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Eco Smart Solar Powered Irrigation System

B A Sujathakumari[1], M Baluchandra[2], Sumanth P[3]
[1,2,3]Department of E&C, Sri Jayachamarajendra College of Engineering, JSS Science and Technology University, Mysuru, Karnataka, India
Emails: *sujathakumari@sjce.ac.in[1], mamidibalu2020@gmail.com[2], sumanthp23401@gmail.com[3]*

Abstract
The ECO SMART solar powered irrigation system represents a novel approach to sustainable agriculture, integrating renewable energy and advanced technology to optimize water use and enhance crop productivity. This system harness solar energy sources to power an automated irrigation network, reducing dependence on non-renewable energy sources and lowering operational costs for formers. By utilizing smart sensors and IoT technology, the system monitors soil moisture levels and crop requirements in real-time, implementation and performance evaluation of Eco Smart Solar Powered Irrigation System, highlighting its potential to revolutionize agricultural practices in arid and semi-arid regions. The results demonstrate significant water savings and energy efficiency, making this system a viable solution for sustainable agriculture in the face of climate change and increasing water scarcity.
Keywords: *Renewable Energy, Solar Power, Climate Adoption, Sensor Technology, Water Resource Management*

1. Introduction
The Eco Smart solar powered irrigation system presents a comprehensive solution aimed at optimizing solar energy utilization in agricultural settings. As the global demand for renewable energy production. This system addresses the critical challenges of maximizing solar panel efficiency and effectively utilizing solar power for irrigation alignment of solar panels with the sun throughout the day, thereby maximizing energy generation and consumption, providing valuable insights for system optimization and maintenance. The integration of solar power for irrigation offers a sustainable solution to meet agricultural energy needs while reducing dependency on traditional grid electricity. This approach not only yields cost savings for formers but also reduces carbon emission and increases resilience to combination of sensors, actuators and control algorithms to dynamically adjust the orientation of solar panel based on the real-time environmental conditions, such as solar irradiance and panel inclination angles. This ensures that the panels operate close to their maximum power point, thereby enhancing overall energy yield. A network of sensors, including solar irradiance sensors, temperature sensors, and tilt sensors, is deployed to collect the necessary environmental data for optimizing solar panel positioning. The power management system within the system, regulates the flow of generated power to the irrigation system, prioritizing energy allocation for irrigation purposes.

2. Previous Work Done
This paper illustrates on the wireless sensor real time monitoring node for a paddy field data collection. These nodes are integrated with multiple sensors, STM32 microcontroller, LCD, GPRS and an automatic solar power tracking module. Data's are gathered such as moisture, temperature, pH, and water level and light intensity for every 2hrs processed using Kalman filtering and these data are transmitted to the remote server [1]. From this process, the system manages power consumption efficiently and it also ensures for the continuous operation during the periods of lower sunlight. This paper results in system accuracy and reliability in power management and data transmission. This paper describes on automatic solar panel positioning of the control system which maximizes solar energy conversion by tracking the movement of the sun throughout the day [2]. The system adjusts the solar panel which is interfaced with servomotor using Arduino Uno and LDRs to capture the optimal sunlight. This results in significant improvement in

