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Smart Agriculture: Cost Optimization Through IoT-Enabled Remote Monitoring, Animal Deterrence and Precision Irrigation

*Rakesh Roshan[1], Subhra Debdas[2], Srikanta Mohapatra[3], Pankaj Kumar[4], Nitai Pal[5], K. Parvin[6]
[1,2,3,6]School of Electrical Engineering, Kalinga Institute of Industrial Technology (KIIT) Deemed to be University, Bhubaneswar751024, Odisha , India
[4]Department of Electrical and Electronics Engineering, Manipal Institute of Technology, Manipal Academy of Higher Education, Manipal, Karnataka 576104, India
[5]Department of Electrical Engineering, Indian Institute of Technology (Indian School of Mines), Dhanbad, Jharkhand 826004, India

ABSTRACT
India's agriculture industry has a difficult time cutting expenses without sacrificing crop production. This research suggests uses of Internet of Things (IoT) devices to propose a framework for cost optimization in agriculture. We introduced a multifaceted strategy that incorporates: Using cameras to monitor fields remotely and monitor crops in real time, Automated systems for discouraging animals with remote-controlled buzzers ,utilizing intelligent sensors and actuators to manage irrigation precisely With our IoT-based system, farmers can keep an eye on their fields from a distance, identify possible problems, and take preventative action to avoid damaging their crops. The technique minimizes agricultural losses from animal encroachment, maximizes crop utilization, and lowers labour expenses. Our pilot study's findings show a notable decrease in the expenses related to: Labour, Use of water and Crop loss. Our research indicates that the suggested IoT-enabled framework can significantly optimize agricultural expenses, improving their profitability and sustainability. By advancing smart agriculture techniques, this research opens a new door for upcoming advancements in resource management and cost optimization in farming.

Keywords-Smart-farming, Animal deterrence, Renewable energy, Precision Irrigation and Cost Optimization

I. INTRODUCTION

It is challenging for the agriculture sector to reduce costs without compromising crop yields and quality[1]. It is anticipated that by 2050, there will be 9.7 billion people on the planet earth, making it imperative to increase agricultural output and efficiency and same time in India agricultural sector faces many challenges that hampers its growth and productivity[2]. Some of the key challenges are: Structural Challenges like limited irrigation facility (only 45% land having irrigation facility forcing farmers

to depend on monsoon, inadequate infrastructure for cold storage chain, low crop yields, conventional farming practices , soil degradation, Environment and climatic challenges and human resource shortages.

These challenges force to policy makers to rethink of transformation of conventional agriculture and look for a new alternatives. The IOT based smart farming can be best solution of all the above cited challenges and same time its open a new door of endless opportunities for the people who involved in agriculture sector[3]. Implementation of IOT in farming have tremendous potential in India because of several advantages over conventional farming like increased crop yields, efficient utilization of water, reduced land requirements, improved crop quality, reduced soil and reduced labor cost. Agriculture methods can be completely changed by utilizing IoT enabled devices like smart irrigation systems, buzzers that can be controlled remotely, and cameras for remote surveillance of crops in the field. Farmers can also make data-driven decisions by using remote monitoring to track crop health, soil conditions, and weather patterns in real-time. Systems of animal deterrence shield crops from harm, lowering losses and raising yields. Water use is optimized via precision irrigation and renewable sources of energy used for irrigation purposes also make it cost and energy efficient alternative of conventional irrigation System.

This study investigates the financial advantages of using IoT technology in agriculture, with an emphasis on cost reduction[4]. This study attempts to provide light on how crop yields, water usage, and labour expenses are affected by IoT devices. The goal is to offer insights into how smart agriculture could revolutionize the sector. The results of this study will support the global

endeavor to guarantee food security and lessen environmental impact by assisting in the development of efficient and sustainable agriculture[5].

The integration of IoT-based technology in farming poses several challenges for Indian farmers. The high upfront costs of IoT devices, sensors, and software can be prohibitive for small-scale farmers[6]. Additionally, these devices require regular maintenance and repair, adding to the overall cost. However, in the long term, IoT-based farming practices can help reduce the overall cost of productivity[7].

