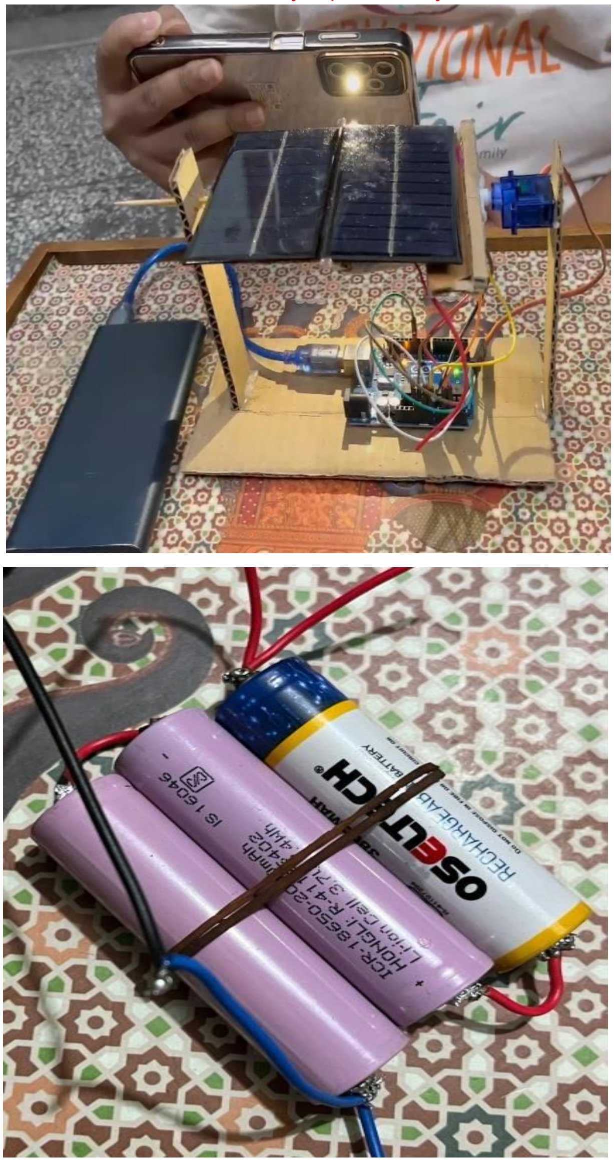

Fig 5. Solar Tracker System

VI. SMART IRRIGATION SYSTEM

In smart irrigation system, when the soil moisture level gets lower than 50% the Normally Open (NO) state of the relay gets activated which sends an electrical signal that turns on the water pump for 5 seconds, after that if the soil moisture level gets more than 50% then the NO state of the relay gets deactivated and the water pump stops, if the soil moisture level still remains less than 50% then the water pump automatically turns on for the next 5 seconds.

Smart irrigation systems represent a significant advancement in agricultural technology, aimed at improving water efficiency and crop health. These systems are made to optimize the use of water in agricultural sectors, ensuring plants to receive the proper amount of water at the preferred time.[6]