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energy generation compared to stationary panels, which addresses the need for renewable and non-renewable resources. This paper describes the development on solar tracker robots which enhances the efficiency of solar panel throughout the day by following the sun's position [3]. This process is controlled by a Digilent Zybo board with Zynq-7000 SoC, to detect the sunlight and adjusting the panel positioning both in horizontal and vertical axes, photoresistors and pyrheliometric sensors are used. This article presents on novel single-axis solar tracking system using a principle of second order level. The system explains on balancing water and a PV panel mass on either side of a fulcrum, which eliminates the need of an external motor [4]. The system was tested and demonstrated over 90 days, resulting the improvement in energy efficiency compared to conventional single-axis solar trackers was about 22.93%. This article introduces a cost effective solar powered water supply with a battery backup, A four-phase switched reluctance motor are used for enhanced reliability. This design eliminates improving system efficiency and compactness in the system and also the need for intermediate MPPT dc-dc converter [5]. The novel control scheme with a filter of sinusoidal integrator ensures higher power quality and seamless operation across all modes, including grid tied scenarios. The capability of system to feed solar power back into the offered grids. This results are validated through simulations and experiments. This paper explores on the use of STMicroelectronics 32-bit ARM used as a maximum power point tracking (MPPT) controller to improve the conversion efficiency in standalone solar systems. Both MATLAB-Simulink and STMicroelectronics-32 are used or simulations and practical test are conducted and evaluating the performance using three MPPT algorithms: Perturbation & Observation (P&O), Fuzzy logic (FL) and Incremental Conductance(IC). From this algorithms, the main aim is to identify which is most suitable for small-scale solar energy system. The result indicates Fuzzy Logic algorithm is better tracking system of the maximum power point under variable weather conditions [6]. It also demonstrates Rapid control prototyping tools supports Fuzzy Logic algorithm, is a cost effective solution for improving conversion of solar energy in resource-limited regions like Syria. This paper explains the impact of partial shading on PV fed water pumping systems, mainly highlighting challenges faced by power converters and system efficiency [7]. The result demonstrates on partial shading which leads to severe efficiency drops and failure in water pumps, even with sufficient power present in PV terminals, taking this study as a crucial reference for optimizing PV water pump systems under varying conditions. The paper introduces a grid interactive solar powered water pumping system with an advanced control, ensuring efficient MPPT, enhanced performance with system reliability and efficiency are validated through simulations and testing [8]. These papers discusses on various advancements on solar powered systems for agricultural and energy management applications. It includes key innovations like real-time monitoring, optimizing solar efficiency in solar robot trackers and also a grid interactive solar water pumping system. These system explains on utilizing microcontrollers, sensors and algorithms to enhance the energy efficiency especially like partial shading. Here technologies mainly focusing on solar energy utilization, improving system reliability and reducing human intervention in agricultural conditions. [9-12]

3. Methodology

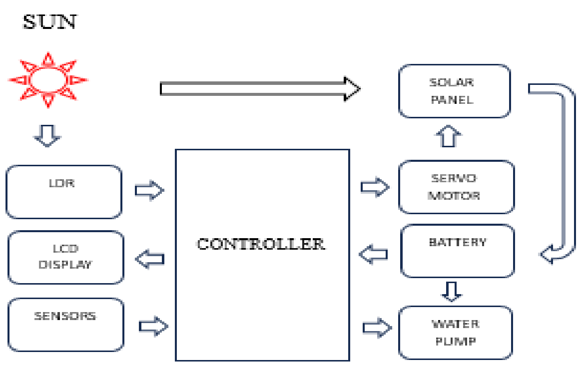

Figure 1 **Block Diagram of Eco Smart Solar Powered Irrigation System**

As shown in Figure 1, The system involves several key steps to optimize solar energy utilization for irrigation. Firstly, algorithms are developed to dynamically adjust the orientation of the solar panel based on the environment factors like sun position and shading effects, maximizing energy capture.

Sensors, including LDR are integrated to gather real-time data for precise panel positioning. Control mechanisms are then implemented to translate this data into accurate adjustments of panel angles. A monitoring system is designed to track panel performance and environmental condition continuously, providing feedback for powering water pump and equipment. Energy management algorithms ensure efficient use of solar energy, including storage and distribution. Rigorous testing and validation validate the system reliability with ongoing optimization for improving performance. Through these steps the system aims to enhance agricultural efficiency and sustainability through optimizing solar energy utilization for irrigation purpose. [13-15]