Furthermore, the lack of technical literacy among farmers can hinder the effective use of IoT devices. Many farmers may struggle to interpret the data generated by these devices, making informed decision-making challenging. Rural areas often face limited internet connectivity and frequent power outages, which can disrupt the functioning of IoT devices[8].

To address these challenges, it is essential to provide farmers with user-friendly devices, integrate renewable energy sources, and offer proper counseling on the future benefits of IoT-based farming practices[9]. By doing so, we can facilitate the widespread adoption of IoT technology in Indian agriculture, ultimately leading to increased efficiency, productivity, and profitability for farmers."

A. Key challenges in Indian agriculture sector

Indian agriculture sector faces several challenges that affects productivity and sustainability[10]. Some of key challenges are insufficient investment, inadequate infrastructure and poor connectivity, such as underdeveloped transport and storage facilities, that hinder the efficient transportation and timely management of supply chain system [15], [16]. Another issue is the restricted availability of credit and insurance programs, which restrict farmers' ability to purchase high-quality seeds, invest in contemporary technology, and manage crop failure risks. The dispersion of land holdings and the prevalence of small-scale farming present additional difficulties, making mechanization and economies of scale challenging.

Moreover, climate change, water scarcity, and unpredictable weather patterns make Indian agriculture more vulnerable [19]. Additionally, the adoption of novel practices is hampered by farmers' ignorance of and lack of training in improved farming techniques as well as the slow dissemination of research and development findings. To maximize the profitability of farmers, to make farming a lucrative carrier option for rural youth and prevent migration of rural population from rural area to city, these IOT based technologies play a pivotal role.

B. Integration of IOT-based technology in agriculture

With the use of smart farming tools, farmers can accurately monitor and manage their crops and make data-driven decisions about pest control, fertilization, and irrigation [24]. IoT, machine learning, and data analytics are some of the technologies that farmers may use to increase crop health, reduce resource waste, and boost overall agricultural productivity. Using smart farming practices ensures food security for present and future generations by boosting agricultural profitability and competitiveness while simultaneously promoting environmental sustainability. Different kinds of sensors are used to measure the moisture content of soil [22]. Each sensor serves a specific purpose in determining the soil's moisture content. Tensiometers give accurate and reliable measurements of the water potential of soil. However, they are limited to specific soil types and require considerable labor for installation and maintenance. However, it has been observed IOT based smart farming can make a lots of positive difference in agriculture sector of India in terms of increased efficacy and productivity, cost saving, improved decision making, increased crop yield, enhanced farmers live hood, addressing water scarcity and several environmental benefits.

II. RELATED WORK

Several applications of the Internet of Things (IoT) have been developed, such as smart factories [2], smart agriculture [1], smart devices [3], smart homes and cities [4], [5], linked transportation [7], smart health care systems [6], and smart unmanned aircraft [8.]The application of wireless sensor technology such as smart agriculture precision [18], frost event prediction [18], soil farming precision [17], and irrigation sensor networks [15–18] has been introduced by different researchers. Investigations Conducted on wireless sensors Users can use networks to collect sensor data and send it to central servers [21].By analyzing a range of challenges and obstacles in farming, the Internet of Things has contributed to a substantial transformation in the agricultural sector[13]. Asma naseer & Muhammad Shmoon has been given very systematic review of agriculture system, potential challenges and

limitations [11]. With the aim of enabling upcoming scholars eager to contribute to and progress in their pursuit of a deeper understanding of this field of study, this paper offers a thorough overview of the numerous facets of IoT in agriculture

S.P. Singh and Gaurav Dhiman [23] present a novel fitness-function for energy harvesting in Internet of Things-based applications. The findings show that, in the IoT-service network, the suggested strategy performs better in terms of energy harvesting QoS, delay, service cost, and maximum coverage area.

III. PROPOSED SYSTEM

In this research work we have developed an IOT based smart farming model prototype which is enabled with smart irrigation system, animal deterrence system and real time remote surveillance of agricultural field through WiFi enabled camera. The conventional agriculture sector faces three major challenges theft of cash crops, inefficient and weather dependent irrigation system and damage of crops by wild and domesticated animals. This research work is quite helpful in addressing these challenges effectively.

