Samarra Journal of Pure and Applied Science

www.sjpas.com

p ISSN: 2663-7405
e ISSN: 2789-6838

Revolutionizing Agriculture: IoT Empowered Smart Greenhouses for Enhanced Productivity

Mohamed Ismail Lafta[1*] and Wisam Dawood Abdullah[2]
1- Computer Science Department Computer Science and Mathematics College, Tikrit University Tikrit, Iraq
2- Cisco Networking Academy, Tikrit University, Tikrit, Iraq

https://doi.org/10.54153/sjpas.2024.v6i2.837

Article Information

Received: 06/03/2024
Revised: 20/03/2024
Accepted:05/04/2024
Published: 30/06/2024

Keywords:

IoT agriculture, IoT greenhouse, IoT smart farm, Internet of Thing greenhouse, and Internet of Thing agriculture.

Corresponding Author

E-mail:
mohammedi.lafta@st.tu.edu.iq
Mobile: 07731989725

Abstract

Recent advances in smart agriculture, facilitated by the Internet of Things (IoT), are revolutionizing traditional farming methods and transforming them into efficient practices. IoT technology has been widely applied in greenhouse management, enabling the seamless exchange and transfer of large data sets. Smart agriculture integrates information and communications technology to innovate traditional agricultural methods, promising benefits such as increased productivity, reduced costs through reduced resource use, labor efficiency, and improved product quality. Our study focuses on using sensors to monitor soil moisture, temperature, and light for optimal plant growth. An experiment was conducted on growing three types of radish plants in a smart greenhouse using an Internet of Things system and a traditional greenhouse.. The study took approximately 50 days, and the results were compared with the cultivation methods used in traditional greenhouses. The ratio of wet weight to vegetative growth was impressive and good. Meanwhile, it was lower in traditional greenhouses. As for the wet weight of the roots, the smart greenhouse significantly outperformed the traditional greenhouse. The average weight recorded in the smart home was 4.8873 grams, while in the traditional greenhouse, it was 3.2953 grams. These results confirm the potential of IoT technology to enhance agricultural productivity..

Introduction:

Agricultural production and food security are anticipated to be substantially influenced by climate change [1, 2]. The development of agricultural production is substantially impacted by factors such as urban population concentration, climate change, crop diseases, and greenhouse gas emissions. These challenges underscore the imperative to address the escalating requirements for energy and food. The regions of the Middle East, which have limited water resources, will be especially susceptible to the effects of climate change [3, 4] . Agriculture is among the most significantly impacted industries since crop development is predominantly influenced by soil humidity, temperature, and relative humidity [5]. Irrigation is essential for agricultural production to supply the water needs of crops grown in greenhouses. Poor irrigation scheduling and improper use of water resources are common factors that limit production in various agricultural areas [6]. Wastage over-irrigation can sometimes lead to diseases in crops. Soil moisture, Temperature, and Relative humidity along with light illumination around the plant are also key parameters to control [7]. Over the last decade, Internet of Things technology has been extensively utilized for greenhouse environmental monitoring and control [8]. In regions with severe climates, greenhouses provide the ideal environment for increasing crop yield and quality due to their controllable nature [9].

IoT implementations in the agricultural sector consist of greenhouse production, precision agriculture, and management of agricultural apparatus [10]. Smart Farming is a novel concept in agriculture that aims to revolutionize food management and production. Smart Farming can be seen as the advancement of Precision Agriculture. Smart Farming attempts to enhance productivity and enhance the quality of the end output while decreasing production costs [11]. Sensors are crucial for gathering environmental data in greenhouse farming. Multiple sensors gather different environmental data. Sensors need to have minimal power consumption and be cost-effective to implement under normal operating conditions [12].

Agricultural environment monitoring has become a crucial field of control and protection providing a real-time system with the physical world [13]. Implementing state-of-the-art technologies in the agricultural sector to increase the output's quality and quantity constitutes intelligent agriculture. It enables farmers to increase yields while reducing resource consumption [14]. Several previous studies that have used IoT technologies in smart agriculture are reviewed, including the proposed and implemented use of IoT in smart greenhouses and some of these studies. Nafis Sadique Sayem , et al. proposed an IoT-powered smart agro-farm security system. the system identifies unlawful access and sends real-time alarms to the farmer's residence and mobile device [15].