Fig 6. Smart Irrigation System

VII. RESULT ANALYSIS

Solar Tracker System

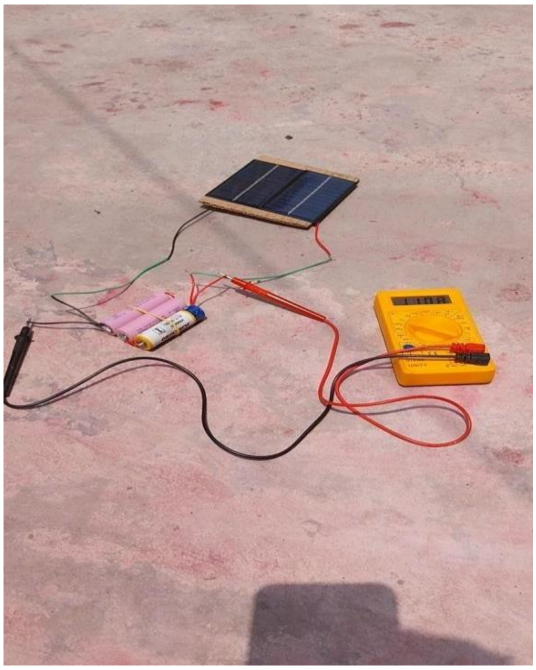

Fig 7. Solar Panel Charging 11.1V Battery Bank

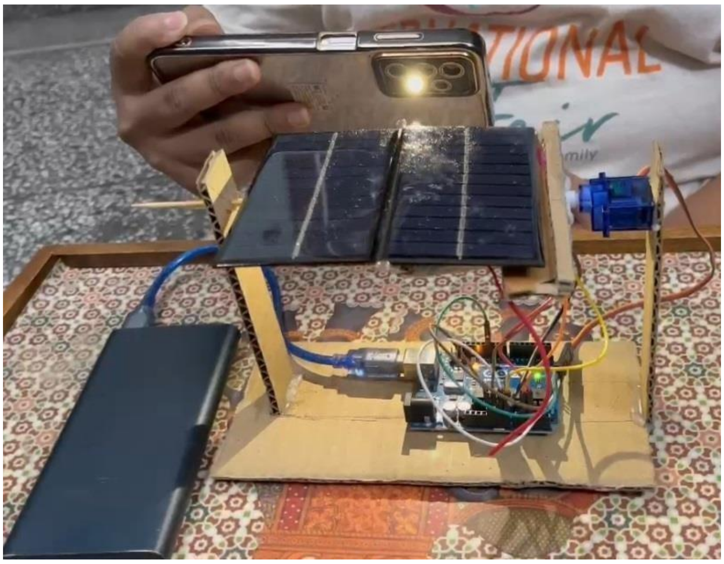

Fig 8. Solar Panel Moving Towards High Intensity Light

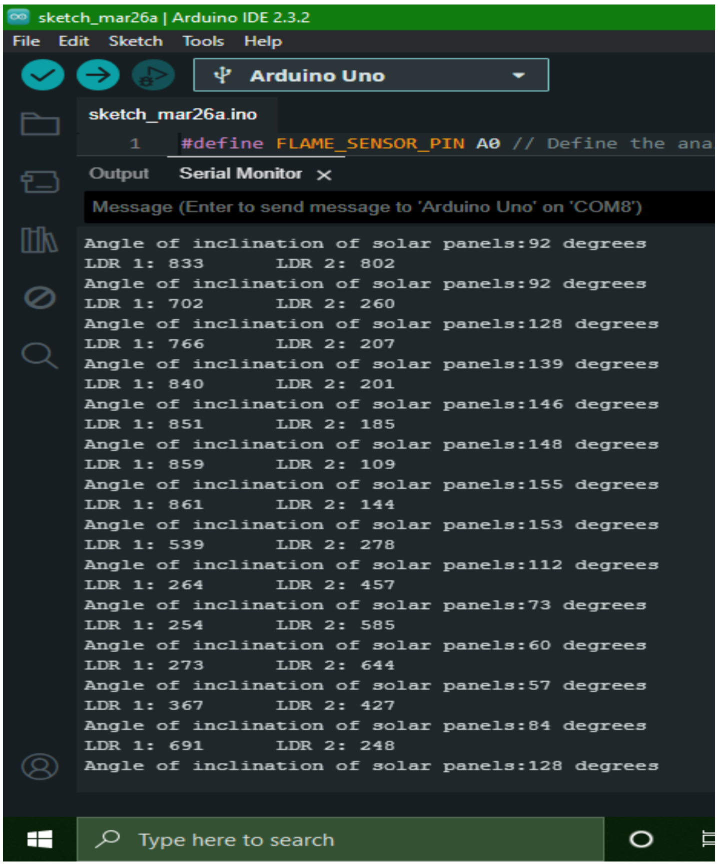

Fig 9. Logger Showing Angle Of Inclination Of Solar Panel In Serial Monitor

Smart irrigation System

Fig 10. Pump On when Dry
(Relay NO Activated)

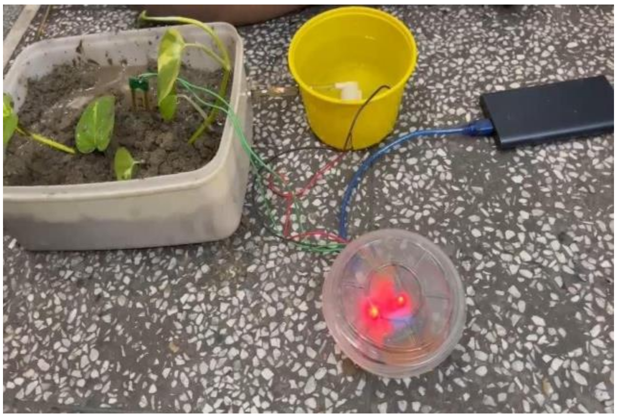

Fig 11. Pump Off When Soil Gets Moist
(Relay NO Deactivated)