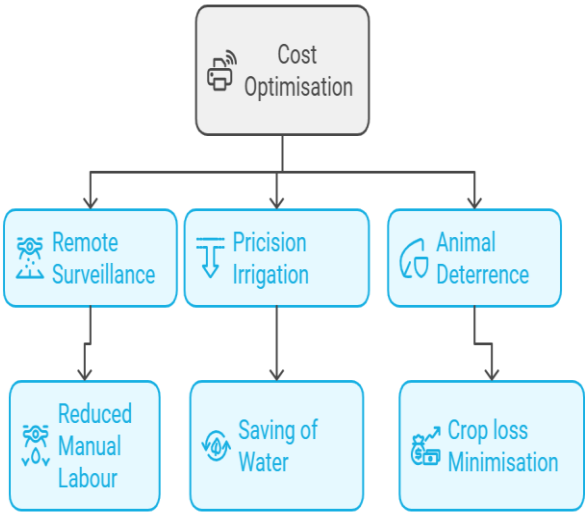

Fig.1-Flow chart for cost optimization

A. *Remote Field Monitoring Using Camera*

The remote surveillance of the field is achieved by ESP32-CAM. It is a, low-cost, versatile and miniature camera module controlled by the ESP-32 micro controller and supplied through the USB port or a battery.

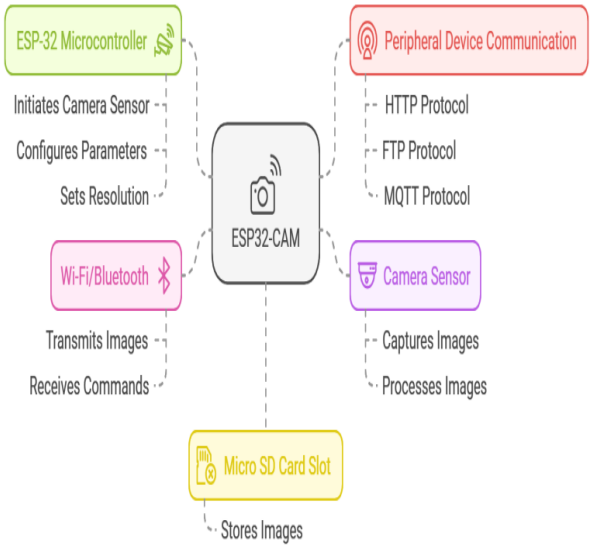

Fig.2- Flow Chart of Smart Surveillance system

The important component of ESP-32 Cam includes ESP-32 micro controller, USB port (for programming and power), Flash LED (Optional), Micro SD card slot, and Flash Lens(optional)**.** The micro controller initiates the camera sensor, configures other parameters and sets the resolution. The camera captures images and sends it to the ESP32 micro-controller. The ESP32 can process, resize and format the images and The Images can be stored in the micro-SD card, or it can be transmitted wirelessly through Wi-Fi or Bluetooth. It can also communicate with other peripheral devices or servers using different protocols like HTTP, FTP and MQTT.

B. *Smart irrigation system*

This system Utilizing cutting-edge IoT technology, the solar-powered smart irrigation system maximizes water use and supports sustainable agriculture. This system, which is outfitted with solar panels, soil moisture sensors, and Internet of Things-based remote control, automates irrigation scheduling based on real-time data analysis. Soil Moisture sensor transmit data to the micro controller and it initiates the action of motor as per pre-decided value of moisture for particular field or crop. The level of moisture is decided considering several factors like type of soil, type of crops and weather conditions. The irrigation controller then receives commands and modifies the water valves to provide the crop with precisely the right amount of water. Farmers may check water usage, get warnings for abnormalities,

and make data-driven decisions with the help of remote monitoring and control capabilities.

