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Effective Study of An Autonomous Hydroponic System Using Solar Energy and IoT Monitoring Technology

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Abstract

This paper presents the development, and performance evaluation of a Solar Photovoltaic (PV)-powered Automatic Nutrient Mixing System integrated with IoT-based monitoring for sustainable agriculture. The system was tested under real environmental conditions to assess electrical performance, nutrient concentration control, and operational stability across multiple crop growth phases. The research site demonstrated suitable conditions for solar energy harvesting, with high annual Global Horizontal Irradiation with an average temperature of 27.2 °C, wind velocity of 1.7 m/s, and relative humidity of 83.8%. Electrical performance results indicated that PV voltage ranged from 26 V to 40 V, while battery voltage was consistently maintained between 25 V and 28 V. Output current varied proportionally with PV voltage, and the generated power reflected actual field conditions. The Automatic Mixing System successfully controlled Total Dissolved Solids (TDS) concentrations according to plant growth stages. Nutrient levels ranged from 500–800 ppm during vegetative stages and increased to 1000–1500 ppm during fruiting stages, meeting crop nutrient demands. Water level monitoring ensured accurate tracking of nutrient solution consumption, with timely manual replenishment preventing operational interruptions. Comparison with previous studies showed a small percentage error of 4–5%, validating the system's accuracy and reliability. Overall, the integration of Solar PV energy with IoT-based nutrient management provides an energy-efficient, stable, and sustainable solution for precision agriculture, demonstrating strong potential for long-term smart farming applications.

1. Introduction

Solar energy is one of the most well-known energy sources, and the technology related to solar energy is rapidly developing. The main factors driving the rapid growth of solar energy technology is that sunlight is available throughout the world, and the amount of sunlight received by the Earth is high all year round. This indicates that the sun is an inexhaustible and free source of energy for our planet [1].

In recent years, the agricultural sector has experienced rapid growth worldwide. Several new farming techniques have been developed to overcome the limitations of traditional soil-based agriculture, and one of the most advanced and popular methods is hydroponics. Due to its advantages in addressing the weaknesses of traditional farming, this modern agricultural method has become a preferred choice among commercial farmers.

Sakthivel et al [2] highlighted a solar-powered hydroponic systems reduce energy consumption and carbon emissions compared to traditional soil-based farming methods. This research demonstrated that by using photovoltaic (PV) panels to power irrigation pumps, water filtration systems, and LED grow lights, farmers could achieve energy independence and lower operational costs. Nwankwo et al [3] proposed the integration of hybrid solar-wind systems to ensure a constant energy supply for hydroponic systems, particularly in areas with inconsistent solar radiation. The authors showed that combining solar panels with wind turbines could provide a more reliable power source for energy-intensive hydroponic farms, reducing dependence on the grid. Next, Almeida et al [4] explored the integration of IoT (Internet of Things) devices into solar-powered hydroponic systems. Their study emphasized the use of solar energy to power sensors that monitor environmental parameters like temperature, humidity, and nutrient concentration, improving crop management through real-time data and automation. Chavez et al [5] performed a cost-benefit analysis of solar-powered hydroponic systems. They found that although the initial investment in solar panels and supporting infrastructure is high, the long-term savings on energy costs and reduced environmental impact offer a compelling case for investment. Tian et al [6] demonstrated the advantages of solar-powered greenhouses, where solar panels supply electricity for internal climate control systems, improving the efficiency of hydroponic farming by extending the growing season and reducing heating costs. López et al [7] found that solar energy could be used to power both the water circulation pumps and lighting. Their study suggested that combining aquaponics with solar power would enhance food production efficiency while minimizing water and energy usage.

Next, Patel et al, [8] explored the use of solar energy in vertical hydroponic farming, where crops are grown in stacked layers, often in urban environments. Solar panels can power LED grow lights and irrigation systems, significantly reducing the energy footprint of vertical farms. Rashid et al [9] developed a solar-powered system that uses sensors to control variables like nutrient delivery and irrigation automatically. This system significantly reduces the need for manual labor and improves resource efficiency. Hassan et al [10] discussed the limitations of solar energy, including intermittency, the need for energy storage, and the high initial investment costs. They concluded that energy storage systems, such as batteries, are critical to ensuring uninterrupted power supply. Zhang et al [11] investigated solar-powered nutrient delivery systems, which are crucial in hydroponic systems where nutrient management is key to optimizing crop growth. The study demonstrated that solar energy could efficiently power pumps and nutrient mixing systems, ensuring precise nutrient delivery to plants. Gupta et al [12] focused on integrating artificial intelligence (AI) with solar-powered hydroponics. AI can be used to analyze data from sensors to predict crop growth patterns, optimize resource allocation, and adjust the energy usage of the system. Singh et al [13] demonstrated that solar-powered hydroponic systems could reduce water usage by up to 90% compared to traditional farming. Solar-powered systems also allow for better control of water distribution, improving overall resource efficiency. Patel and Khan [14] analyzed the environmental benefits of using solar energy in hydroponics, including the reduction of greenhouse gas emissions and the mitigation of climate change impacts. Their life cycle assessment showed that solar-powered hydroponic systems have a significantly lower environmental footprint compared to traditional agriculture. Kamarulzaman et. al [15] discusses a solar powered of hydroponic for monitoring system. A solar energy is the main source of an Arduino Uno, a microcontroller to control all the sensors then collecting the data and display the data to users. This sensor will monitor those elements and help the users in the hydroponics system. The value of temperature, water level and pH had been measured and collected to be analyzed. The result shows the effectiveness of a solar-powered hydroponic monitoring system. S. Mekhilef et. al [16] discusses the solar energy application in agriculture and focuses on the solar photovoltaic (PV) and solar thermal in pumping of water, drying crops, the storage of cooling and producing heating or cooling greenhouse. Next, M. Dursun et. al [17] discusses solar energy application in agriculture. In this research, solar energy as a main supply to a brushless DC motor for storing and transferring of water from a pool to drip irrigation. Torshizi et.al [18] this paper discusses the use of solar energy in agriculture system such as to do several farm works, pumping water for irrigation, monitoring system and others. The research found that solar energy technologies for farming is divided into two systems which are photovoltaic cell system and uses solar capture heating system. S.A. Jumaat et. al, 2025 [19] discusses an automated hydroponic system with a sensor-based fertilizer concentration detection mechanism connected to a nutrient reservoir. This research is to saves an electricity also to optimizes a fertilizer usage and reduces plant maintenance time, a contributes to sustainable agriculture by harnessing a green energy technology while to minimizing a fertilizer and a water consumption and reducing environmental pollution.

