ISSN No:-2456-2165

Agricultural Advancements through IoT and Machine Learning

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Abstract:- A Smart Agriculture system employs sensor technology and data analytics to enhance agricultural practices, leading to increased crop yields and reduced waste. Various sensors such as soil moisture, temperature, humidity, and light intensity detectors are utilized to monitor and analyze data for optimal crop growth and improved farming techniques including irrigation, fertilization, and pesticide management. These systems find application in diverse agricultural environments like open fields, orchards, and greenhouses, providing valuable insights for informed decision-making. Some systems integrate sensor-based technologies for enhanced efficiency, offering cost-effective and easily implementable solutions. This paper aims to compare and comprehend existing smart farming models, presenting a novel approach to integrating Machine Learning and Internet of Things (IoT) in real-time agricultural settings.

Keywords:- *Precision Agriculture, Smart Irrigation, Crop Management, Water Management, Digital Agriculture, Smart Agriculture, Machine Learning.*

I. INTRODUCTION

Agriculture is an important part of the human being's life since it provides survival to billions of people worldwide, feeds and provides them with fiber, food, and other requirements. However, but the modern farming and traditional agricultural p practices are facing lots of issues which results in climatic changes, resources depletion, and population increment. To solve these issues facing the agriculture sector, the concept of smart agriculture system has raised as one of the good options for increasing yield, reducing environmental pollution, and improving the sustainability of agricultural practices [1].

Smart agriculture system refers to the implementation of modern, advanced technologies and data analytics into agricultural processes to increase production and growth. This involves the deployment of sensors, drones, and additional technologies to monitor crucial soil parameters like moisture levels, assess weather conditions such as temperature, and make informed decisions regarding irrigation, fertilization, and pesticide management for optimal crop cultivation. Smart agriculture systems also have the possibility to appreciate the clearness of the supply chain from farm to consumer by providing real-time data on product quality and safety [2].

The implementation of smart agriculture system has the possibility to revolutionize the agriculture sector, with benefits for both farmers and customers [3]. However, other difficulties remain to be faced by farmers, including the high cost of setting up new technology, the need for sufficient groundwork and connectivity, and the probability of unexpected consequences like concerns and issues about data privacy [4].

➢ *Problem Statement*

Traditional farming practices maximum times depend on experience and intuition rather than data-driven decision-making. Moreover, farmers in rural locations and village areas may have limited knowledge to real-time environmental and soil data, which may lead to less efficiency and lower yield. While IoT-based smart agriculture systems are becoming more popular now-a-days, they require significant investment and groundwork, which may not be practical for all farmers. As a result, there is a need for a lower-cost smart agriculture system which provides the farmers with real-time data and environmental conditions and soil moisture levels without depending on IOT is required..[2]

The main goal of this research is to develop a smart agriculture system that includes less-cost sensors and advanced communication technology to provide farmers with real-time data on environmental conditions and soil moisture levels. The system will collect and transmit data to a main database, in which farmers will be able to access with the help of a mobile or web-based applications. The device will give farmers information about a variety of environmental factors such as temperature of the atmosphere, humidity in the soil, moisture in the soil, light intensity at the crop, etc. Furthermore, the system will provide soil moisture data, which is very important for enhancing agriculture practices and avoiding over-watering to the crop, which can lead to reducing agricultural yields and water waste.

This study will estimate the performance of the smart agriculture system in terms of data accuracy, reliability, and usability of the system. It will also check out the system's influence on crop production, water usage, and overall profitability due to the system. This study has the intention to create an adaptable and accessible solution for farmers in rural areas to improve their agricultural practices and increase productivity by building a lower-cost smart agriculture system using IoT.