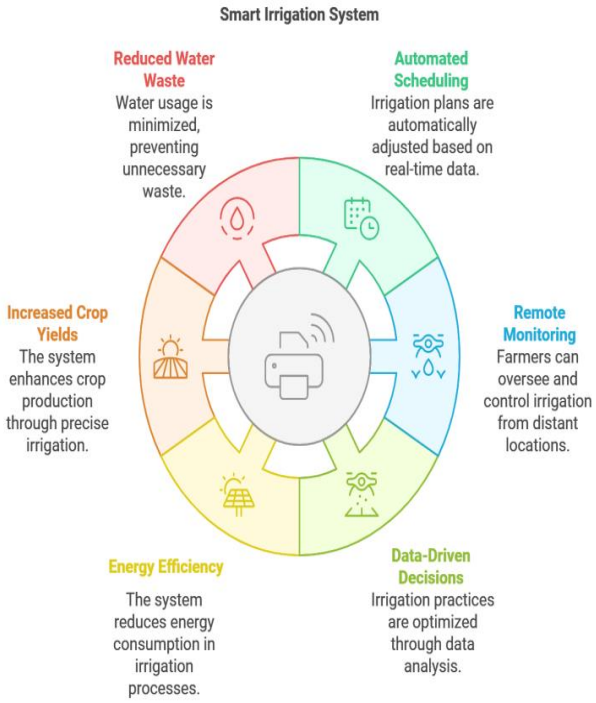

Fig.3 -Flow chart for smart irrigation system

This system is an environmentally friendly and financially feasible option for contemporary agriculture since it minimizes energy usage, boosts crop yields, and eliminates water waste. Smart irrigation systems powered by solar energy have many benefits, such as lower energy expenses, more efficiency, and environmental advantages. By allowing smart irrigation systems to function autonomously, solar power lessens dependency on the electrical grid and lowers operating costs. Solar energy also makes it possible for automated irrigation scheduling, real-time monitoring and control, and water optimisation, all of which increase crop yields and decrease water waste. In addition, solar energy is a stable, long-lasting power source with low maintenance costs.It is also clean and sustainable, lowering greenhouse gas emissions and preventing climate change.

C. Buzzer based Animal deterrence system

A buzzer-based animal deterrence system is an efficient way to prevent crops from wildlife and domesticated animals. This creative system detects incoming animals using IR motion sensors, then sounds like a loud, high-frequency buzzer to frighten and discourage them. These sensors and buzzers, which are positioned thoughtfully across the farm's perimeter, combine to form a virtual fence that protects crops damage from birds and animals. This system is wireless, solar-powered, energy-efficient, and simple to set up. Farmers can adapt the device to animal dangers by varying the buzzer frequencies and sensitivity. Farmers may take immediate action against enduring risks and found a real-time notifications sent to their smart devices. This information may quite be helpful to protect the farm land from any major and minor damage by animal and birds. Farm production and sustainability are improved by this environmentally friendly method, which minimizes crop damage and chemical repellents.

D. *Integration of renewable sources*

Sustainable agriculture depends on the incorporation of renewable energy sources, which allow farmers to minimize their environmental effect and lessen their dependency on non-renewable energy. IOT-based agricultural solutions rely heavily on solar energy. According to this study, solar-powered Internet of Things gadgets like buzzers, cameras, and intelligent irrigation systems maximize agricultural productivity while significantly lowering energy expenses. Remote monitoring is made possible by solar-powered cameras, and crop damage is reduced with solar-powered buzzers that discourage animals. Additionally, sophisticated irrigation systems that run on solar power maximize water use and cut wastage in significant amount. Farmers can increase agricultural yields, lower energy costs, and help to create a more sustainable future by utilizing renewable energy. This study shows how renewable energy can revolutionize agriculture and guarantee a robust and ecologically responsible food supply chain.