Next, Amy Lizbeth *et. al* [20] are developed a monitoring and controlling the pH of nutrient solution in a hydroponic system. A Water culture system are the systems of leafy lettuce. These are highly costly devices that can be used in locations where there is little or no electric. The Arduino uno microcontroller used to construct a nutritious water flow system and manage the amount of water in hydroponic tubes [20]. Ullah. A*. et. al* in [21] used an ESP32 microcontroller to control the pump in the suggested system. The pump pull water from a reservoir connected to a standard water line. In paper [22], Keethana *et. al* are developed a sensor, light-emitting diode bulbs, water spray, and a pump capable of successfully decreasing the concentration of dioxide, temperature, and water level. In paper [23], pH, water level, ambient temperature, and relative humidity are constantly monitored to give the best environment for plant development The irrigation system is managed by water and nutrient input. Sensor data and cloud-based technology may be used as backup to store, manage, apply, and communicate information through the internet.

Table 1 *Summary of references of solar energy in hydroponic system*

Sr. No.	Technology	Benefit	Reference
1	Pump for irrigation Water filtration and LED grow lights	Hydroponic systems reduce energy consumption and carbon emissions energy independence and lower operational costs.	[2]
2	Hybrid renewable energy	constant energy supply reducing dependence on the grid.	[3]
3	IoT (Internet of Things) devices	Their study emphasized the use of solar energy to power sensors that monitor environmental parameters like temperature, humidity, and nutrient concentration, improving crop management through real-time data and automation.	[4]
4	Renewable energy	cost-benefit analysis of solar-powered hydroponic systems. the long-term savings on energy costs reduced environmental impact	[5]
5	Greenhouse the internal climate control systems	extending the growing season by reducing heating costs.	[6]
6	Water circulation pumps and lighting Combination aquaponics	enhance food production efficiency minimizing water and energy usage.	[7]
7	vertical farming LED grow lights and irrigation systems,	reducing the energy	[8]
8	uses sensors to control nutrient delivery and irrigation automatically.	reduces the nutrient and water. improves resource efficiency.	[9]
9	energy storage	energy storage systems, such as batteries, are critical to ensuring uninterrupted power supply.	[10]

Sr. No.	Technology	Benefit	Reference
10	pumps and nutrient mixing systems	Nutrient management is key to optimizing crop growth. efficiently power, precise nutrient delivery to plants.	[11]
11	artificial intelligence (AI)	analyze data from sensors to predict crop growth patterns, optimize resource allocation, adjust the energy usage of the system.	[12]
12	Controlling the water for irrigation	reduce water usage by up to 90% compared to traditional farming. better control of water distribution, improving overall resource efficiency	[13]
13	Greenhouse	the reduction of greenhouse gas emissions and the mitigation of climate change impacts. have a significantly lower environmental footprint	[14]
14	Monitoring system	The value of temperature, water level and pH had been measured and collected solar-powered hydroponic monitoring system.	[15]
15	Greenhouse	pumping water, drying crops, cooling the storage and producing heating/cooling greenhouse.	[16]
16	Dripping	power up brushless DC motor for water storing in a pool and transferring of water waited in pool to drip irrigation.	[17]
17	Water pumping for irrigation Monitoring system	solar energy technologies photovoltaic cell system heating system	[18]
18	sensor-based fertilizer concentration detection mechanism connected to a nutrient reservoir.	saves electricity optimizes fertilizer usage and reduces plant maintenance time. sustainable agriculture by harnessing green energy technology minimizing fertilizer and water consumption and reducing environmental pollution.	[19]
19	Sensor for pH Nutrient	Reduce and save the quantity of nutrient	[20]
20	Controller	Monitor the water flow and water level	[21]
21	Controller	Save the water and long-life of water pump	[22]
22	Sensor, LED	Reduce the CO2, temperature	[23]
23	Irrigation System and IoT	Save the water and nutrient	[24][25][26][27]
24	Renewable energy integration	Solar panels and wind turbines are increasingly used to power vertical farming operations	[28]

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Sr. No.	Technology	Benefit	Reference
25	Indoor vertical systems	The procedure allows growing organic pesticide-free produce in an artificially controlled indoors without chemical additives	[29]

2. Method and Material

This session discussed the method and materials of research. In general, this research has three (3) main parts: Solar Photovoltaic (PV) Energy system, Hydroponic System and Mix Automatic System. Figure 1 shows the completion of the project.

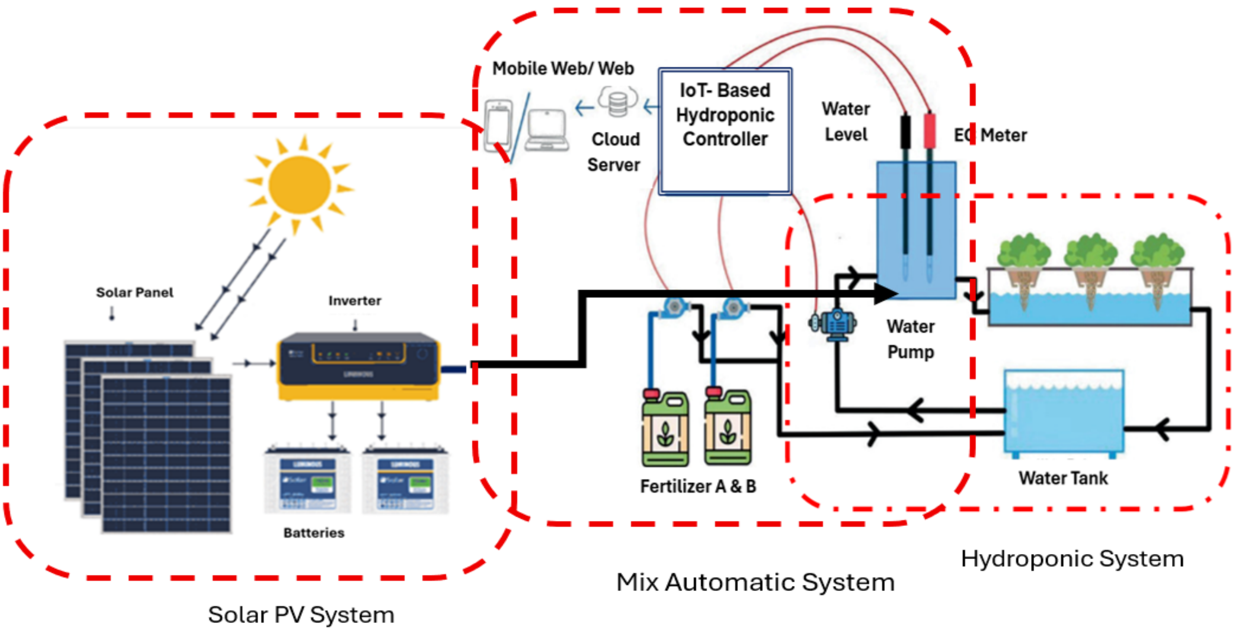

Fig. 1 *The concept of research*

The entire study consists of three main parts: Electricity Generation System using Solar PV Panel, Automatic Mixing System, Hydroponic System with Hygrowpot. Figure 2 illustrates the three main components of this research project. Figure 3 shows the front and side views of the complete hardware setup for the research.