Al-Ali, A. R., et al. proposed a system that uses a single-board system-on-a-chip controller (the controller) with Wi-Fi and a solar cell for power. The controller reads field soil moisture, humidity, and temperature sensors and sends irrigation pump actuation commands [16]. Amit Kumer Podder, et al. proposed an Internet of Things (IoT)-enabled Smart AgroTech system that takes into account soil moisture, humidity, and temperature as essential agricultural parameters in the context of urban agriculture. The proposed system determines whether to initiate or discontinue irrigation [17]. Gilroy P. Pereira, et al proposed The ESP32 was utilized in the development and testing of an IoT-enabled automated drip irrigation system. To gather water data, manually water plants, deactivate the automated watering function and generate graphs derived from sensor readings, the ESP32 establishes communication with the Blynk application [18]. , et Rho, Jeong-Min, et al proposed The developed a smart greenhouse system that allows anyone to effortlessly grow plants indoors, even without any expertise in the field. Our system takes into account the key factors that affect plant growth, such as temperature, humidity, and soil moisture. Incorporating Raspberry Pi and Arduino, the system effectively monitors the greenhouse's condition using sensors [19].

This paper proposes the design and implementation of a low-cost IoT-based global warming, soil moisture, and light intensity monitoring system, which is connected to an ESP32 device. Where it differs from previous studies is that it is based on the Internet of Things. The system includes measuring parameters: soil moisture, greenhouse temperature, and light intensity. Previous studies did not work on these criteria.

Methodology:

Real-time monitoring of greenhouses makes IoT infrastructure in the agricultural field more complex [20, 21]. The ESP32 router connects the sensors in the proposed system. A DHT22 device was used to measure temperature, a soil moisture detector to measure moisture content in the soil, and an LDR to measure light intensity. Figure 1 shows the final design of the proposed system after connecting all the sensors to the ESP32, the soil moisture sensor, the greenhouse temperature sensor, and the light intensity sensor. In this paper, IoT-based smart agriculture is used to monitor a smart greenhouse model. An ESP32 device is placed that controls temperature, soil moisture and light intensity. The smart decision is made based on the real information coming from the greenhouse. This is to help farmers by monitoring environmental conditions in greenhouses. The goal of IoT-based smart agriculture technology is to control temperature, humidity, and light intensity. The ideal threshold values were used to compare with the readings received from the sensors based on consultation with an expert in the field of plants and knowledge of the ideal values for the plant in terms of temperature, moisture of soil, and light intensity.