IV RESULT & ANALYSIS

In the proposed IoT-based agricultural monitoring system the system consist of a camera for remote monitoring, 4 smart buzzers for animal deterrence, a moisture sensor for smart irrigation, IOT gateway for data transmission and solar panel for power supply. The Fig.4 shows real time status of agricultural field from control room

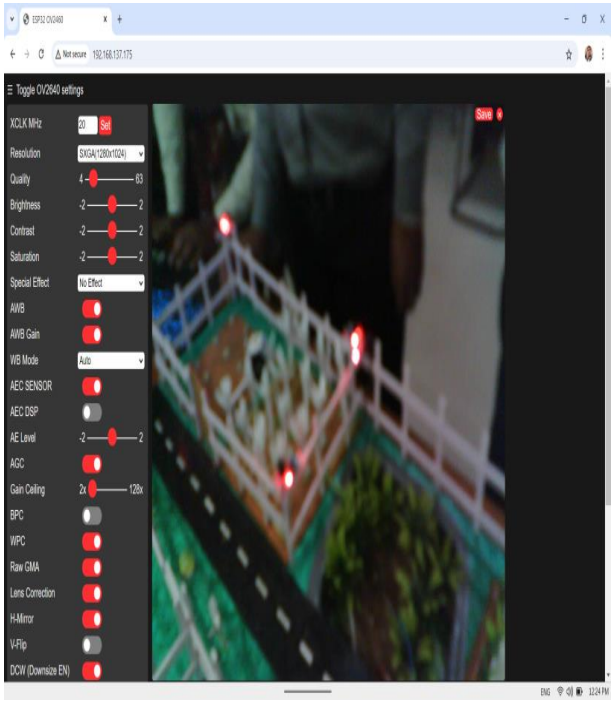

Fig.4 -Remote Surveillance of Field from control room

The outcomes show how well the suggested IoT-based agricultural monitoring system optimizes agricultural expenses. The system resulted in significant reduction in labour cost by implementing remote surveillance, optimization of water consumption through smart irrigation, increase in crop yield due to optimum utilization of water, reduction in crop damage by animal deterrence system and less dependency on grid power by utilizing renewable sources of energy.

Fig.4 shows a level of moisture at different conditions and when moisture is reached predefined threshold value motor is automatically turned off or when moisture level goes below the threshold value motor is automatically turned on. The level of moisture can be easily assessed by-any android based devices or personal computers. The integration of irrigation system with solar energy is possibly the best application of solar energy because it overcomes the problem of reliability of solar energy, in stormy weather where solar radiation is very less in such condition there is no requirement of irrigation but in hot weather there is abundant solar input is available the agricultural field can be easily irrigated by solar power.

Integration of renewable energy sources with irrigation systems not only increases overall reliability of system but also provides cost effective solution of irrigation.

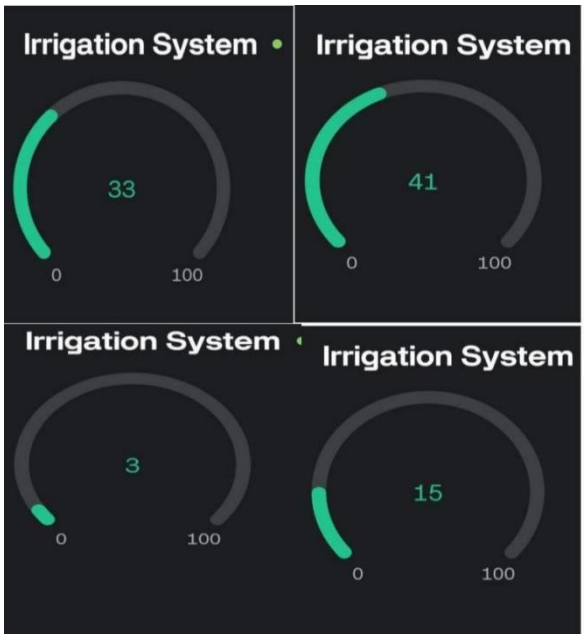

Fig.5 -Moisture level at different conditions for soil

V.CONCLUSION

This study used cutting-edge tools including smart irrigation systems, buzzers, and cameras to provide a comprehensive Internet of Things-based approach to agricultural cost optimization. By enabling farmers to remotely monitor and manage agricultural areas, the proposed architecture reduces manpower costs and boosts crop yields. With the scalable and adaptable solution of the proposed system, farmers may make data-driven decisions and respond swiftly to changing climatic conditions. With an estimated significant amount of cost reduction and a potential rise in income of the farmers, this IoT-based approach has the potential to completely transform the agriculture sector.