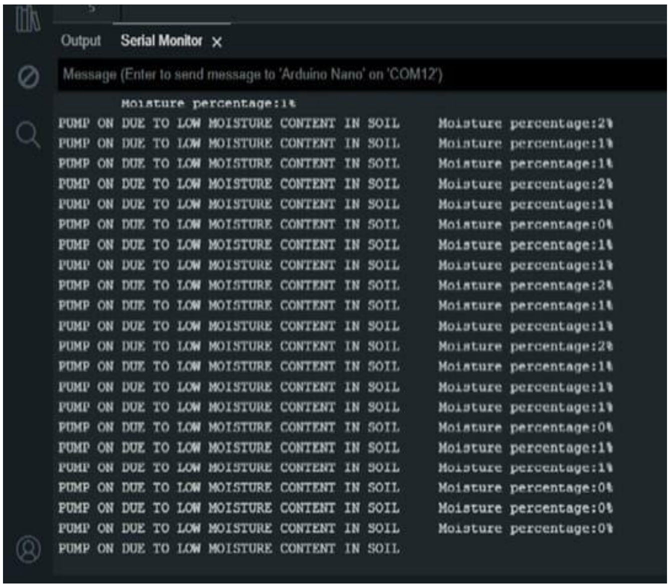

Fig 12. Logger Showing ON State and Soil Moisture Content in Serial Monitor

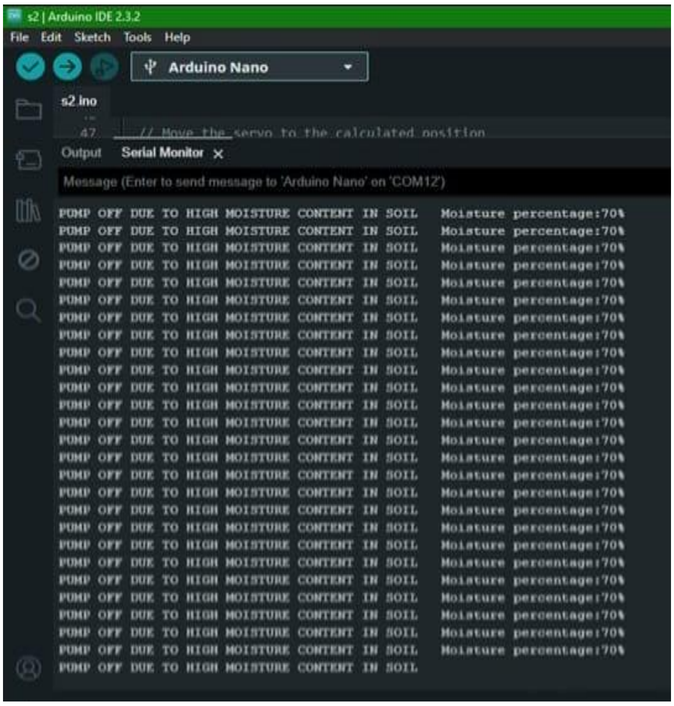

Fig 13. Logger Showing OFF State and Soil Moisture Content in Serial Monitor

Features	Our Model (Solar Powered Automated Irrigation System with Advanced Solar Tracking)	Model A (Basic Solar Irrigation) [12]	Model B (Hybrid Solar & Grid Powered Irrigation) [13]
Source of energy	Solar powered with LDR based solar tracking facility.	Solar powered but no solar tracking facility.	Solar powered with grid backup power system.
Efficient usage of water	Soil moisture sensor provides real time data on soil moisture levels ensuring efficient water usage.	Timer based watering system is used. Moderate water usage.	Moisture sensors are used ensuring efficient water usage.
Automated control	The system assembles solar power with tracking system, watering controls, sensors to run automatically	Only watering is automated.	System is fully automated with manual override features.
Installation cost	Affordable cost (Including cost of electronic components).	Lower cost (Cost of solar panels. No electronic components required).	Huge cost (Cost of both solar panel connections and grid connection systems).
Maintenance demands	Requires very less maintenance after installation.	Requires very less maintenance because of lesser number of moving parts.	Requires routine maintenance for multiple connection systems.

