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# IOT Equipped Sustainable Farming: A Review of Applications and Challenges

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**Abstract:- The rapid population growth is a compelling surge need for food which results in a shift towards smart farming practices. Moreover, agriculture is facing with several issues such as shrinking natural resources, limitation of cultivable land, unpredictable weather conditions, increase in crop diseases. Consequently, the Internet of Things (IoT) and artificial intelligence (AI) are being associated with agriculture to reduce operational efforts while increasing productivity. Radio frequency identification, wireless sensor networks (WSN), cloud computing, end-user apps, and middleware systems are a few of the technologies that are integrated into the Internet of Things. In this paper, numerous applications and challenges of IoT have been discussed. Further, an ecosystem for agriculture is presented which discusses that how IoT is solving different challenges faced by the farmers.**

***Keywords:-*** *Agriculture, Internet of Things, Ecosystem.*

## I. INTRODUCTION

Globally, agriculture is a main source of food production. In this way, agriculture is one of the significant industries that has a major contribution to the economy and produced huge employment sources [1]. A few years ago, everything in agriculture was done manually including cattle monitoring, soil nutrition measuring, water supply to crops, crop health monitoring, etc. In the last two decades, a handful of innovations have been developed to improve agricultural production while having limited resources and efforts. Despite that, the rate of high population was never allowed to match the demand and supply constantly. As per predicted information, the population of the world is expected to touch 9.8 billion by 2050, which will result in approximately 25% more demand of food from the current situation [2]. Despite the insight commonality may have concerning agrarian practice, fact is that nowadays the agriculture science is delivering more accurate, precise and vigorous data than ever. It could be possible with the use of technology in several applications of agriculture [3]. Currently, Internet of Things is also being used for smart irrigation, crop monitoring systems, weather forecasting, automated farm equipment, livestock tracking, supply chain optimization and several other tasks used for food production. The IOT is enabling agriculture to become data-based, significantly improving to more timely and cost-effective production along with farm management and minimal environmental impact [4]. The first and foremost purpose of IoT is to interconnect computing devices, machines (both digital and mechanical machines), objects, and users using the web interface and mobile applications [5]. Secondly, sensors and actuators typically interact with one another in an IoT network to accomplish tasks like intelligent positioning, perception, tracking, and monitoring. By transforming traditional control into an intelligent control through dynamic remote control in an IoT network, productivity and efficiency are increased [6]. The biggest problem arises from security risks and attacks on devices, networks, and data because every device in an IoT network needs to communicate with every other device [7,8]. The involvement of IOT results in the integration of multiple sensors, cloud computing, machine learning, big data and IOT technologies required for farming etc. The idea behind IoT-based agriculture is to boost food product quality and yield by incorporating IoT technology into agricultural (farming) processes. These technologies include IoT sensors, wireless communication, cloud computing, machine learning, and big data [9]. Furthermore, farming based on IOT is highly beneficial and is helping in food scarcity problem which is increasing day by day given the concerning rate of population growth. However, the installation of a variety of networked devices, may provide certain difficulties [10]. Therefore, this research work presents an overview of the uses of IoT in agriculture in 5 cases (i) data collection using IoT sensors in agriculture (ii) risk mitigation using collected data which can help farmers to make projections about their crop productions. (iii) cost management would mean the farmers have precise knowledge of their resource consumption. (iv) Automation: automated devices introduced in the production cycle will increase efficiency and reduce operational costs (v) Enhanced product quality with quality control [10]. In another research, it is anticipated that developing nations will account for nearly all of the aforementioned population growth [11]. On the other hand, the urbanization trend is continuing at an accelerated pace and it is predicted that about 70% of the world's population will be urbanized by 2050 (currently 49%) [12]. Furthermore, income levels are expected to be multifold in the near future while driving the food demand. By 2050, food production should also have doubled in order to feed this larger, wealthier, and urban population [13, 14]. Specifically, to meet the need of 470 million tonnes, the existing 2.1 billion tonnes of annual cereal production should reach almost 3 billion tonnes, and the annual meat production should rise by more than 200 million tonnes [15, 16]. The crops playing important economic roles in several countries have become challenging to produce at an industrial scale. Recently, the bioenergy based on the food- crops market is increasing, also. Even before a decade, only the production of ethanol utilized 110 million