REFERENCES

[1] N. Ahmed, D. De, and I. Hussain, ‘‘Internet of Things (IoT) for smart precision agriculture and farming in rural areas,’’ IEEE Internet Things J., vol. 5, no. 6, pp. 4890–4899, Dec. 2018.

[2] A. H. Bagdadee, L. Zhang, and M. S. H. Remus, ‘‘A brief review of the iot-based energy management system in the smart industry,’’ in *Artificial Intelligence and Evolutionary Computations in Engineering Systems*. Singapore: Springer, 2020, pp. 443–459.

[3] H. Nagamma, ‘‘IoT based smart security gadget for women’s safety,’’ in *Proc. 1st Int. Conf. Adv. Inf. Technol. (ICAIT)*, Jul. 2019, pp. 348–352.
[4] R. Kaur, P. Vats, M. Mandot, S. S. Biswas, and R. Garg, ‘‘Literature survey for IoT-based smart home automation: A comparative analysis,’’ in *Proc. 9th Int. Conf. Rel., INFOCOM Technol. Optim. (Trends Future Directions) (ICRITO)*, Sep. 2021, pp. 1–6.
[5] Z. Chen, C. B. Sivaparthipan, and B. Muthu, ‘‘IoT based smart and intelligent smart city energy optimization,’’ *Sustain. Energy Technol. Assessments*, vol. 49, Feb. 2022, Art. no. 101724.
[6] M. N. Mohammed, S. F. Desyansah, S. Al-Zubaidi, and E. Yusuf,‘An Internet of Things-based smart homes and healthcare monitoring and management system: Review,’’ *J. Phys., Conf. Ser.*, vol. 1450, no. 1, Feb. 2020, Art. no. 012079.
[7] E. F. I. Raj and M. Appadurai, ‘‘Internet of Things-based smart transportation system for smart cities,’’ in *Advanced Technologies and Societal Change*. Cham, Switzerland: Springer, 2022, pp. 39–50.D. A. Sungheetha and D. R. Sharma R, ‘‘Real time monitor- ing and fire detection using Internet of Things and cloud based drones,’’ *J. Soft Comput. Paradigm*, vol. 2, no. 3, pp. 168–174,Jul. 2020.
[8] D. A. Sungheetha and D. R. Sharma R, ‘‘Real time monitor- ing and fire detection using Internet of Things and cloud based drones,’’ *J. Soft Comput. Paradigm*, vol. 2, no. 3, pp. 168–174,Jul. 2020.
[9] J. Xu, B. Gu, and G. Tian, ‘‘Review of agricultural IoT technology,’’ *Artif.Intell. Agricult.*, vol. 6, pp. 10–22, Jan. 2022.
[10] (2022). *World Economic Situation and Prospects As of Mid- 2022*. Accessed: Jun. 14, 2023. [Online]. Available: www.un.org/ development/desa/dpad/publication/world- economic-situation-and-prospects-as-of-mid-2022/
[11] (Sep. 2019). *How to Feed the World in 2050 By Fao*. Accessed: Jun. 14, 2023. [Online]. Available: https://www. fao.org/wsfs/forum2050/wsfs-forum/en/
[12] A. D. Tripathi, R. Mishra, K. K. Maurya, R. B. Singh, and D. W. Wilson, ‘‘Estimates for world population and global food availability for global health,’’ in *The Role of Functional Food Security in Global Health*. Amsterdam, The Netherlands: Elsevier, 2019,pp. 3–24.
[13] M. S. Farooq, S. Riaz, A. Abid, K. Abid, and M. A. Naeem, ‘‘A survey on the role of IoT in agriculture for the implementation of smart farming,’’ *IEEE Access*, vol. 7, pp. 156237–156271, 2019.
[14] M. Raj, S. Gupta, V. Chamola, A. Elhence, T. Garg, M. Atiquzzaman, andD. Niyato, ‘‘A survey on the role of Internet of Things for adopting and promoting agriculture 4.0,’’ *J. Netw. Comput. Appl.*, vol. 187, Aug. 2021, Art. no. 103107.
