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Applications Of Internet of Things(IoT) in Agriculture: The Need and Implementation

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***Abstract*— Humans are motivated to improve agricultural yields by implementing new technologies due to the world's growing population. Precision agriculture, which is expected to raise crops considerably, could be achieved via the Internet of Things (IoT). However, a significant investment in IoT systems for agriculture and farmers who are not computer aware make the large-scale implementation of IoT systems in agriculture problematic. As a result, it is advocated that the focus on the deployment of agriculture IoT systems be widened to include the entire life cycle of agriproducts. While adopting agricultural IoT systems, energy factor must be in consideration. Farmers' interest in IoT technologies will rise significantly if green IoT systems are used throughout the agri-product life cycle. Regarding IoT-based agricultural network technologies, several aspects, including network architecture and layers, network topologies, and network protocols, have been investigated. This research investigates the ways in which Internet of Things (IoT)-based agricultural systems may be combined with other important technologies, such as cloud computing, large amounts of data storage, and analytics. This study also discovers security issues in IoT agriculture. There have also been a few examples of successful IoT-based agriculture rules and policies that various countries have implemented. However, there are still many unanswered questions about IoT agriculture research.**

Keywords*— *IoT, Smart Agriculture, Application, Management, Security

I. INTRODUCTION

The Internet of Things (IoT) refers to the process through which everyday objects are given artificial intelligence by virtue of their connection to the internet. This technology has a direct connection between computer-based systems and the physical world. The Internet of Things (IoT) enables internet-connected sensors to communicate and cooperate. As a result, everything from weather stations and computers to pumps and barns can be watched and controlled remotely in real-time.

Data is king in the Internet of Things. As our world becomes increasingly interconnected via technology, data becomes an increasingly valuable resource. Farmers may be able to make better judgments with the data they receive from their gadgets, allowing them to produce more efficiently and safely while also responding to changing conditions more quickly[1]. In addition, farms can free up time, money, and resources by remote monitoring of agricultural conditions and infrastructure.

As a result of internet-enabled physical agricultural resources[2]:

- Can speed up routine farm inspections significantly by using remote monitoring to keep an eye on crop conditions and infrastructure.
- to aid producers in making better decisions using data analytics
- real-time data throughout the whole value chain, allowing farmers to more accurately and swiftly match their products to the needs of the market.
- Food waste reduction, accelerated time to market, and enhanced traceability to provide healthy, environmentally friendly products for our clientele.
- Growing productivity and innovation will enhance the ability to adapt to new and emerging technologies and invest in research and development (R&D).

However, the high price tag of introducing Internet of Things devices into farming is a major drawback. Controlled-environment agriculture, such as greenhouses and cattle ranches, is the most common application of IoT devices now in use. There is still a long way to go before the world's food crisis can be alleviated by large-scale open-field farming. The presence of two variables may hamper promotion. First, an agri-life product's life cycle should be considered in IoT-based agriculture, not just its growth cycle. An important factor that affects crop yields and production behaviour is the quality and distribution of agricultural components. Farmers' interest in IoT devices is difficult to spark without a full life cycle that includes IoT technologies[3].

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To begin, there is more than just technical difficulty involved in deploying IoT solutions in the farming sector; there are also financial, operational, and management (FOM) issues to consider. It should take the high cost of the investment into account first. A lack of attractive benefits and conveniences means that neither large-scale nor small-holder farmers will endure the costs. Unfortunately, the vast majority of research to far has concentrated on the mechanics of plant growth[4].

II. Process and Entities of IoT based Agriculture

Four critical elements of IoT-based smart farming are shown in Figure 1. The physical structure, data collection, processing, and analytics are the four essential components. Precision agriculture cannot function without a sound physical design. The system's architecture controls sensors, actuators, and other devices. Soil, temperature, weather, light, and moisture, for example, can all be detected by a sensor[5].

On the other hand, devices perform a variety of control functions, including node finding, device identification, and naming. Any device or sensor can carry out these tasks by using a microcontroller. All required to carry out this command is a computer or other remote device with the Internet access.