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tons of coarse grains (approximately 10% of the world's production) [16-20]. In the above-mentioned series of research work, it has been described that IOT technology can be used to enhance agriculture products. In this paper, looking at the challenges of the agriculture field, an eco-system is presented which consists of the advanced IOT technologies at different stages of agriculture. The presented ecosystem can assist the farmers in growing crops effectively along with a multifold increase in their income. In this research work, Section 2 presents an eco-system for IOT based agriculture. Section 3 discusses the various applications. Various challenges of agriculture have been presented in Section 4 while Section 5 concludes the paper.

## II. ECO-SYSTEM FOR AGRICULTURE

The presented eco-system model comprises the sensor platform and associated sensing technologies. The sensors incorporated in the circuit capture analog parameters and digitize the measurement of physical objects. It includes the parameters of their environments related to animals, plants, soil, and water. Applications related to agriculture require the identification of specific measurement parameters and corresponding sensors. The sensor computing platforms are also determined by the general attributes of the Internet of Things ecosystem, such as hardware, operating systems, and network stack protocols. The type of plant, crop, or animal under consideration (such as wheat, rice, oats, palm, or olive tree) and the farm environment in which the species is being studied (such as large fields, small/medium-sized farms, indoor horticulture, greenhouses, beehives, fishery and aquaculture, and leisure agriculture) influence the identification of measurement parameter requirements. Additionally, IOT can be used for specialised purposes including pest control, early warning systems, food tracking, traceability, and animal food supply chain monitoring. Figure 1 illustrates the eco-system. Sensor device platforms, as shown in Fig. 1, consist of both hardware and software components. The software's functional component is in charge of overseeing the hardware platform and offering a range of services to applications running at the top layer. Operating systems (OS) are essential to the sensor device platform's operation. Farming is made smarter, more profitable, and time-efficient by incorporating IOT into every stage of the process.

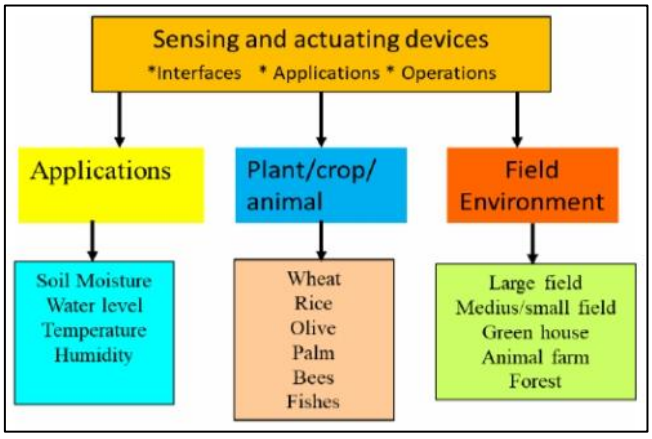

Fig 1 Eco-system for IOT based Agriculture

## III. VARIOUS APPLICATIONS

Numerous applications of agriculture are enhanced by applying IOT. A few are included as follows. Smart Irrigation Systems Irrigation systems can use IOT-enabled sensors to monitor soil moisture levels, weather conditions, and crop requirements, simultaneously and thus it is termed as a smart irrigation system. IOT allows for precise and automated irrigation, conserving water with optimized crop yield. Moreover, to determine the irrigation needs of the landscape, IOT uses weather data or soil moisture data. Smart irrigation technology maintains the quality of agro products by maximizing irrigation efficiency and minimizing water waste [?].