2.1 Electricity Generation System Using Solar PV Panels

This section focuses on the generation of electrical energy from solar PV panel. The solar PV system comprises the main components: one (1) unit of 405W solar PV panel, two (2) units of 12V 200Ah Lead-Acid batteries, and one (1) unit of 1200W Inverter with MPPT (Maximum Power Point Tracking). Parameter of solar panel PV as tabulated in Table 2. These components work together to store and convert solar energy for use in the system.

Table 2 *Parameter of solar panel 405W [30][31][32]*

Parameter	Value [Unit]
Nominal Power (P_{mpp})	405W
Short Circuit Current (I_{sc})	11.19A
Open Circuit Voltage (V_{oc})	45.09V
Current at maximum power (I_{mpp})	10.7A
Voltage at maximum power (V_{mpp})	37.85V
Maximum System Voltage (V_{sys})	1000V

2.2 Automatic Mixing System

This section consists of one (1) unit Arduino controller, two (2) EC meter sensors for nutrient concentration detection, one (1) water level sensor, and two (2) 5W DC pumps. The two EC sensors are installed in the nutrient tank to measure the nutrient concentration level, while the water level sensor is placed at the top of the main nutrient tank [33]. The system automatically detects the nutrient concentration and water level. If the EC reading is lower than the pre-set value, the pump will be activated to transfer fertilizer from the secondary tank into the main nutrient tank, ensuring continuous and accurate nutrient mixing.

2.3 Hydroponic System with Hygrowpot

This section involves a hydroponic system that uses 36 units Hygrowpot with cocopeat as a soil replacement medium. Nutrient water is circulated through the pipes, where it flows through and nourishes the plants, then returns to the main nutrient tank (a black reservoir tank). The system includes one (1) large water tank, two (2) units of 5W DC pumps, and four (4) units of PVC pipes with each pipe containing nine (9) unit of Hygrowpot planting pots. In total, the system consists of 36 pots using coconut husk (cocopeat) as the primary planting medium. The nutrient water flows continuously through the PVC pipes and recycles back into the main nutrient tank [19]. Fig. 2 and 3 shows the main parts of research and view of hardware of research.

(a) Solar PV System **(b) Automatic mixing system** **(c) Hydroponic system with Hygrow-pot**

Fig. 2 *Main parts of research*

(a) **(b)**

Fig. 3 *(a) Front view; (b) Side view of hardware setup of research*

The study was conducted in three phases:

- Phase I: December 2023 to January 2024
- Phase II: May to July 2024
- Phase III: December 2024 to January 2025

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Table 3 lists the vegetable samples used throughout the study period, which spanned from December 2023 to January 2025. From December 2023 to January 2024 (2 months), the study focused on fruiting vegetables, specifically Solanum lycopersicum var. cerasiforme (cherry tomato) and Capsicum annuum (chili pepper). The second phase of the study was conducted over 3 months, from May to July 2024, and involved the climbing vegetable Cucumis sativus Linn. (cucumber). The third phase was carried out from December 2024 to January 2025 (2 months), focusing on leafy vegetables, specifically Tropical Chinese Cabbage King.

Table 3 *The sample of plant for research*

Duration of Phase	Name of Plants	Photo of Plants
Phase I (2 months) December 2023 ~ January 2024	Solanum lycopersicum var. cerasiforme	
	Capsicum annuum	
Phase II (3 months) May ~ July 2024	Cucumis sativus Linn	
Phase III (2 months) December 2024 ~ January 2025	Tropical Chinese Cabbage King	

Upon completion of the hardware development phase, each subsystem is calibrated and commissioned individually, namely the Solar PV System and the Automatic Mixing System. Fig. 4 shows the battery voltage measurements obtained from the Solar PV system, recorded at 24.8 V. These readings indicate the operational status and charging performance of the PV-battery configuration.

Subsequently, the Automatic Mixing System is calibrated by configuring the required nutrient concentration setpoint in parts per million (ppm), as shown in Figure 5. For fruit-bearing vegetable cultivation, the ppm value is set to 1260 ppm to meet the specific nutrient requirements. In addition, the water level measurement is monitored through the same system interface, as presented in Figure 5a, enabling real-time observation of the nutrient solution level within the reservoir.

Fig. 4 *Results of battery voltage and restore voltage from solar PV system*

(a)

(b)

Fig. 5 *(a) Results of PPM value and water level; and (b) Setting value of PPM in automatic mixing system*

3. Results and Discussion

The location of research in Green and Sustainable Energy (GSEnergy) Focus Group Testing site, Blok E5, Universiti Tun Hussein Onn Malaysia (UTHM), Parit Raja, Johor, Malaysia lies between 1.5111°N Latitude and 103.510°E longitude. The latitude of location is 1.8524°, the longitude is 103.0842°, the altitude is 11M above sea level and time zone is 8.0. Table 4 tabulated global horizontal and horizontal diffuse irradiation of location. Table 5 tabulated the temperature, wind velocity and ratio of relative humidity of location. The total Global Horizontal in 12 months is 1672.1 kWh/m^2/year, and Horizontal Diffuse Irradiation is 932.40 kWh/m2/year. Based on Table 5 the average of temperature, wind velocity and ratio relative humidity is 27.2 ^{0}C, 1.7 and 0.838, respectively.