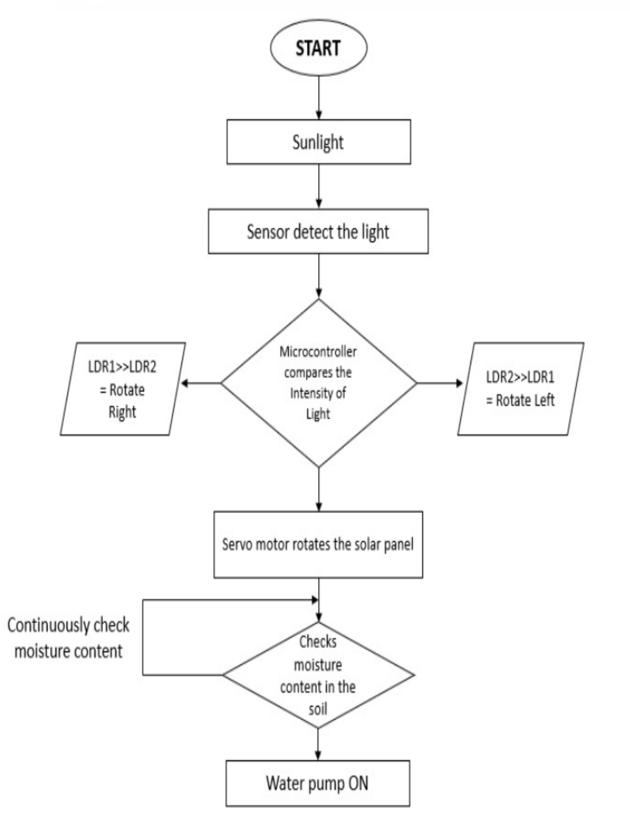

Figure 2 **Flow Chart of the System**

As shown in Figure 2, We design a solar-powered system integrated solar tracking and automated irrigation to optimize energy usage and agricultural productivity. The system features two light dependent resistors on a solar panel to detect sunlight intensity from different angles. An Arduino microcontroller processes LDR data to control a servo motor, dynamically adjusting the panel's orientation for maximum sunlight capture. A charge controller manages power generation and battery charging, ensuring stable operation. Additionally, a soil moisture sensor triggers irrigation pump through an Arduino controller relay, maintaining optimal soil moisture levels. This setup ensures continuous, efficient power supply and automated irrigation enhancing solar energy utilization and crop health.

4. Proposed Work

The proposed work includes various hardware and software requirements:

4.1. Hardware Components

Figure 3 **Arduino Mega 2560 (Atmega2560)**

It is a microcontroller board. The operational frequency is about 16MHz and 4 UART's. Here all the components integrated to the board i.e. sensors, servomotor, irrigation pump and LCD display to work as a solar powered irrigation system. (Refer Figure 3)

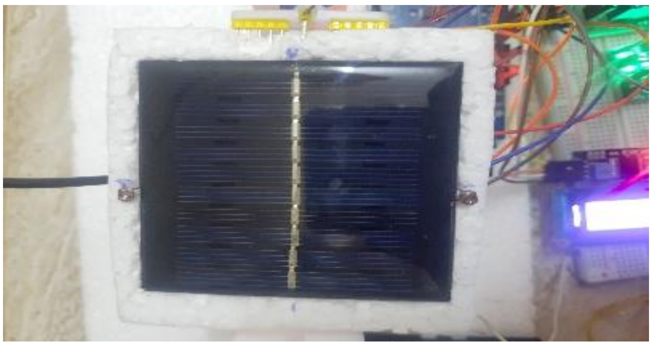

Figure 4 **Solar Panel**

As shown in Figure 4, Solar Panels are lightweight, small size with long-life cycle and coated with an

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aluminum frame. Its operating voltage is 5V with current capacity of 100mA. Its dimension is 70 X 70mm compact. Here the solar panel is interfaced with LDR to generate the power from the sunlight and to detect the maximum intensity produced through sunlight by LDR's and provides data from the microcontroller.

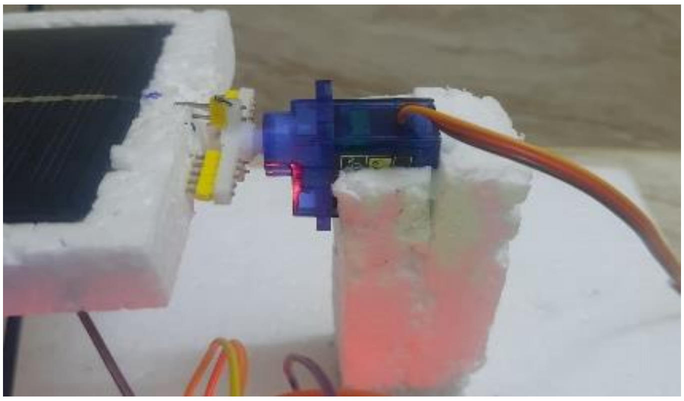

Figure 5 Servomotor SG90 Integrated to Solar Panel

As shown in Figure 5, Servomotors are smaller and having lightweight of 9 g. It rotates approximately up to 180 degrees with operating voltage and speed of 4.8V and 0.1s/60 degree respectively. Here the servomotors are controlled by the microcontroller and it is mainly used for panel positioning, where it tilts the solar panel when maximum intensity of light falls on it provided by LDR's.