➢ *Objective*

Agriculture is an important sector for worldwide food production and economic development. Without agriculture it is difficult for human survival. The smart agricultural system will be able to provide the things such as crop management, provide the farmers with best solutions implement traditional and modern farming methods increase the profitability of the crop and farmers. with the help of the sensors such as temperature sensor which will help in the monitoring of the temperature required for the crop, humidity sensor which helps in the measurement of the humidity at the crop environment, light intensity sensor which helps us to find the intensity of the light required for the crop and finally soil moisture sensor which helps us in the measure of moisture in the soil .Through this data the farmer is able to get the knowledge that how much he need to give the water to the crop, at which light he must grow the crop and other important things which will help to more productivity and less wastage of water, high yield of crop . so due these sensors and devices the farmer will decrease the risk of crop and without harming the nature and environment agriculture practices will be developed with high accuracy and efficiency so that the production will be easier and the human survival will be with less disease prone and healthy.

II. LITERATURE REVIEW

Vispute, S. et al [5] suggested that smart agriculture systems can be designed using detectors with the help of the machine learning, it will also improve the productivity, crop growth and will be helpful for the agriculture and farming with high yield of the crop. M. L. Saini et al [6] described about the communication established among transducers and control board and suggested an error control mechanism between IoT devices.

"Manglani T et al [7] elaborated about cultivation of crops with assistance of IoT technology. The conducted research on a system utilized in a cultivatable field for chip cultivation. Their work led to a 41 percent increase in yield and a 20 percent reduction in water consumption when compared to conventional and other prevailing methods of human development. Borelli F et al [8] and Vispute S. [9], have defined in another study that sensors are employed to manage the entire system through IoT and measure and the growth, yield, and health of vegetable crops in cultivatable fields. These sensors and devices assess limiting factors such as temperature, moisture, soil humidity and health, light intensity, and other specified parameters.

Shailaja Pede et al [10] investigate how the information collected from sensors and devices is employed to optimize the landscape of cultivatable fields. The data of parameters are required to store using some appropriate technology. Blockchain technology can be used as support system in this proposed model.

Varun Sapra et al [12] worked on a network for identification of disease by using of deep learning. It may be useful for system where IoT based paste control agriculture system is used so that any disease can identify at its early stage in crops. Ayaz M et al [13] the system was tested and calibrated the sensors connected to the control board, resulting in a 28 percent reduction in water consumption and an increase in crop yield by over 10 percent and helps to prepare the fields for next crop. Sensors will also be employed to gauge the health of soil and need of compost in field. Abhiram MSD et all [14] propose that, in a study conducted for demonstration purposes, detectors and sensors are employed to measure the growth of strawberries in a field and monitor the temperature, humidity and light intensity etc. Prathibha SR et al [20] extends the use of these sensors and detectors to detect the symptoms of any types of fungus or bacteria. The gathered data and information are then utilized to irrigation the pesticides on infected crops and other controlling methods.

Shilpi K. et al [16] scholars in the field, have reported a business models algorithm which can be integrated with the proposed system by the crop producer to find the opportunity of sale region or store the crop for upcoming season. Patil KA et al [17] define that in general, smart agriculture systems that rely on detectors and sensors can provide valuable information to enhance agricultural practices, while minimizing the waste. Rajesh K et al [18] IoT based systems may offer a broader perspective for long life of crops in storages houses, crops health and texture are being monitored by sensors. Fig. 1 shows a decision support system.