Table 4 *Global horizontal and horizontal diffuse irradiation*

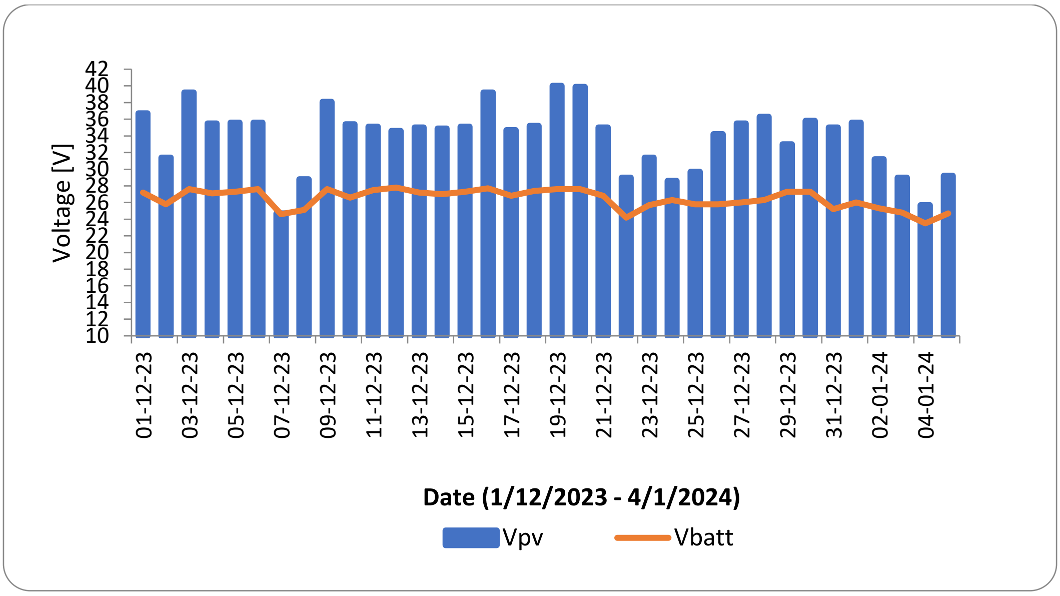
Interval beginning	GlobHor kWh/m²/mth	DiffHor kWh/m²/mth
January	143.0	72.86
February	149.9	77.01
March	160.0	84.89
April	147.2	81.76
May	143.8	80.32
June	131.0	70.62
July	141.1	80.68
August	137.4	76.87
September	134.5	80.89
October	134.0	81.71
November	123.6	71.63
December	126.6	73.16
Year	1672.1	932.40

Table 5 *Temperature, wind velocity and ratio relative humidity*

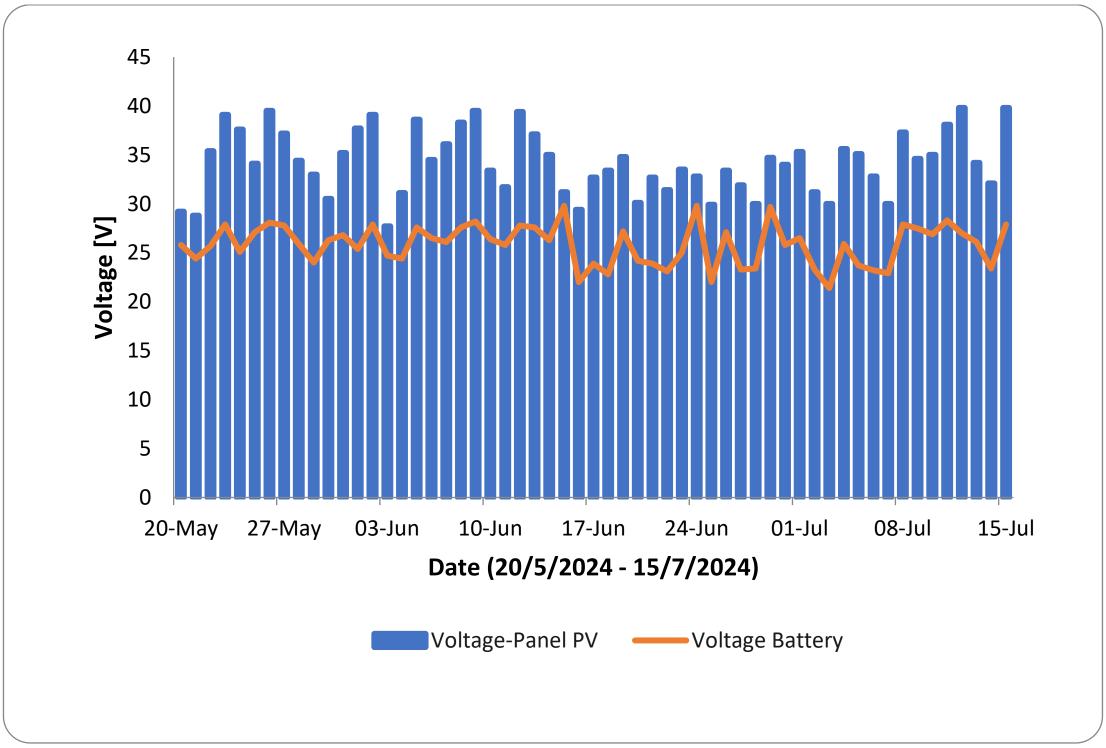
Interval beginning	T_Amb (˚C)	WindVel/ m/s	RelHum ratio
January	26.6	2.3	0.822
February	27.1	2.5	0.799
March	27.5	1.8	0.807
April	27.3	1.3	0.863
May	28.0	1.5	0.831
June	27.4	1.6	0.856
July	27.4	1.7	0.826
August	27.3	1.6	0.828
September	26.9	1.7	0.860
October	27.3	1.4	0.829
November	26.5	1.3	0.887
December	27.3	1.8	0.844
Year	27.2	1.7	0.838