[15] (Sep. 2019). *Global Smart Agriculture Marke*. Accessed: Jun, 14, 2023. [Online]. Available: https://www.zionmarketresearch.com/report/smart-agriculture-market
[16] L. García, L. Parra, J. M. Jimenez, J. Lloret, and P. Lorenz, ‘‘IoT-based smart irrigation systems: An overview on the recent trends on sensors and IoT systems for irrigation in precision agriculture,’’ *Sensors*, vol.no 4, p. 1042, Feb. 2020.
[17] W.-L. Chen, Y.-B. Lin, Y.-W. Lin, R. Chen, J.-K. Liao, F.-L. Ng, Y.-Y. Chan, Y.-C. Liu, C.-C. Wang, C.-H. Chiu, and T.-H. Yen, ‘‘AgriTalk: IoT for precision soil farming of turmeric cultivation,’’ *IEEE Internet Things J.*, vol. 6, no. 3, pp. 5209–5223, Jun. 2019.
[18] J. Mendez and D. Dasig, ‘‘Frost prediction in highland crops management using IoT-enabled system and multiple regression,’’ in *Internet of Things and Analytics for Agriculture*, vol. 2. Cham, Switzerland: Springer, 2020, pp. 261–288.
[19] Sharma, H. and Kumar, P., 2024. Solar Photovoltaic Powered Automatic Irrigation System for the Agriculture Sector. In *The Internet of Energy* (pp. 295-311). Apple Academic Press.
[20] .O. Friha, M. A. Ferrag, L. Shu, L. Maglaras, and X. Wang, ‘‘Internet of Things for the future of smart agriculture: A comprehensive survey of emerging technologies,’’ *IEEE/CAA J. Autom. Sinica*, vol. 8, no. 4, pp. 718–752, Apr. 2021.
[21] C. Maraveas and T. Bartzanas, ‘‘Application of Internet of Things (IoT) for optimized greenhouse environments,’’ *AgriEngineering*, vol. 3, no. 4,pp. 954–970, Nov. 2021.
[22] B S Sagar, Bansilal Bairwa, Sanjana K Hulsure, Sushmita S Walikhindi, M Supritha, Shreya Shankar Patgar. "Optimizing Pesticide Spraying Efficiency through Disease Leaf Detection Mechanism", 2023 IEEE 2nd International Conference on Industrial Electronics: Developments & Applications (ICIDeA), 2023
[23] S. Ratnaparkhi, S. Khan, C. Arya, S. Khapre, P. Singh, M. Diwakar, andA. Shankar, ‘‘Smart agriculture sensors in IoT: A review,’’ *Mater. Today, Proc.*, vol. 2, pp. 1–12, 2020, doi: 10.1016/j.matpr.2020.11.138.
[24] R. Akhter and S. A. Sofi, ‘‘Precision agriculture using IoT data analytics and machine learning,’’ *J. King Saud Univ. - Comput. Inf. Sci.*, vol. 34, no. 8, pp. 5602–5618, Sep. 2022.
[25] W. Tao, L. Zhao, G. Wang, and R. Liang, ‘‘Review of the Internet of Things communication technologies in smart agriculture and challenges,’’ *Comput. Electron. Agricult.*, vol. 189, Oct. 2021, Art. no. 106352.
[26] Kanwalpreet Kour, Malvinder Singh Bali, Deepali Gupta, Kamali Gupta. "IoT-Based Model for Saffron Cultivation and Growth Parameter Analysis and Monitoring by Using AquaCrop", 2023 IEEE 2nd International Conference on Industrial Electronics: Developments & Applications (ICIDeA), 2023
[27] Karisma Mohapatra, Debabrata Singh, Anil Kumar Biswal. "IoAT-based Smart Farming Technology", 2023 IEEE 2nd International Conference on Industrial Electronics: Developments & Applications (ICIDeA), 2023