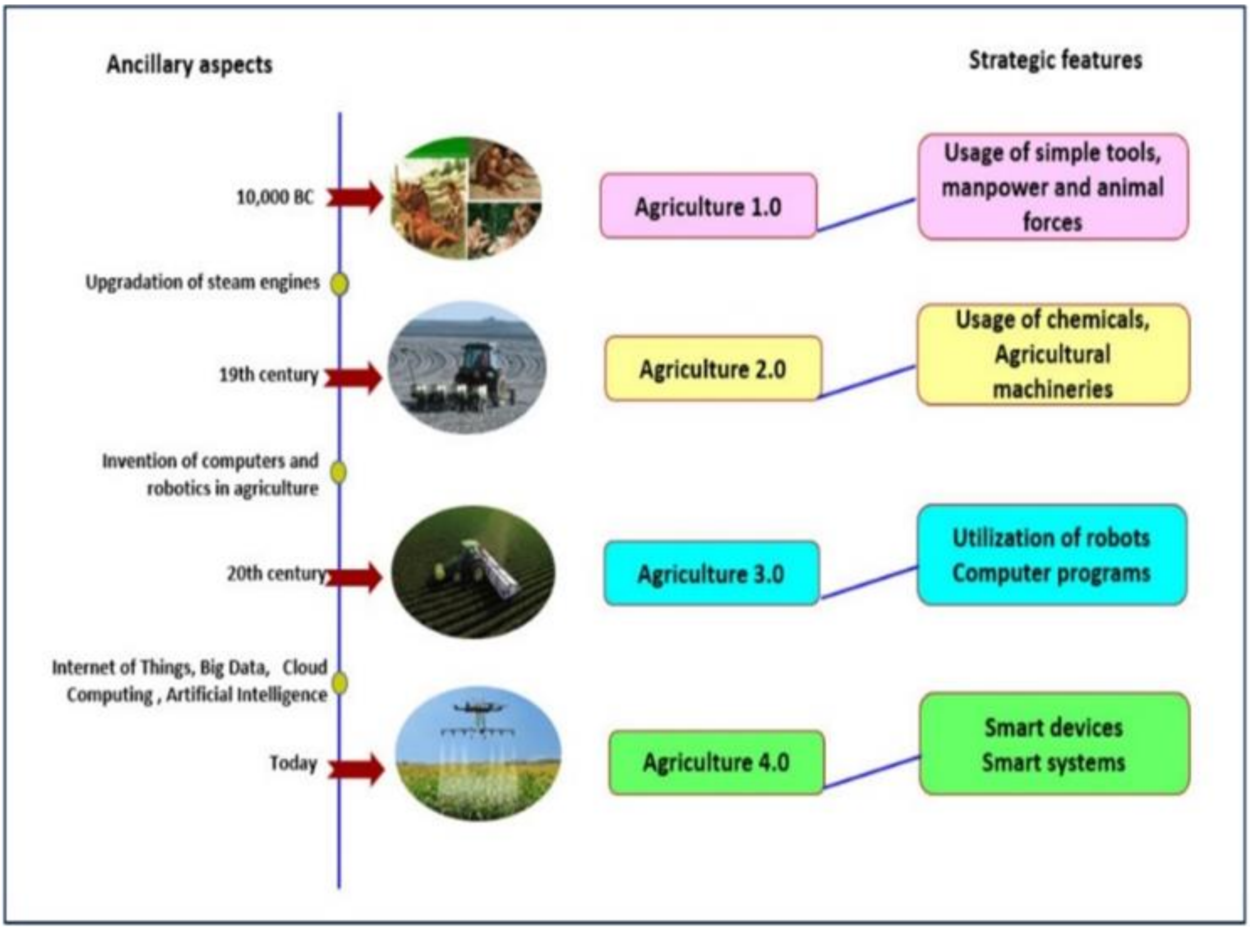

Fig 1 Agricultural Decision Support System Framework [22]

III. IMPLEMENTATION

The implementation and working of smart agriculture system involve several steps and components. The following are the sensors used for the implementation of the smart agriculture system

➢ *Soil Moisture Sensor*

To measure the moisture content in the soil, soil moisture sense is used. It provides useful data on water availability in the soil, which is very important for consistent water management crop growth and plant yield. Soil moisture sensor is generally fixed by keeping it into the ground at particular depth height that correlate with the root area of the crop being observed. The number of sensors and arrangement of sensors are found by the size of the area and layout of the observed location. It is necessary to fit the sensors apart from direct sunlight at daytime, rocks and pebbles, and roots of plant to maintain and provide exact measurements.