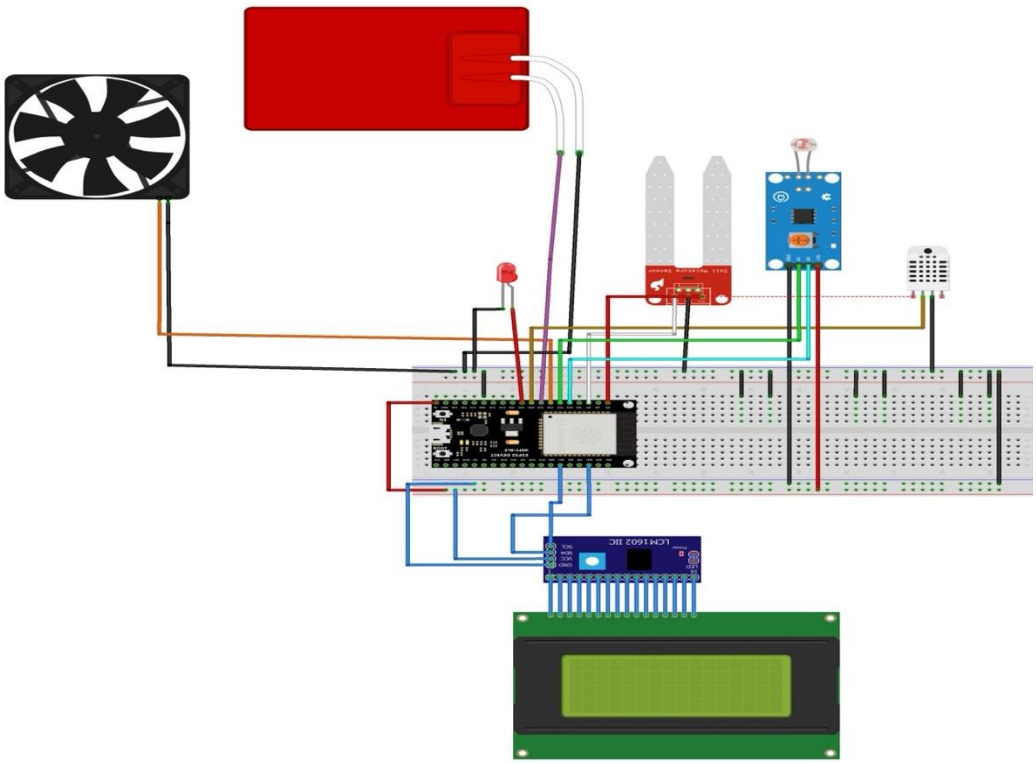

Fig. 1 Design of the proposed system.

Figure 2 shows a flowchart of the sensor control mechanism connected to the ESP32. It serves as a representation of the sensor control mechanism by reading and processing data by the ESP32, which then compares the sensor data reading with the threshold value that has been memorized to determine whether to turn the pump on or off. A soil moisture sensor was used to monitor the moisture level in the soil. It measures the humidity and compares it to the value stored in the ESP32. When soil moisture drops to 46% or less, the ESP32 activates the irrigation pump. The irrigation pump will be stopped if the soil moisture level exceeds 46. A DHT22 sensor connected to the ESP32 has also been used to regulate the heating and cooling processes. The ESP32 controls the operation of the heater inside the smart greenhouse if the sensor reading coming from the greenhouse is below 23°. To raise the temperature to the ideal threshold level stored in the ESP32, but if the temperature rises to more than 23°, the cooling fans are turned on and continue to work until the temperature drops to the required level. An LDR sensor was also used to illuminate the greenhouse and provide sufficient light rays to continue the process of photosynthesis. If the light intensity is less than 300_{ohms}, the lighting will turn on, and if it is more, it will turn off. The process is repeated throughout the system's operation, and the optimal threshold values for comparison can be changed at any time to provide optimal conditions for plant growth.

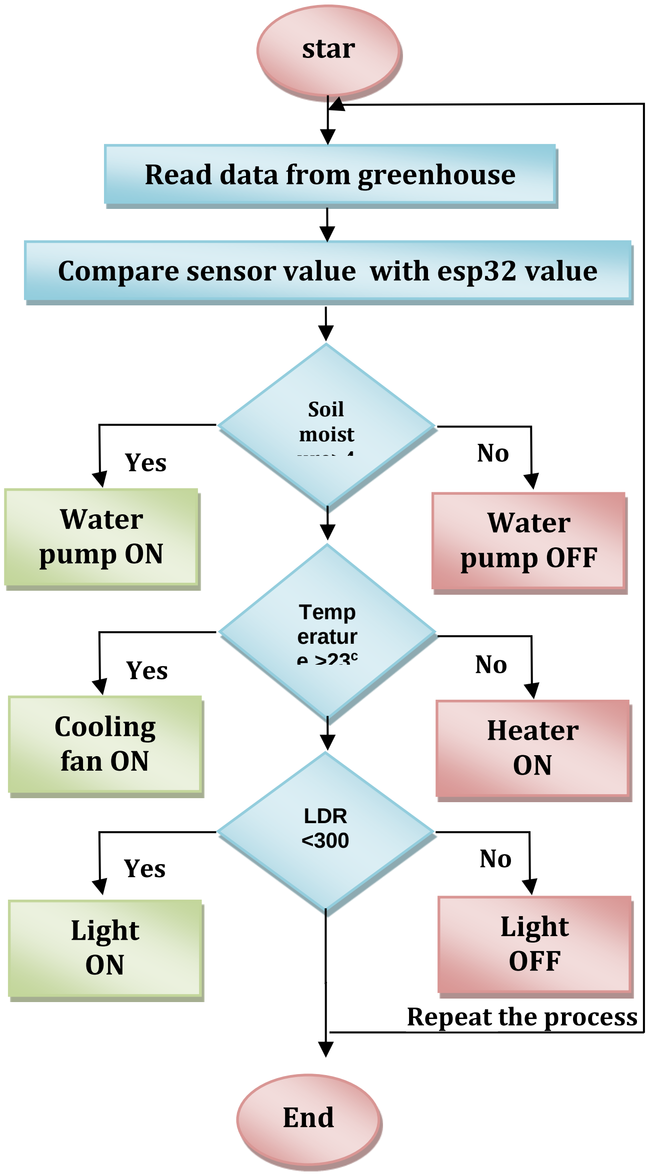

Fig. 2 The flowchart of the proposed system.