3.1 Output Voltage of PV Panel and Battery

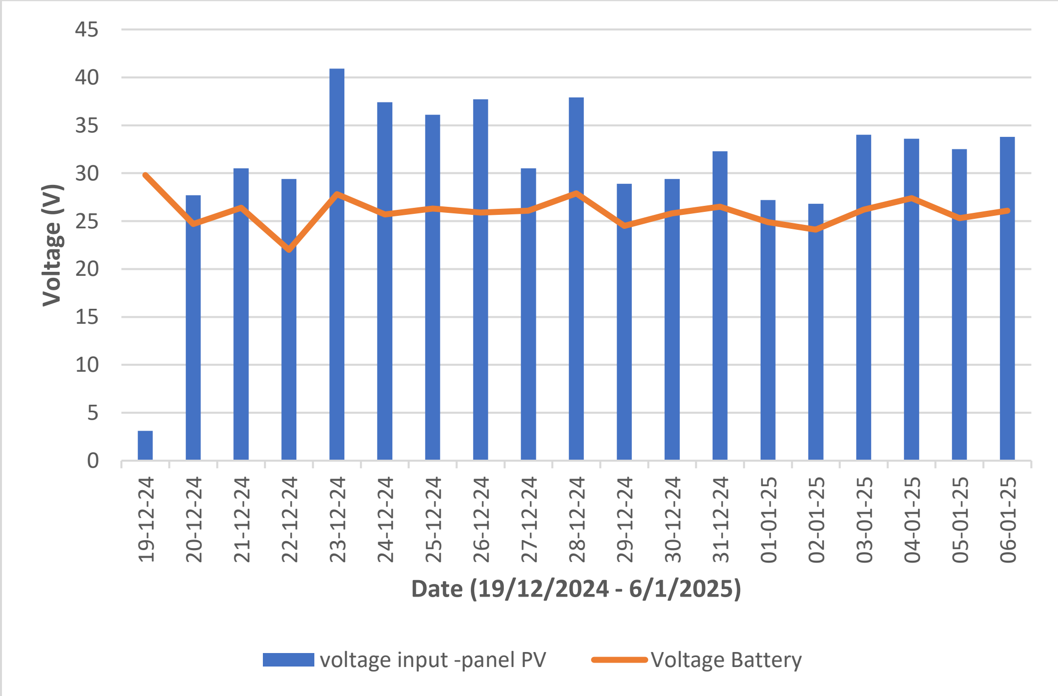
Fig. 6 shows the output voltage on the PV panel, V_{pv} and the voltage of the battery, V_{batt} for Phase I, II and III. The figure indicates that the voltage ranges from 30V to 40V for V_{PV} such as in specification of solar panel PV is Table 1. The highest voltage was recorded on 19th, 20th December 2023, 12th July and 23th December 2024, at 40V. The lowest V_{pv} was recorded on 7th December 2023, at 26V. Referring to Table 3 and Table 4 irradiation and Temperature of July and December are 141.1kWh/m^2/mth, (27.4˚C) and 126.6kWh/m^2/mth (26.7˚C) respectively. This shows that irradiation and temperature affect the rate of electrical energy generation. The V_{batt} readings are around 25V to 28V, based on the battery specifications [26][27]. The result obtained falls within the range specified in Table 1, namely 37.85V and 25V for Solar PV voltage and battery voltage.



(a) Ouput voltage of Phase I



(b) Output voltage of Phase II

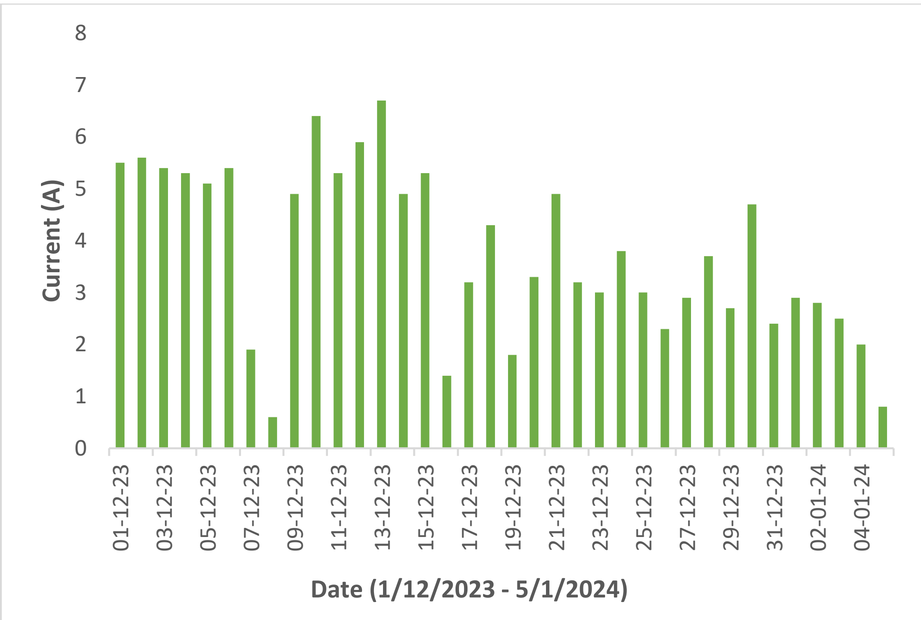


(c) Output voltage of Phase III

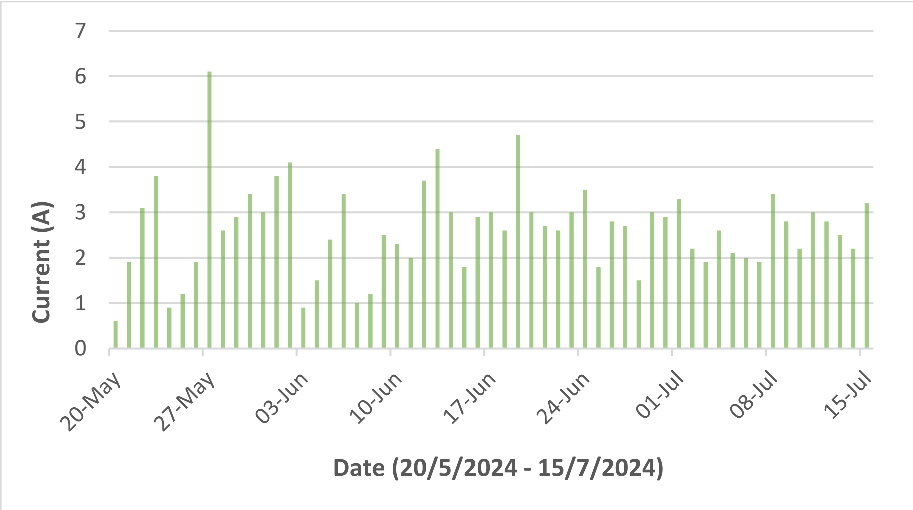
Fig. 6 *Output voltage of Phase I, II and III*