Crop Health Monitoring IoT devices such as drones and sensors are used to collect real-time data on crop health, detecting early signs of diseases, pests, or nutrient deficiencies. This enables timely intervention and reduces crop losses. Further, it also includes monitoring of numerous parameters such as temperature, humidity, pest intrusion, seed and soil quality, etc. In this way, it enables better decision-making in terms of crop health and quality.

Weather Forecast Integration Integration of IoT with weather forecasting systems, provides accurate and localized weather predictions to the farmers. This information aids in making informed decisions regarding planting, harvesting, and crop management.

Automated Farm Equipment Several farm equipment such as tractors and other farm machinery enabled with IoT devices for real-time tracking, maintenance monitoring, and performance optimization. This increases operational efficiency and reduces downtime.

Livestock Tracking IoT-enabled tracking devices are implemented for agriculture livestock to monitor their health, location, and behaviour. This data assists farmers in managing grazing patterns, preventing theft, and ensuring animal welfare.

Supply Chain Optimization As another application, IOT is being used for monitoring and optimizing the entire agricultural supply chain, from field to market. This includes tracking the transportation and storage conditions of crops to maintain quality and reduce waste.

## IV. CHALLENGES IN FARMING

Modern IoT solutions and technologies are being applied to agricultural processes these days in order to reduce waste, increase production, and boost operational effectiveness. As an illustration, consider the use of subter- ranean remote sensors to monitor blueberry irrigation in Chile, which has resulted in a 70% reduction in water waste, and the application of data analysis in Slovenia and India to anticipate and prevent crop diseases [16]. However, some challenges are there which are faced by the farmers. One of the biggest issues that farmers face is the lack of infrastructure. These include climate change, crop disease, soil degradation,

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underground water, infertility of soil, pollution, small landholding etc. Climate change is one of the effects that affect farmers' ability to grow food. Increasingly unpredictable weather and more extreme events - like floods and droughts - change growing seasons, limit the availability of water, allow weeds, pests, and fungi to thrive, and can reduce crop productivity [22]. Additionally, demand for more food of higher quality is rising day by day which is to be fulfilled by the farmers. In recent years, pollution has impacted the fertility of the soil which also results in the degradation of crop production. Society has rising expectations of farmers to reduce their impact on the environment, increase the nutritional content of crops, and further minimize chemical residues in crops and the environment [22]. Additionally, the quantity of land that may be used for agriculture is decreasing due to soil erosion, and crop pollination is being impacted by a decline in biodiversity. At the same time, farmers are under pressure to conserve water and use fewer agricultural inputs. In addition, road conditions, transportation facilities, and others are also a few challenges in this field. Poor transport services on which Farmers have to depend, increase their costs significantly. Farmers must adopt climate-smart methods in order to reduce the greenhouse gas emissions caused by agriculture while they adjust to these changes; this will require many to go on a new learning journey.

## V. CONCLUSION

This article has presented a literature review that presents a discussion on selective high-quality research articles published in the domain of IoT-based agriculture. Thereafter, a eco-system is also presented for IOT-based agriculture to enhance the production and increase the income of farmers. Moreover, several IoT agriculture applications, sensors/devices, and challenges in agriculture have been presented. The most intriguing aspect is that governments from many nations are funding this field of study, and many of them have IoT agriculture regulations. Other than this, a framework has been used to contextualise all of the key elements of IoT-based agriculture.

## REFERENCES


[1]. Vangala, A., Das, A.K., Chamola, V., Korotaev, V. and Rodrigues, J.J., 2023. Security in IoT-enabled smart agriculture: Architecture, security solutions and challenges. Cluster Computing, 26(2), pp.879-902.

[2]. Ayaz, M., Ammad-Uddin, M., Sharif, Z., Mansour, A. and Aggoune, E.H.M., 2019. Internet-of-Things (IoT)-based smart agriculture: Toward making the fields talk. IEEE access, 7, pp.129551-129583.

[3]. Yang, J., Sharma, A., & Kumar, R. (2021). IoT-based framework for smart agriculture. International Journal of Agricultural and Environmental Information Systems (IJAEIS), 12(2), 1-14.