Proposed system:

In this section, the architecture of the proposed system is described. Figure 3 shows the internal components of the system, including the connections between the sensors and the

Esp32 on the board to protect the device. Esp32 is integrated into the circuit and connected to a 24-hour power supply. By connecting the ESP32 outputs, the soil moisture sensor is connected through the PCV port to read soil moisture data, and through port 35 the irrigation process can be regulated by turning on or off the irrigation pump. Port 25 of the ESP32 is connected to the DHT22 sensor to turn on or off the heating and cooling systems through port 33 for heating and 32 for fans. An LDR sensor was also connected to control the light intensity, and ports 13 and 12 were used to connect it to the ESP32, and the lighting work is regulated based on the light intensity reading. So it turns on during the night and turns off during the day.

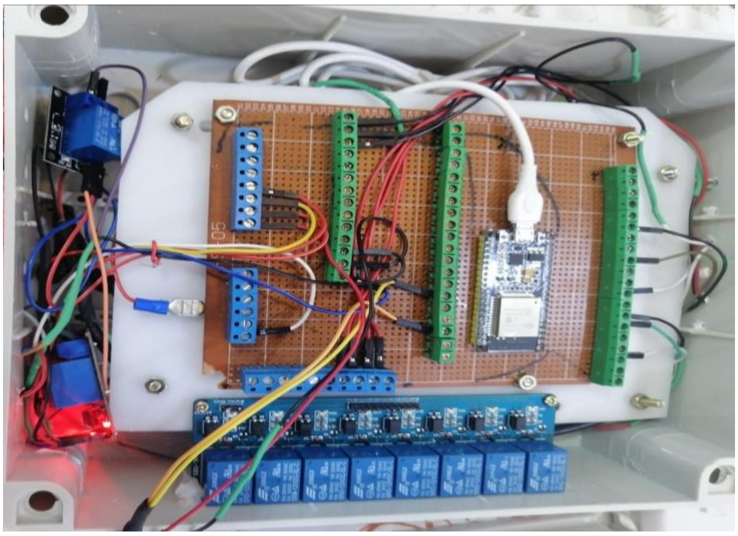

Fig. 3 Internal components of the system.

Figure 4 shows the smart greenhouse. The proposed system has been developed, where watering is done through distillation and heating and cooling is done through heating and cooling devices.

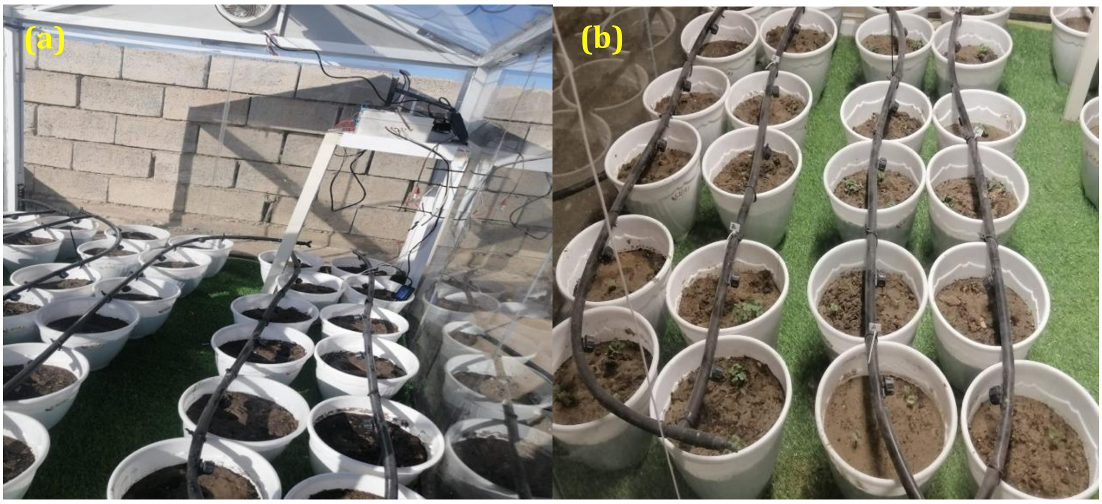

Fig. 4 Deployment of smart greenhouse.