3.2 Output Current of System

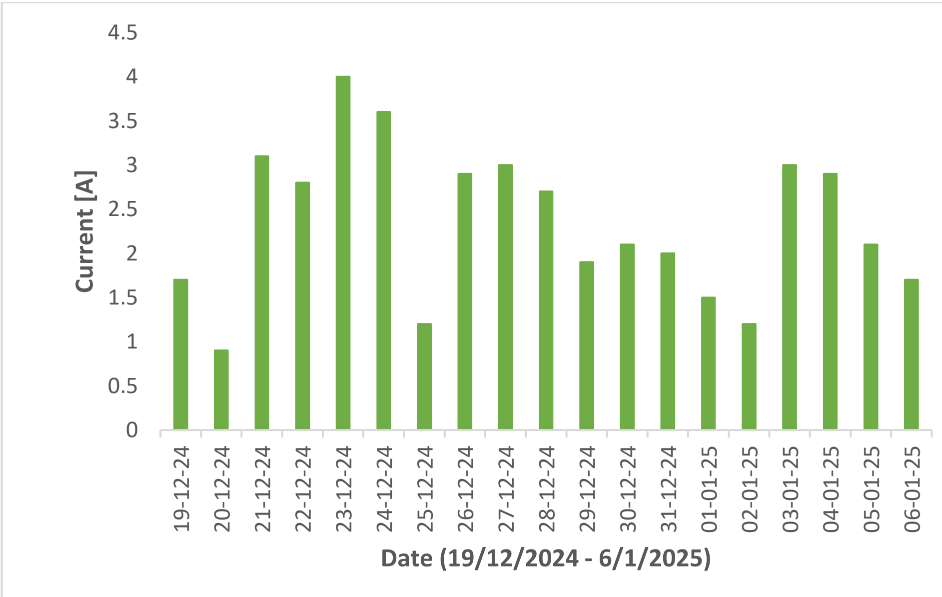
Fig. 7 shows the ouput current of system for Phase I,II and III. The current readings are directly proportional to the V_{pv}. The highest current was recorded on 13th December 2023, 27th July at 6.8A, while the lowest was 0.5A on 8th December 2023. The result obtained falls within the range specified in Table 1, namely 11.7A.



(a) Output current of Phase I



(b) Output current of Phase II

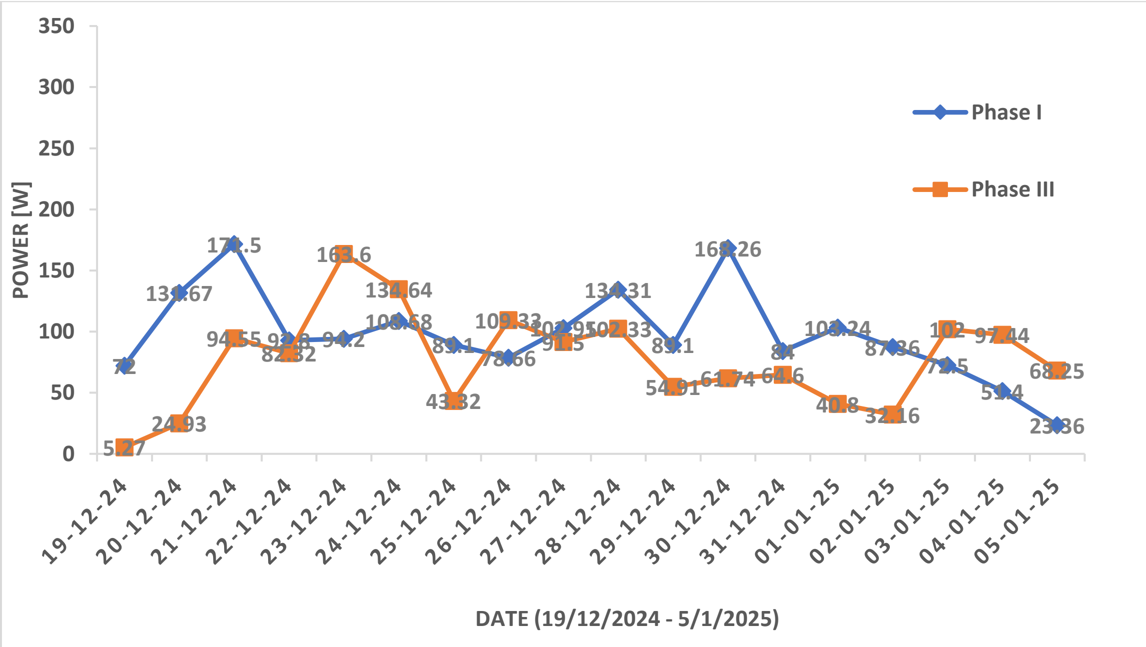


(c) Output current of Phase III

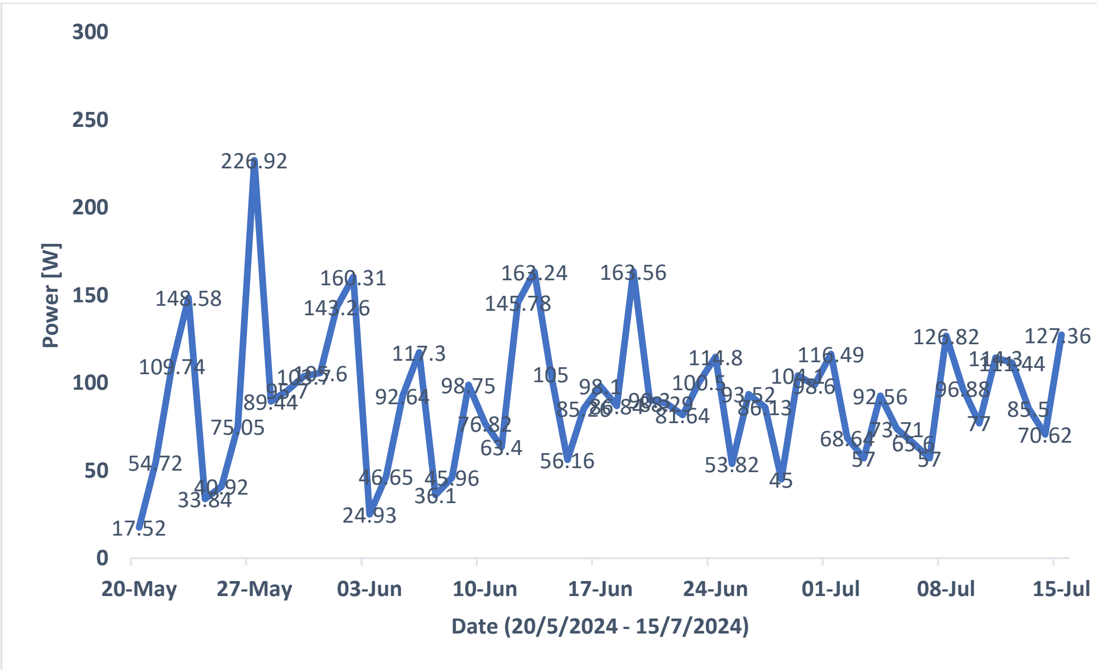
Fig. 7 *Output current of Phase I, II and III*