The information that is collected by soil moisture sensors can be used for different applications. Farmers can use the information collected from sensor to maximize irrigation schedules in farming, reduction of overwatering or under watering of the crop, which helps to preserve water resources and improves crop health, Growth and yield. The soil moisture sensor is useful in environmental, nature observation and survey. For studies related to the climate changes, hydrology, and science researches the sensor provides useful information. By observing moisture levels in the soil, scientists can better predict drought conditions in future, and estimate the health of biological community.

➢ *Light Intensity Sensor*

To measure the amount of light that is present at the crop environment, Light intensity sensors are used. To measure the amount of light in a specific area or to detect the intensity of light in a particular location they can be used [19]. Light intensity sensors generate the output signal which indicates the intensity of light by finding out the radiant energy that is present in an unmeasurable wavelength range.

➢ *Humidity Sensor*

A humidity sensor, as indicated by reference [20], is a device designed to measure and monitor the moisture content or humidity level in the air or a specific environment. It holds significant importance across a wide array of applications, including weather monitoring, HVAC systems, industrial operations, and agriculture. In the realm of weather monitoring and climate studies, these sensors find application in weather stations and meteorological instruments to observe and track humidity levels for accurate weather forecasting [21]. Additionally, in HVAC systems, humidity sensors play a critical role in controlling indoor humidity levels to prevent issues like mold growth, condensation, and discomfort stemming from air that is excessively dry or humid.

- *Temperature Sensor*

The device that monitors and detects the temperature of the surrounding environment or an object is called Temperature sensor [22]. It is majorly employed in different industries, scientific research, and day-to-day uses [23]. When observing a temperature sensor, consider the following elements such as accuracy, temperature range, response time of sensor, and environmental conditions. Regular calibration and maintenance are compulsory to ensure accurate and better temperature measurements [24].

Moreover, temperature sensors are crucial instruments that enable precise temperature monitoring and control in different types of industries and applications. These sensors allow systematic processes, improve product quality, and provide quality and safety in a variety of day-to-day situations.

IV. METHODOLOGY

The methodology of smart agriculture systems involves the use of sensors, data analytics, and automation to optimize agricultural practices and increase crop yields while reducing waste. The steps involved in the methodology can be summarized as follows:

- *Sensor Deployment*

Sensors are deployed in the agricultural setting to gather information on framework such as soil moisture sensor, temperature sensor, humidity sensor, and light intensity sensor. The detectors and sensors can be wired or wireless and can be placed in various places, such as in the soil, near to plants, or at the surrounding environment.

- *Data Collection and Storage*

The data gathered by the sensors and detectors are transformed to a main central system, where they are stored and processed further. The data collected can be stored in a database or a cloud-based platform.

- *Data Analysis*

The data collected and the information gathered from the sensors are examined using data analytics tools to provide perception into crop growth and to enhance agricultural practices such as irrigation, fertilization, and pest control. The data can be examined in real-time or at particular- time intervals.

- *Decision Making and Automation*

The understanding derived from the data analysis are used to intimate decision-making processes, such as fixing irrigation schedules and applying fertilizers in particular locations. Automation modern technologies such as drones and robotics can also be used to perform tasks such as crop monitoring and harvesting.

- *Feedback and Monitoring*

The system gives feedback on the accuracy of the decisions and results made based on the data analysis. The system can also monitor the accuracy and productiveness of the sensors and provide us the alerts if there are any issues in the system.

- *Maintenance*

The system requires day-to-day regular maintenance which includes the sensor calibration, firmware updates, and hardware replacement if any needed.

The implementation of smart agriculture system can be varied depending on the particular needs and resources of the agricultural field setting. However, but the working principles such as collecting data through sensors, analyzing the data to provide awareness, and using the insights to inform decision-making methods and automate tasks will remains same.