Table 1. Comparative Analysis of Our Model with Existing Systems

VIII. FUTURE SCOPES

A solar tracker irrigation project holds significant potential for both current and future applications. Some future scopes are -

- AI and Machine Learning- We can implement artificial intelligence to improve the decision making in the field of irrigation by collecting and analysing the weather patterns, soil moisture levels and crop requirements to optimize water usage and energy efficiency.
- Predictive Maintenance- By merging all the predictive analytics to analyse the well-being of the irrigation components, this will reduce the downtime and will extend the lifespan of the system.
- Research and collaboration- Constant research and collaboration among the engineers, agriculturists, and policy makers are very important for the growth of innovation in the solar tracker irrigation technology. By sharing knowledge, resource stakeholders can prevail over all the challenges, and it will unseal the full potential of legitimated agriculture.
- Energy Storage Solutions- By making an improved energy storing system, just like super capacitors or batteries to store the extra energy, solar energy can be used later on during the cloudy day or after the sun set which keep the continuous flow in the irrigation field.
- IoT and Remote Monitoring- If we integrate IoT with this system we can also measure temperature and intensity of sunlight. By making mobile apps or website for this system, it will make more easier for the farmers to control and monitor the system from anywhere.
- Water Harvesting and Recycling- By adding the water harvesting system which collects and recycle water, this will create the dependency on external water resources and will promote the sustainability for irrigation.
- Scalability and Modular Design- Future designs can prioritize scalability and modular construction, allowing farmers to easily expand their irrigation systems as their needs grow. This flexibility accommodates varying land size and agriculture practices. [7]

IX. CONCLUSION

The automatic irrigation system with solar tracking will serve several benefits to farmers. The system fortifies the definite usage of water which will be required for crops. This automated system not only supplies watering to the plants accordingly as required but also it reduces physical labour. This system needs minimal maintenance cost as it operates automatically. To acquire the future irrigation rate, we can suggest the usage of this automatic irrigation system. The use of solar photovoltaic technology for powering the irrigation systems shows that the challenges and the obstacles in the field of irrigation gets over for the long term. This system offers solutions in utilizing renewable resources in a smart way.[8]

X. REFERENCES

[1] Nader Barsoum [2010], Global Journal on Technology, Vol.01, 1985-9406.

[2] TiberiuTudorache [2012], U.P.B. Sci. Bull, Vol.74, ISSN 11454-234.

[3] Minor M. Arturo W.C.E. Vol. II (2010).

[4] S.Abdallah Desalination ELSEVIER 220(2008) 669- 676. pp. 1446–1456.

[5] Ali Ibrahem Al-Mohammed and Mohammed A. AlMothafar - Journal of Renewable Energy "Design and Implementation of a Smart Solar-Powered Irrigation System".

[6] M. Pavithra, M. Srinath, M. Sharath Babu, and R. Tejaswini - International Journal of Engineering Research & Technology (IJERT) "Development of Solar Tracking and Automatic Irrigation Control System".

[7] G. Priya, T. V. D. Ranjith, K. Swathi, and M. M. Priya - International Journal of Engineering & Technology "Solar Powered Smart Irrigation System Using IoT".

[8] Saru Jain, Anuja Saraswat, and S. Lakshmi - Procedia Computer Science "A Smart Irrigation Control System for Precision Agriculture Based on Wireless Sensor Networks".

[9] V. Madhurima and K. S. Shiva - International Journal of Pure and Applied Mathematics "IoT Based Smart Irrigation System and Solar Tracking".

[10] M. Saranya Nair and Karan Bhatia – International Journal of Civil Engineering and Technology “A Solar Tracker Assisted Automatic Irrigation System For Agricultural Fields”.

[11] Shruti Bansod, Rishita Jaiswal and Priyanka Sargam - International Journal of Advance Research in Science and Engineering “Arduino Based Water Irrigation System”.

[12] Charmaine Samala Guno and Casper Boongaling Agaton- MDPI, Multidisciplinary Digital Publishing Institute “Socio-Economic and Environmental Analyses of Solar Irrigation Systems for Sustainable Agricultural Production”.

[13] Divyesh Chandra, Pankaj Kumar Appu Singh, Tauhid Alam , Ramniwas Bishnoi , Ajit Kumar Singh- ResearchGate “ Developing Hybrid Wind and Solar Powered Irrigation System”.