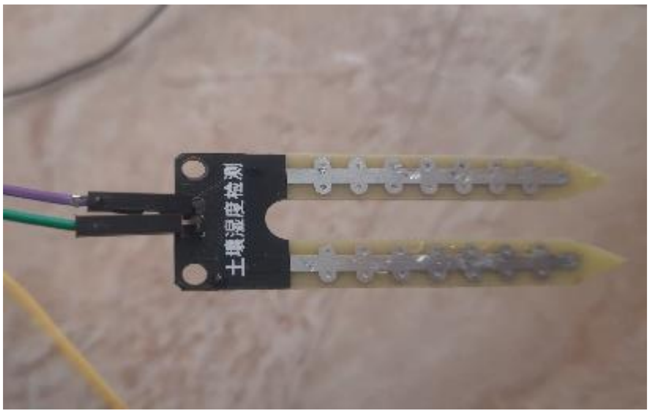

Figure 6 Moisture Sensor FC-28

Soil Moisture consists of two probes which are coated with an immersion gold and LED indicates output. It's operating voltage and current is about 3.3V to 5V and 15mA respectively. The dimension is 3.2 cm X 1.4cm. Moisture sensors continuously checking the wetness level of the soil, if soil finds the low moisture level in the soil it immediately sends the signal to trigger the irrigation pump through microcontroller. (Refer Figure 6)

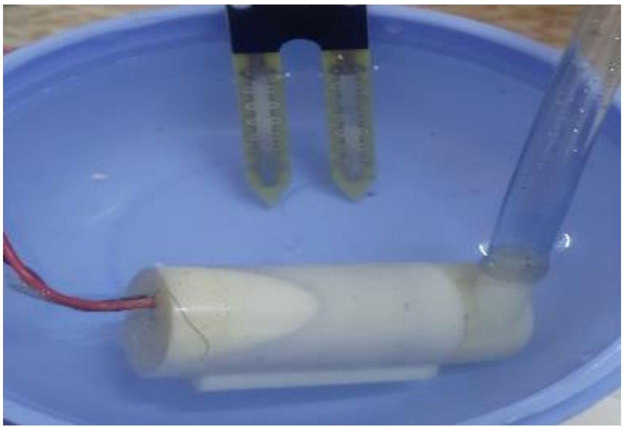

Figure 7 DC Water Pump for Irrigation

It is a submersible water pump having small size, low cost and which can be operated up to 3 to 6 V with an operating current 220mA. Pump can take up the water up to 120 liters per hour through pipe which is connected to the motor outlet. Here the pump starts pumping the water from the well, when microcontroller receives the low level soil moisture signals from the moisture sensor. (Refer Figure 7)

Figure 8 Battery for Storage

These batteries are rechargeable batteries with a nominal voltage of 3.7V. Its storage capacity is 3800mAh with an external dimension of 18mm X 65mm. Here the batteries are used to store the power generated from the solar panel and this generated

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power is utilized for all environmental conditions. (Refer Figure 8)

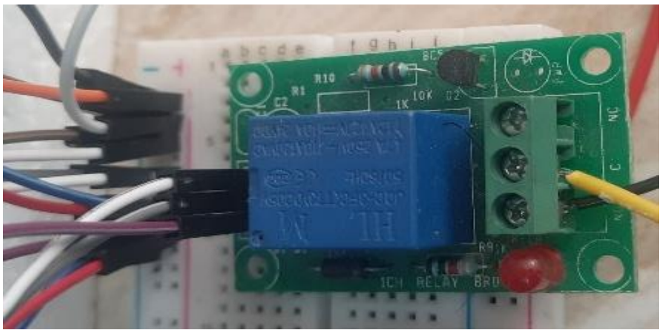

Figure 9 **Relay Module**

Relay Module consist of higher optocouplers isolation and lower-level triggering. Its operating voltage is up to 5V to 24V with current capacity of 30A. Its dimension is 72mm X 40mm X 24mm. Here relay is used by the microcontroller to trigger the irrigation pump when moisture leads to low level and voltage sensor is used to sense the charging level in the battery. (Refer Figure 9)

Figure 10 **I2C Interfaced LCD Display**

I2C Module interfaced with LCD display with an operating voltage of 5V. It works under temperature range from -200C to +700C. Its dimension is 74.2 X 25.2mm. Here LCD displays the real time information about the users and about the status of the system and stored voltage level in the system as shown in the fig 10

4.2. Software Components

Arduino IDE is a software tool that allows user to write, edit and upload code to the microcontroller board. It also includes integrated libraries, one click uploading codes to boards, supports multiple programming languages and built in serial monitor for debugging. Here Embedded C is constructed and uploaded in an Arduino microcontroller board using Arduino IDE. (Refer Figure 11)