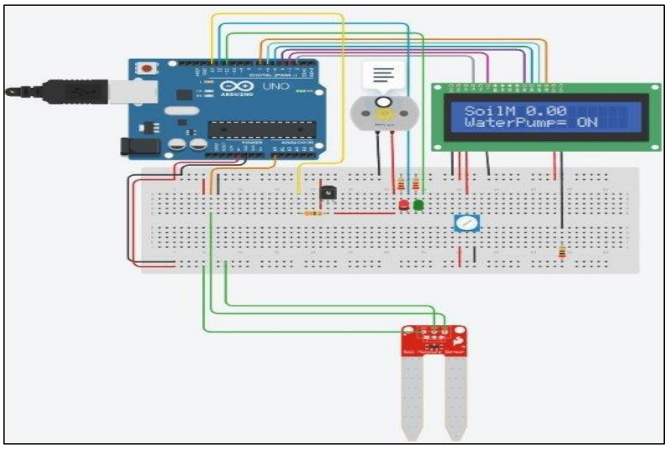

Fig 2 Smart Irrigation System using Arduino

Fig 2 illustrates a smart irrigation system utilizing Arduino, which reads sensor values and controls the start/stop of the irrigation system. Typically, soil moisture levels range from 10% to 45%, but they can be higher immediately after watering. In this simulation, the basic operation of soil moisture is as follows: when the moisture percentage falls between 0 and 10, the water pump will activate automatically to irrigate the soil. If the moisture percentage falls between 10 and 45, it is considered to be within the normal range. However, if the moisture percentage exceeds 45, a notification will be sent to the owner indicating that the soil moisture is too high, allowing them to adjust the water supply outside of the farm.

V. RESULT AND DISCUSSION

An automated smart agriculture system was created which reduces the time and resources that are required to conduct manually. This system uses various types of sensors and Arduino which communicate with sensors and take appropriate actions. This system measures soil moisture, humidity of the crop, light intensity required for the crop, temperature and the level of water in fields. This system works well in the ideal settings, and improvement can be made when the conditions are not ideal. By combining these technologies, farm productivity could be raised overall, crop yields could be increased, and resource management could be optimized. We'll go over some of the most important findings and revelations from the use of ML and IoT in smart agriculture in this section.

➢ *Precision Farming*

The combination of IoT sensors and ML algorithms allows for precision farming techniques. These kinds of devices can gather real-time data on crop health, weather, soil conditions, and equipment performance. After that, intelligent decisions about pesticide, fertilizers, and irrigation is made using this data. Increased crop yields, less waste, and more effective resource allocation are the outcomes.

➢ *Crop Monitoring and Disease Detection*

AI models are used to examine pictures and information from Internet of Things gadgets such as cameras, sensors, and drones. These systems can identify early warning indicators of illnesses, pests, or nutritional deficiencies by spotting patterns and anomalies. This decreases the need for excessive chemical fertilizers and enables farmers to take prompt action to prevent widespread crop damage.

➢ *Livestock Management*

Livestock health and behavior are tracked through the use of IoT sensors. This data can be processed by ML algorithms to determine when animals are in distress or require medical attention. As a result, damage is decreased, animal welfare is increased, and livestock farming is more efficient overall.

➢ *Predictive Analytics for Crop Yields*

In order to precisely predict crop yields, machine learning models can examine forecasts, historical data, and present circumstances. These forecasts can be used by farmers to more effectively plan harvesting and distribution, minimizing food waste and ensuring a steady supply of food.

➢ *Environmental Sustainability*

Machine learning and Internet of Things technologies assist farmers in making ecologically conscious decisions by evaluating weather data, crop health, and soil conditions. They could use less water, adopt organic farming practices, and reduce soil erosion to support sustainable agriculture.

VI. CONCLUSION

Smart agriculture systems present a viable way to improve agricultural growth, yield, and sustainability. However, large investments in infrastructure, technology, and farmer training in cutting-edge technologies may be necessary for their effective implementation and maintenance. The results show that smart agriculture systems result in better crop growth, yields, and efficiency as well as lower water usage, increased accuracy, and increased efficiency in agricultural practices. Farmers can efficiently optimize irrigation and fertilization schedules, monitor crops for pests and diseases, and reduce waste by utilizing sensors, detector devices, and data analytics. Furthermore, contemporary technologies like robots and drones are capable of carrying out jobs like harvesting and crop monitoring. Farmers are given real-time feedback from this system, which helps them make better decisions. By addressing issues with food security, the implementation of smart agriculture systems can support sustainable agricultural practices. Farmers can increase overall profitability, cut waste, and make better decisions with the help of these technologies, all while improving the planet's long-term health.