Results and Discussion:

Two greenhouses were created. The first "smart" greenhouse is equipped with a system equipped with sensors that can measure the temperature of the greenhouse, and the level of soil moisture, and control the turning on and off of lights inside the greenhouse. Three varieties of radishes were grown: the first variety is a Dutch variety, which has the symbol A, the second variety is a Syrian variety, which has the symbol B, and the third variety is an Italian variety, which has the symbol C in both. After picking the fruits from both greenhouses, the results were compared. The traditional greenhouse has the symbol (TG), and the smart greenhouse has the symbol (SG). It is necessary to analyze the project results to differentiate between them. For the proposed system, an examination of results for conventional and smart greenhouses was conducted. The SPSS program was used to perform statistical analysis of the results for each of the proposed categories, and each of the attributes and the proportions of each attribute were discussed.

• **Average wet weight of vegetative growth**: Table 1 shows the effect of global warming on the wet weight characteristics of vegetative growth. The statistical data indicates that greenhouse-type SG produced superior results compared to greenhouse-type TG, as evidenced by the average moist weight of vegetative growth reaching 1.2676_{mm}. It was superior to the greenhouse-site interaction TG, and the average wet weight of vegetative growth was lower, reaching 1. 2282_{mm}. It is clear from here that the ideal temperature factor and the amount of light have greatly influenced the vegetative growth of the plant.

Table 1: Average wet weight of vegetative growth.

	A	B	C	Average
SG	1.2087	1.2950	1.1810	1.2676
TG	1.2903	1.5533	0.9590	1.2282
Average	1.2495	1.4242	1.0700	

• **Average root weight**: Table 2 shows the effect of global warming on the greenhouse and the average root weight. SG showed the largest root weight value of 3.6339_g, significantly superior to the TG, which gave the lowest root weight value of 2.1913_g. It is clear from here that the ideal temperature and soil moisture factors have a significant impact on the root weights of the plant, as there was a significant difference in production.

Table 2: Average root weight.

	A	B	C	Average
SG	2.8557	3.1587	4.8873	3.6339
TG	1.8313	1.4473	3.2953	2.1913
Average	2.3435	2.3030	4.0913	

Conclusion

The use of the Internet of Things in the agricultural field has become very important because it will lead to knowledge of plant requirements. Farmers often suffer from fungal diseases, due to a lack of knowledge regarding soil moisture, as well as changes in temperature and the amount of light the plant needs, which may affect crop productivity and quantity. Therefore, this study was conducted that focused on implementing an IoT-based smart system to control temperature, soil humidity, and light amount in greenhouses, where sensor data is obtained - which captures vital parameters such as soil moisture, smart greenhouse temperature, and light amount of light. Light - is acquired and sent to the ESP32 for analysis and comparison with the ideal stored values to decide whether to turn on or off the pumps.

Powered by IoT technology, this proposed system provides accurate measurements and insights. There was a difference in the wet weight of roots: the smart greenhouse showed a good advantage in terms of average root weight and wet weight of vegetative growth. It turns out that the plants were good because they had the ideal conditions. The IoT-based system created the ideal conditions, from providing soil moisture to the ideal temperature to providing the right amount of light. Comparison between the smart greenhouse and the traditional greenhouse: Through the results, it was proven that the smart greenhouse. As it relies on data to make decisions. By experimenting with the proposed model, smart greenhouses can be implemented realistically, leading to resource conservation, rationalization of water consumption, and increased productivity. In the future, we hope to develop the proposed system and add more sensors, such as soil alkalinity or acidity sensors, and a distance sensor to avoid crop damage by animals.

Future Works

We faced several challenges while working on this paper, including soil salts resulting from the alkalinity of the water. In the future, we aim to integrate a water salinity and acidity sensor into the system so that it can detect the percentage of alkalinity and acidity that affect the soil using special sensors. We also hope to use a distance sensor to alert farms when animals approach greenhouses to avoid crop damage. We expect that it will help achieve a balance between the alkalinity and acidity of the soil, and protect plants from animals. Which leads to ideal plant growth and increased productivity.