Figure 11 **Arduino IDE Tool**

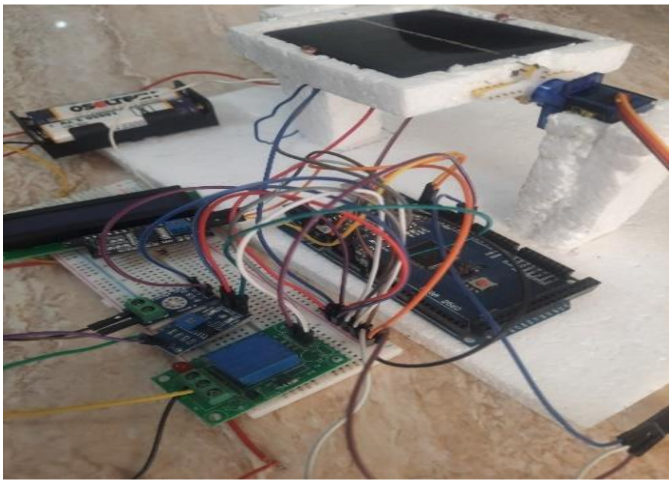

Figure 12 **Proposed Module**

The project aims to develop an integrated solar energy system that combines efficient solar tracking with automated irrigation to enhance energy usage and agricultural productivity. The proposed system employs LDR to detect sunlight intensity, enabling an Arduino microcontroller to adjust the solar panel's orientation for optimal sunlight capture. Additionally, the system will automate irrigation by monitoring the soil moisture levels and activating a pump when needed. Powered by solar charger battery this approach ensures continuous operation even in low sunlight conditions. Software used is Arduino IDE: Embedded C. (Refer Figure 12)

5. Implementation and Results

The proposed system Eco Smart powered irrigation system was designed and tested. The performance was up to the expectation and the main task that

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system performed were positioning the solar panel to the maximum intensity using LDR and driving the irrigation pump when moisture content in the soil is low and displays the charge level using LCD display. Below figures shows the proof of results. (Refer Figure 13)

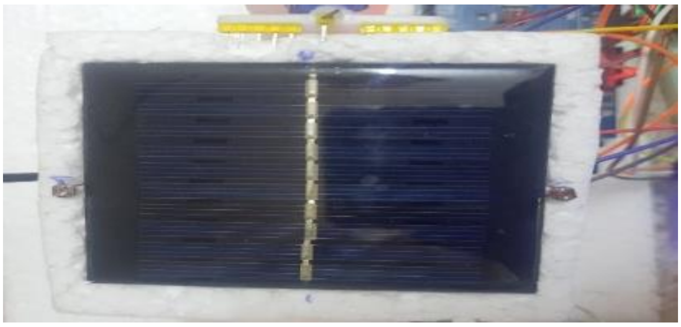

Figure 13 Solar Panel

When the light falls on the solar panel, the panel tracks the maximum light intensity using LDR.

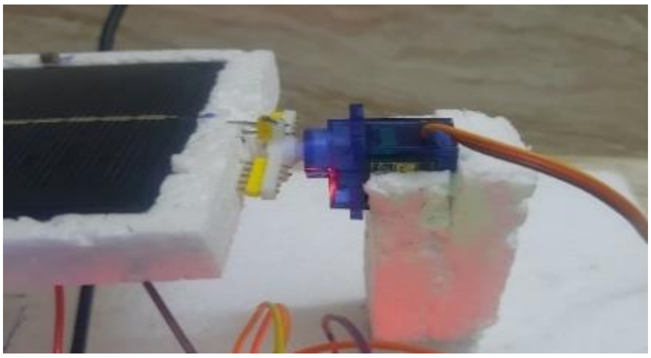

Figure 14 Solar Panel Positioning

As shown in Figure 14, Solar panel is positioned using servomotor in such a way that when the maximum light intensity falls on the panel, it tracks and starts rotating.

Figure 15 Initial Message

When solar panel starts to track, the LCD indicates the initial message as shown in the above figure 15.

Figure 16 Charge Level Indication

The stored energy level in the battery is indicated by the LCD display in the form of voltage as shown in the above figure 16.

Conclusion

In conclusion, the Eco Smart solar powered irrigation system represents a significant advancement in optimizing solar energy utilization for irrigation purposes. By dynamically adjusting solar panel orientation based on environment conditions and integrated real-time monitoring capabilities, the system ensures maximum energy capture efficiency. The integration with irrigation sustainability by providing a reliable and renewable energy source for powering essential equipment. Overall, this innovative system holds promise for revolutionizing agricultural practices by harnessing the solar energy to enhance irrigation efficiency and sustainability.