REFERENCES

[1]. Pyingkodi M, Thenmozhi K, Nanthini K, et al. Sensor Based Smart Agriculture with IoT Technologies: A Review. *2022 Int Conf Comput Commun Informatics, ICCCI 2022*. Published online 2022. doi:10.1109/ICCCI54379.2022.9741001

[2]. El Mezouari A, El Fazziki A, Sadgal M. Smart Irrigation System. *IFAC-PapersOnLine*. 2022;55 (10):3298-3303. doi:10.1016/j.ifacol.2022.10.125

[3]. Chandavale A, Dixit A, Khedkar A, Kolekar RB. Automated Systems for Smart Agriculture. *2019 IEEE Pune Sect Int Conf PuneCon 2019*. Published online 2019. doi:10.1109/PuneCon46936.2019.9105686

[4]. Y. Singh, M. Saini and Savita, "Impact and Performance Analysis of Various Activation Functions for Classification Problems," 2023 IEEE International Conference on Contemporary Computing and Communications (InC4), Bangalore, India, 2023, pp. 1-7, doi: 10.1109/InC457730.2023. 10263129.

[5]. Vispute, S., Saini, M.L. (2022). Automation in Agriculture: A Systematic Survey of Research Activities in Agriculture Decision Support Systems Using Machine Learning. In: Singh, P.K., Wierzchoń, S.T., Chhabra, J.K., Tanwar, S. (eds) Futuristic Trends in Networks and Computing Technologies . Lecture Notes in Electrical Engineering, vol 936. Springer, Singapore. https://doi.org/10.1007/978-981-19-5037-7_56

[6]. M. L. Saini, V. K. Sharma and A. Kumar, "An Efficient Single and Double Error Correcting Block Codes with Low Redundancy for Digital Communications," 2023 International Conference on Advancement in Computation & Computer Technologies (InCACCT), Gharuan, India, 2023, pp. 827-831, doi: 10.1109/InCACCT57535.2023. 10141727.

[7]. Manglani T, Vaishnav A, Solanki AS, Kaushik R. Smart Agriculture Monitoring System Using Internet of Things (IoT). *Proc Int Conf Electron Renew Syst ICEARS 2022*. Published online 2022:501-505. doi:10.1109/ICEARS53579.2022.9752446

[8]. Borelli F, Biondi G, Silva D, Kamienski C. Managing Smart Agriculture: The IoT Entity Management System (IoTEMS). *2021 IEEE Int Work Metrol Agric For MetroAgriFor 2021 - Proc*. Published online 2021:310-314. doi:10.1109/MetroAgriFor52389.2021.9628882

[9]. Vispute, S.; Saini, M.L. Performance Analysis of Soil Health Classifiers Using Data Analytics Tools and Techniques for Best Model and Tool Selection. Int. J. Online Biomed. Eng. 2022, 18, 169–189.

[10]. Shailaja Pede and Madan Lal Saini, "A Brief Bibliometric Analysis and Visualisation of Scopus and WoS databases on Blockchain Technology in Healthcare Domain", Library Philosophy and Practice (e-journal), vol. 5106, 2021.

[11]. M. Gehlot and M. L. Saini, "Analysis of Different CNN Architectures for Tomato Leaf Disease Classification," 2020 5th IEEE International Conference on Recent Advances and Innovations in Engineering (ICRAIE), Jaipur, India, 2020, pp. 1-6, doi: 10.1109/ICRAIE51050.2020.9358279.