3.3 Output Power of System

Fig. 8 shows the output power of Phase I, II and III. The results were obtained from the PV voltage and PV current readings. The maximum voltage and current readings were 37.85 V and 10.7 V, respectively. The results for December and January shown ni Fig. 8(a) and results for May untii July is shown in Fig. 8(b). Based on Fig. 8 (a), the maximum power for December and January is 174.5W at 21st December 2023 and minimum power is 5.27W as 19th December 2024. Next, based on the Fig. 8(b), the maximum power for May until July is 226.92W at 27th May 2024 and the minimum power is 17.52W at 20th May 2024. The result obtained falls within the range specified in Table 1, namely 405 W.



(a) Output power of Phase I and III



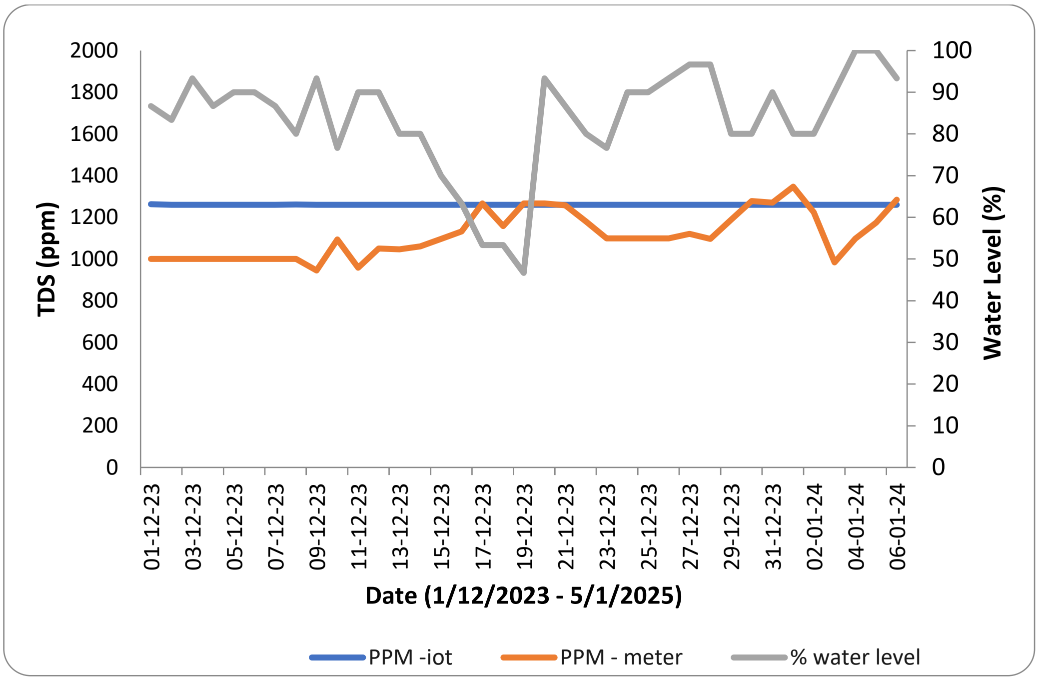
(b) Output power of Phase II

Fig. 8 *Ouput power of Phase I, II and III*

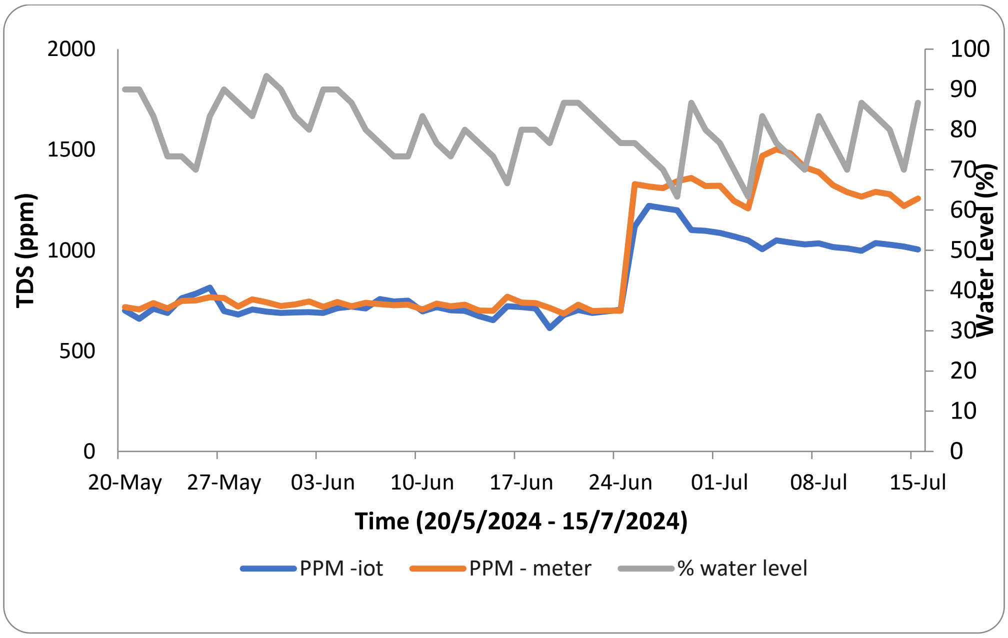
3.4 TDS Value and Percentege of Water Level

Fig. 9 shows the results of the ppm (parts per million) value measured using the IoT method and an EC (electrical conductivity) meter. The ppm readings range from 500 to 700 during the planting period and 1000 to 1500 during the fruiting period of the plants as shows in Fig 9 (a) and (b), which requires a high concentration of fertilizer. The EC meter readings are provided for reference only. Based on the Fig. 9 (b), date of 20th May until 24 June 2024 was the planting period and the ppm reading is below 800, Next starting 24th June until 15th July was fruiting period and the ppm reading was increased to above 1000.