Reference

1. R. Anderson, P. E. Bayer, and D. Edwards, "Climate change and the need for agricultural adaptation," *Current Opinion in Plant Biology,* vol. 56, pp. 197-202, 2020/08/01/ 2020.

2. G. S. Malhi, M. Kaur, and P. Kaushik, "Impact of climate change on agriculture and its mitigation strategies: A review," *Sustainability,* vol. 13, p. 1318, 2021.

3. S. Habib, S. Alyahya, M. Islam, A. M. Alnajim, A. Alabdulatif, and A. Alabdulatif, "Design and Implementation: An IoT-Framework-Based Automated Wastewater Irrigation System," *Electronics,* vol. 12, p. 28, 2022.

4. K. Ibrahim, A. M. Alnajim, A. Naveed Malik, A. Waseem, S. Alyahya, M. Islam, and S. Khan, "Entice to trap: enhanced protection against a rate-aware intelligent jammer in cognitive radio networks," *Sustainability,* vol. 14, p. 2957, 2022.

5. E. Collado, E. Valdés, A. García, and Y. Sáez, "Design and implementation of a low-cost IoT-based agroclimatic monitoring system for greenhouses," 2021.

6. C. M. Angelopoulos, G. Filios, S. Nikoletseas, and T. P. Raptis, "Keeping data at the edge of smart irrigation networks: A case study in strawberry greenhouses," *Computer Networks,* vol. 167, p. 107039, 2020/02/11/ 2020.

7. M. Dholu and K. Ghodinde, "Internet of things (iot) for precision agriculture application," in *2018 2nd International conference on trends in electronics and informatics (ICOEI)*, 2018, pp. 339-342.

8. J. Wang, M. Chen, J. Zhou, and P. Li, "Data communication mechanism for greenhouse environment monitoring and control: An agent-based IoT system," *Information Processing in Agriculture,* vol. 7, pp. 444-455, 2020/09/01/ 2020.

9. A. Sagheer, M. Mohammed, K. Riad, and M. Alhajhoj, "A cloud-based IoT platform for precision control of soilless greenhouse cultivation," *Sensors,* vol. 21, p. 223, 2020.

10. S. Afzali, S. Mosharafian, M. W. van Iersel, and J. Mohammadpour Velni, "Development and implementation of an IoT-enabled optimal and predictive lighting control strategy in greenhouses," *Plants,* vol. 10, p. 2652, 2021.

11. V. Moysiadis, P. Sarigiannidis, V. Vitsas, and A. Khelifi, "Smart Farming in Europe," *Computer Science Review,* vol. 39, p. 100345, 2021/02/01/ 2021.

12. T. Le Van, P. N. Thi, P. V. Minh, H. Le Cong, and T. N. T. Phuong, "Design and Implementation of a Wireless Sensor Network for Smart Greenhouse Controller," *CommIT (Communication and Information Technology) Journal,* vol. 16, pp. 1-8, 2022.

13. T. C. Pham, H. B. Vo, and N. Q. Tran, "A Design of Greenhouse Monitoring System Based on Low-Cost Mesh Wi-Fi Wireless Sensor Network," in *2021 IEEE International IOT, Electronics and Mechatronics Conference (IEMTRONICS)*, 2021, pp. 1-6.

14. R. K. Goel, C. S. Yadav, S. Vishnoi, and R. Rastogi, "Smart agriculture – Urgent need of the day in developing countries," *Sustainable Computing: Informatics and Systems,* vol. 30, p. 100512, 2021/06/01/ 2021.

15. N. S. Sayem, S. Chowdhury, A. H. M. O. Haque, M. R. Ali, M. S. Alam, S. Ahamed, and C. K. Saha, "IoT-based smart protection system to address agro-farm security challenges in Bangladesh," *Smart Agricultural Technology,* vol. 6, p. 100358, 2023/12/01/ 2023.

16. A. R. Al-Ali, A. Al Nabulsi, S. Mukhopadhyay, M. S. Awal, S. Fernandes, and K. Ailabouni, "IoT-solar energy powered smart farm irrigation system," *Journal of Electronic Science and Technology,* vol. 17, p. 100017, 2019/12/01/ 2019.

17. A. K. Podder, A. A. Bukhari, S. Islam, S. Mia, M. A. Mohammed, N. M. Kumar, K. Cengiz, and K. H. Abdulkareem, "IoT based smart agrotech system for verification of Urban farming parameters," *Microprocessors and Microsystems,* vol. 82, p. 104025, 2021/04/01/ 2021.