References

[1]. X. Zhang, J. Du, C. Fan, D. Liu, J. Fang and L. Wang, "A Wireless Sensor Monitoring Node Based on Automatic Tracking Solar-Powered Panel for Paddy Field Environment," in IEEE Internet of Things Journal, vol. 4, no. 5, pp. 1304-1311, Oct. 2017.

[2]. S. Siddula, C. Dennis Gleeson and P. Geetha kumari, "Solar Panel Position Control and Monitoring System For Maximum Power Generation" 2020 International Conference on Smart Technologies in Computing, Electrical and Electronics (ICSTCEE), Bengaluru, India, 2020.

[3]. R. Szabo and R. -S. Ricman, "The Creation Method of a Solar Tracker Using the Zybo

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e ISSN: 2584-2137
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Page No: 2396 - 2402
https://irjaeh.com
https://doi.org/10.47392/IRJAEH.2024.0329

SoC," 202 333rd International Conference Radioelektronik (RADIOELEKTRONIKA), Pardubice, Czech Republic, 2023.

[4]. K. Kumba, S. P. Simon, K. Sundareswaran, P. S. R. Nayak, K. A. Kumar and N. P. Padhy, "Performance Evaluation of a Second-Order Lever Single Axis Solar Tracking System," in IEEE Journal of Photovoltaics, vol. 12, no. 5, pp. 1219-1229, Sept. 2022.

[5]. A. K. Mishra, B. Singh and T. Kim, "An Economical Solar Water Pump With Grid and Battery Backup for Continuous Operation," in IEEE Journal of Emerging and Selected Topics in Industrial Electronics, vol. 4, no. 1, pp. 109-117, Jan. 2023.

[6]. Alhaj Omar, Fuad and Kulaksız, Ahmet "Rapid Control Prototyping Based on 32-bit ARM Cortex Microcontroller for Photovoltaic MPPT Algorithms" International Journal of Renewable Energy Research

[7]. Mudlapur, A., Ramana, V. V., Damodaran, R. V., Balasubramanian, V., & Mishra, S. (2018). "Effect of Partial Shading on PV fed Induction Motor Water Pumping Systems". IEEE Transactions on Energy Conversion.

[8]. A. K. Mishra and B. Singh, "Grid interactive single-stage solar powered water pumping system utilizing improved control technique," IEEE Trans.Sustain. Energy, vol. 11, no. 1, pp. 304–314, Jan. 2020.

[9]. R. Khan, I. Ali, M. Zakarya, M. Ahmad, M. Imran and M. Shoaib, "Technology-Assisted Decision Support System for Efficient Water Utilization: A Real-Time Testbed for Irrigation Using Wireless Sensor Networks," in IEEE Access, vol. 6, pp. 25686-25697, 2018.

[10]. P. K. Kashyap, S. Kumar, A. Jaiswal, M. Prasad and A. H. Gandomi, "Towards Precision Agriculture: IoT-Enabled Intelligent Irrigation Systems Using Deep Learning Neural Network," in IEEE Sensors Journal, vol. 21, no. 16, pp. 17479-17491, 15 Aug.15, 2021.

[11]. S. K. Roy, S. Misra, N. S. Raghuwanshi and S. K. Das, "AgriSens: IoT-Based Dynamic Irrigation Scheduling System for Water Management of Irrigated Crops," in IEEE Internet of Things Journal, vol. 8, no. 6, pp. 5023-5030, 15 March15, 2021.

[12]. S. Murshid and B. Singh, "Implementation of PMSM Drive for a Solar Water Pumping System," in IEEE Transactions on Industry Applications, vol. 55, no. 5, pp. 4956-4964, Sept.-Oct. 2019.

[13]. A. K. Mishra and B. Singh, "An Efficient Control Scheme of Self-Reliant Solar-Powered Water Pumping System Using a Three-Level DC–DC Converter," in IEEE Journal of Emerging and Selected Topics in Power Electronics, vol. 8, no. 4, pp. 3669-3681, Dec. 2020.

[14]. M. Saeedi and R. Effatnejad, "A New Design of Dual-Axis Solar Tracking System With LDR Sensors by Using the Wheatstone Bridge Circuit," in IEEE Sensors Journal, vol. 21, no. 13, pp. 14915-14922, 1 July1, 2021.

[15]. S. Shukla and B. Singh, "Reduced-Sensor-Based PV Array-Fed Direct Torque Control Induction Motor Drive for Water Pumping," in IEEE Transactions on Power Electronics, vol. 34, no. 6, pp. 5400-5415, June 2019.