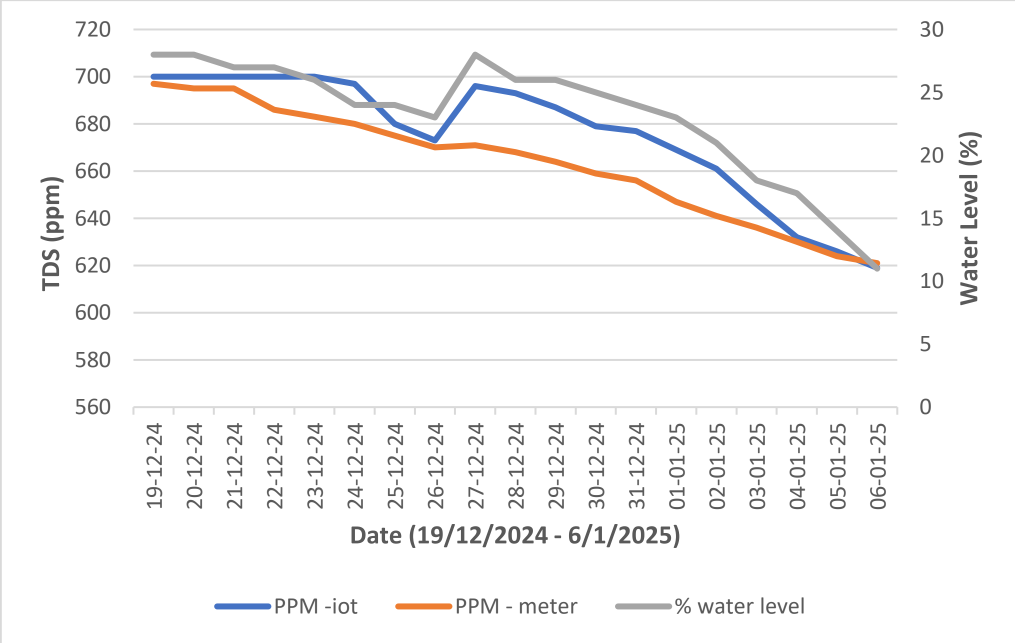
Meanwhile, the water percentage readings are around 80% or higher. Based on the Fig. 9(a) on 19th December 2023, the water percentage are dropped to 50%, indicating that the water level decreased to half after the system had been operating for 19 days at fruiting period. On the 20th day, water was manually added, raising the water level to 90%. Next, based on results in Fig. 9(c), on 5th January 2025 the water is dropped to 50% after 18 days and next the day the water was manually added in the tank.



(a) TDS value and percentage of water level of Phase I



(b) TDS value and percentage of water level of Phase II



(c) TDS value and percentage of water level of Phase III

Fig. 9 *Results of TDS value and percentage of water level of Phase I, II and III*

3.5 Comparison of TDS Value with Previous Paper [29]

Table 6 presents a comparison between the measured TDS readings and the values reported in paper [29]. The results indicate that, from Week 1 to Week 4, the TDS values reported in paper [29] were 1250 ppm, 1265 ppm, 1255 ppm, and 1255 ppm, respectively. In contrast, the TDS reading for Test System Phase 1 remained constant at 1200 ppm throughout the four-week period. The percentage error between the two sets of data ranges only between 4% and 5%, indicating good agreement with the reference study. These readings were recorded during the fruiting stage of the plants, where nutrient concentration requirements are typically higher to support fruit development.

Table 6 *Comparison the results with previous paper [29]*

Item	Week 1	Week 2	Week 3	Week 4
Results from Paper [29]	1250 ppm	1265 ppm	1255 ppm	1255 ppm
Test System Phase I	1200ppm	1200 ppm	1200 ppm	1200 ppm
Error %	4%	5%	4%	4%

4. Conclusions

The findings of this study An Autonomous Hydroponic System Using Solar Energy and IoT Monitoring Technology confirm that the developed Solar Photovoltaic (PV)-powered Automatic Mixing System operates reliably and effectively under actual environmental and agricultural conditions. The research location demonstrates favourable climatic characteristics, including high annual Global Horizontal Irradiation and stable average ambient temperature, wind velocity, and relative humidity. These environmental parameters provide suitable conditions for consistent solar energy harvesting and support the long-term feasibility of integrating renewable energy systems into precision agriculture applications.

From the electrical performance analysis, the Solar PV system exhibited stable and predictable behaviour throughout all experimental phases. The PV output voltage ranged between 26 V and 40 V, remaining within the specified operational limits of the solar module. Peak voltage values were recorded during periods of higher irradiation, while lower voltage values corresponded to reduced solar intensity, confirming the direct influence of environmental factors on energy generation. Similarly, the battery voltage was consistently maintained between 25 V and 28 V, indicating proper charging regulation and effective energy storage management. The output current, which varied proportionally with PV voltage and solar irradiation, remained within the allowable system rating. Although the measured output power did not reach the nominal rated capacity of 405 W, the obtained results accurately reflect real-time field operating conditions rather than ideal laboratory performance. Overall, the PV-battery subsystem demonstrated stable functionality and compliance with design specifications across all phases of operation.

In terms of nutrient management, the Automatic Mixing System effectively controlled and monitored Total Dissolved Solids (TDS) concentration according to plant growth requirements. During the vegetative stage, ppm values were maintained between 500 and 800 ppm, while during the fruiting stage, concentrations increased to between 1000 and 1500 ppm to support higher nutrient demand. The integration of IoT-based monitoring with EC meter validation ensured measurement reliability and consistency. Water level monitoring further demonstrated the system's capability to track nutrient solution consumption over time. Although the reservoir level decreased to approximately 50% after extended operation during fruiting stages, timely manual replenishment restored optimal levels and prevented operational disruption. Furthermore, comparison with previously published research showed a minimal percentage error of 4–5%, indicating strong agreement with established reference data. This close correlation validates both the accuracy of the sensing system and the effectiveness of the nutrient control strategy.

In conclusion, the integration of the Solar PV system with the IoT-enabled Automatic Mixing System proves the energy-efficient, and suitable for sustainable agricultural implementation. The system maintains electrical stability, ensures accurate nutrient regulation, and adapts effectively to environmental variations, demonstrating strong potential for long-term smart farming applications.

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Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: ***study conception and design:*** *Siti Amely, Ahmad Fateh, Ansar;* ***data collection:*** *Muhamad Syafiq;* ***analysis and interpretation of results:*** *Siti Amely, Suriana, Muhammad Nafis;* ***draft manuscript preparation:*** *Siti Amely, Muhammad Syafiq. All authors reviewed the results and approved the final version of the manuscript.*

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