18. G. P. Pereira, M. Z. Chaari, and F. Daroge, "IoT-Enabled Smart Drip Irrigation System Using ESP32," *IoT,* vol. 4, pp. 221-243, 2023.

19. J.-M. Rho, J.-Y. Kang, K.-Y. Kim, Y.-J. Park, and K.-S. Kong, "IoT-based Smart Greenhouse System," *Journal of The Korea Society of Computer and Information,* vol. 25, pp. 1-8, 2020.

20. M. R. M. Kassim, "IoT Applications in Smart Agriculture: Issues and Challenges," in *2020 IEEE Conference on Open Systems (ICOS)*, 2020, pp. 19-24.

21. V. K. Quy, N. V. Hau, D. V. Anh, N. M. Quy, N. T. Ban, S. Lanza, G. Randazzo, and A. Muzirafuti, "IoT-enabled smart agriculture: architecture, applications, and challenges," *Applied Sciences,* vol. 12, p. 3396, 2022.

IRAQI Academic Scientific Journals
Samarra Journal of Pure and Applied Science
SJPAS
مجلة سامراء للعلوم الصرفة والتطبيقية
www.sjpas.com
p ISSN: 2663-7405
e ISSN: 2789-6838

إحداث ثورة في الزراعة : الدفيئات الزراعية الذكية التي تعمل على تمكين إنترنت الأشياء لتعزيز الإنتاجية

محمد اسماعيل لفتة[1]*، وسام داود عبدالله[2]
1- قسم علوم الحاسوب، كلية علوم الحاسوب والرياضيات، جامعة تكريت، تكريت ، العراق
2- أكاديمية سيسكو للشبكات، جامعة تكريت، تكريت، العراق

معلومات البحث:
تأريخ الاستلام:
تاريخ التعديل :
تأريخ القبـــول:
تاريخ الـــنشر:
الكلمات المفتاحية:
زراعة إنترنت الأشياء، دفيئة إنترنت الأشياء، المزرعة الذكية لإنترنت الأشياء، دفيئة إنترنت الأشياء إنترنت الأشياء والزراعة.

معلومات المؤلف
الايميل: mohammedi.lafta@st.tu.edu.iq
الموبايل: 07731989725

الخلاصة:
تعمل التطورات الحديثة في الزراعة الذكية، والتي يسرتها إنترنت الأشياء (IoT)، على إحداث ثورة في أساليب الزراعة التقليدية وتحويلها إلى ممارسات فعالة. لقد تم تطبيق تكنولوجيا إنترنت الأشياء على نطاق واسع في إدارة البيوت المحمية، مما يتيح التبادل والنقل السلس لمجموعات البيانات الكبيرة. تدمج الزراعة الذكية تكنولوجيا المعلومات والاتصالات لابتكار أساليب زراعية تقليدية، وفوائد واعدة مثل زيادة الإنتاجية، وخفض التكاليف من خلال تقليل استخدام الموارد، وكفاءة العمالة، وتحسين جودة المنتج. تركز دراستنا على استخدام أجهزة الاستشعار لمراقبة رطوبة التربة ودرجة الحرارة والضوء لتحقيق النمو الأمثل للنبات. أجريت تجربة على زراعة ثلاثة أنواع من نباتات الفجل في دفيئة ذكية باستخدام نظام إنترنت الأشياء والدفيئة التقليدية.. واستغرقت الدراسة حوالي 50 يوما، وتمت مقارنة النتائج مع طرق الزراعة المستخدمة في البيوت البلاستيكية التقليدية. وكانت نسبة الوزن الرطب إلى النمو الخضري رائعة وجيدة. وفي الوقت نفسه، كان أقل في الدفيئات التقليدية. أما بالنسبة للوزن الرطب للجذور، فقد تفوقت الدفيئة الذكية بشكل كبير على الدفيئة التقليدية. وبلغ متوسط الوزن المسجل في المنزل الذكي 4.8873 جرامًا، بينما بلغ في البيت المحمي التقليدي 3.2953 جرامًا. تؤكد هذه النتائج قدرة تكنولوجيا إنترنت الأشياء على تعزيز الإنتاجية الزراعية.