[12]. Varun Sapra, Madan Lal Saini, "Deep learning network for identification of Ischemia using clinical data", International Journal of Engineering and Advanced Technology, ISSN: 2249-8958, Volume-8 Issue-5, June 2019.

[13]. Ayaz M, Ammad-Uddin M, Sharif Z, Mansour A, Aggoune EHM. Internet-of-Things (IoT)-based smart agriculture: Toward making the fields talk. *IEEE Access*. 2019;7:129551-129583. doi:10.1109/ACCESS.2019.2932609

[14]. Abhiram MSD, Kuppili J, Manga NA. Smart Farming System using IoT for Efficient Crop Growth. *2020 IEEE Int Students' Conf Electr Electron Comput Sci SCEECS 2020*. Published online 2020. doi:10.1109/SCEECS48394.2020.147

[15]. Varun Sapra, Madan Lal Saini, "Computational Intelligence for Detection of Coronary Artery Disease with Optimized Features", International Journal of Innovative Technology and Exploring Engineering, ISSN: 2278-3075 Volume 8, Issue-6C, Pages 144-148, April 2019.

[16]. S. Kulshrestha and M. L. Saini, "Study for the Prediction of E-Commerce Business Market Growth using Machine Learning Algorithm," *2020 5th IEEE International Conference on Recent Advances and Innovations in Engineering (ICRAIE)*, Jaipur, India, 2020, pp. 1-6, doi: 10.1109/ICRAIE51050.2020. 9358275

[17]. Patil KA, Kale NR. A model for smart agriculture using IoT. *Proc - Int Conf Glob Trends Signal Process Inf Comput Commun ICGTSPICC 2016*. Published online 2017:543-545. doi:10.1109/ ICGTSPICC.2016.7955360

[18]. Rajesh K, Riyaz K, Pallavi B, Reddy CSS, Raamkumar A, Baranitharan B. A Smart Agriculture Storaging System with IOT Based. *2022 Int Conf Intell Controll Comput Smart Power, ICICCSP 2022*. Published online 2022. doi:10.1109/ICICCSP53532. 2022.9862427

[19]. Sapra Varun , Saini M.L and Verma Luxmi, Identification of Coronary Artery Disease using Artificial Neural Network and Case-Based Reasoning, Recent Advances in Computer Science and Communications 2021; 14(8) . https://dx.doi.org/10.2174/2666255813999200613225404

[20]. Prathibha SR, Hongal A, Jyothi MP. IOT Based Monitoring System in Smart Agriculture. *Proc - 2017 Int Conf Recent Adv Electron Commun Technol ICRAECT 2017*. Published online 2017:81-84. doi:10.1109/ICRAECT.2017.52

[21]. M. L. Saini, J. Panduro-Ramirez, J. Padilla-Caballero, A. Saxena, M. Tiwari and K. Ravi, "A Study on the Potential Role of Blockchain in Future Wireless Mobile Networks," 2023 3rd International Conference on Advance Computing and Innovative Technologies in Engineering (ICACITE), Greater Noida, India, 2023, pp. 547-550, doi: 10.1109/ICACITE57410.2023.10182375.

[22]. Dhanaraju M, Chenniappan P, Ramalingam K, Pazhanivelan S, Kaliaperumal R. Smart Farming: Internet of Things (IoT)-Based Sustainable Agriculture. *Agriculture*. 2022; 12(10):1745. https://doi.org/10.3390/agriculture12101745

[23]. Kavita Lal, Madan Lal Saini; A study on deep fake identification techniques using deep learning. AIP Conf. Proc. 15 June 2023; 2782 (1): 020155. https://doi.org/10.1063/5.0154828

[24]. Ioana, M.; George, S.; Cristina, M.B.; Ana-Maria, D.; Marius, A.D. IoT Solution for Plant Monitoring in Smart Agriculture. In Proceedings of the IEEE 25th International Symposium for Design and Technology in Electronic Packaging, Cluj-Napoca, Romania, 23–26 October 2019; pp. 194–197