[4]. Villa-Henriksen, A., Edwards, G. T., Pesonen, L. A., Green, O., & Sørensen, C. A. G. (2020). Internet of Things in arable farming: Implementation, applications, challenges and potential. Biosystems engineering, 191, 60-84.

[5]. Oche, O. E., Nasir, S. M., & Muhammed, A. H. (2020). Internet of Things-based agriculture: a review of security threats and countermeasures. Int. J. Sci. Res. Publ, 10, 738.

[6]. G. Villarrubia, J. F. De Paz, D. H. De, La Iglesia and J. Bajo, Combining multi-agent systems and wireless sensor networks for monitoring crop irrigation. Sensors. 2017, Vol. 17, No. 8, pp. 1775.

[7]. J. M. Talavera, L. E. Tobón, J. A. Gómez, M. A. Culman, J. M. Aranda, D. T. Parra, L. A. Quiroz, A. Hoyos and L. E. Garreta, Review of IoT applications in agro-industrial and environmental fields. Comput. Electron. Agriculture, 2017, No. 142, pp. 283-297.

[8]. C. Brewster, I. Roussaki, N. Kalatzis, K. Doolin, and K. Ellis, IoT in agriculture: Designing a Europe-wide large-scale pilot. IEEE Communication. Magazine, 2017, Vol. 55, No. 9, pp. 26-33.

[9]. L. Li, Application of the Internet of Thing in green agricultural products supply chain management. In Proc. IEEE Int. Conf. Intell. Comput. Technol. Autom. (ICICTA), Shenzhen, China, 2011, No. 1, pp. 1022-1025.

[10]. Iot in Agriculture: 5 best practices use cases for smart farming . Accessed: Feb. 15 2024. [Online]. Available: https://research.aimultiple.com/iot-agriculture/.

[11]. Accessed: Feb. 13, 2024. [Online]. https://ourworldindata.org/world-population-growth

[12]. Accessed: Feb 20 2024. [Online]. https://www.un.org/development/desa/en/news/population/2018-revision-of-world-urbanization-prospects.html

[13]. Accessed: Jan. 20, 2024. [Online]. https://www.un.org/press/en/2009/gaef3242.doc.htm.

[14]. Zhang, X., Davidson, E. A, "Improving Nitrogen and Water Management in Crop Production on a National Scale", American Geophysical Union, December, 2018

[15]. How to Feed the World in 2050 by FAO, available at www.fao.org/wsfs/forum2050/wsfs-forum/en/

[16]. Abhishek D. et al., "Estimates for World Population and Global Food Availability for Global Health", Book chapter, The Role of Functional Food Security in Global Health, 2019, Pages 3-24.

[17]. Elder M., Hayashi S., "A Regional Perspective on Biofuels in Asia", in Biofuels and Sustainability, Science for Sustainable Societies, Springer, 2018

[18]. Zhang, L., Dabipi, I. K. and Brown, W. L, "Internet of Things Applications for Agriculture". In, Internet of Things A to Z: Technologies and Applications, Q. Hassan (Ed.), 2018

[19]. S. Navulur, A.S.C.S. Sastry, M. N. Giri Prasad, "Agricultural Management through Wireless Sensors and Internet of Things" International Journal of Electrical and Computer Engineering (IJECE), 2017; 7(6) :3492- 3499.

[20]. E. Sisinni, A. Saifullah, S. Han, U. Jennehag and M. Gidlund, "Industrial Internet of Things: Challenges, Opportunities, and Directions," in IEEE Transactions on Industrial Informatics, vol. 14, no. 11, pp. 4724-4734, Nov. 2018.

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[21]. Akhter, R., & Sofi, S. A. (2022). Precision agriculture using IoT data analytics and machine learning. Journal of King Saud University-Computer and Information Sciences, 34(8), 5602-5618.
[22]. Accessed: Feb. 16, 2024. [Online]. https://www.syngenta.com/en/innovation-agriculture/challenges-modern-agriculture.