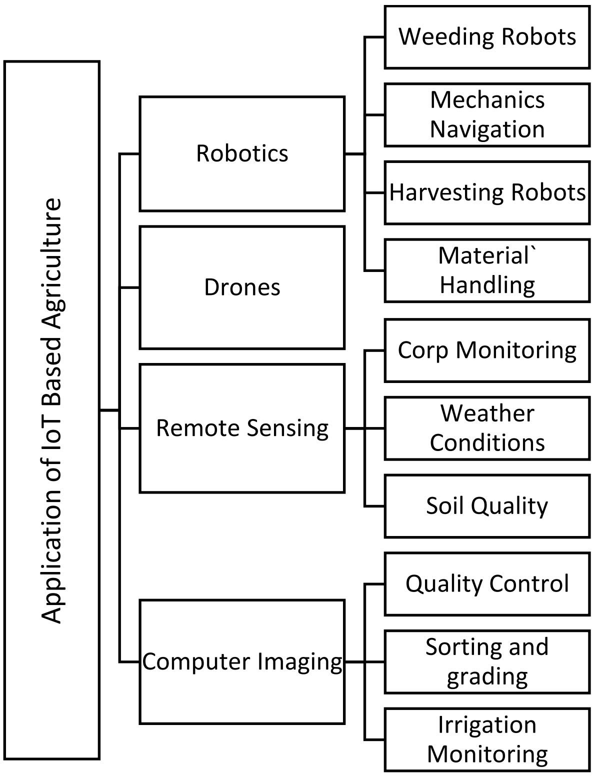

Figure 1: Application of IoT

Both IoT data collection and traditional data collection methods exist. Protocols for collecting data in the Internet of Things include MQTT, WebSocket, AMQP, Node, and CoAP. Protocol for transferring text over the Internet (HTTP). When the situation calls for it, we can use a more excellent range of protocols to implement smart farming. On the contrary, protocols like ZigBee and Wi-Fi have been employed in standard data collecting. Data loading, a decision support system, and data mining are all represented in fig. 1 as part of data processing. Any feature that can use in conjunction with the plan to deliver additional services can be implemented[6].

Tracking and management are two of the most critical components of data analytics. Smart agricultural monitoring can monitor livestock, farms, and greenhouses. For example, a farmer can monitor the health of their cattle using sensors, such as the temperature of the animals' bodies, the heart rate, and the digestive processes that occur. Soil richness and temperature and humidity, and air and water pressure are among the many variables that monitoring apps can report in the field[7]. The monitoring of crop diseases is also included in this service. Incorporating intelligent IoT devices and sensors in an intelligent greenhouse design eliminates the need for manual intervention. It allows the greenhouse to automatically adjust its temperature to meet the needs of the plants.

III. Application of IoT Based Agriculture

It wasn't until 2008 and 2009 that more "things or items" were connected to the Internet than individuals were related to the Internet. In 2010, the total number of Internet-connected devices surpassed 12.5 billion for the first time. The human population expanded to 6.8 billion, bringing the number of connected devices per person to more than one for the first time in history[8].

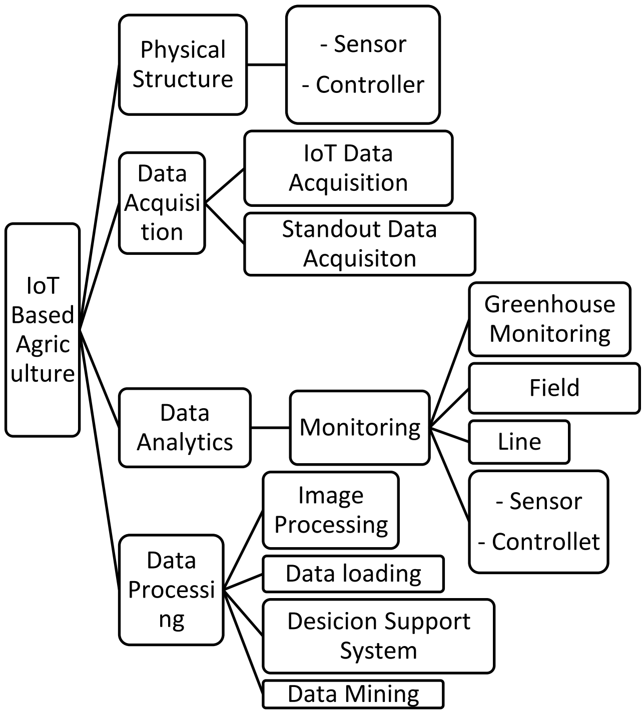

Figure 2: IoT Based Agriculture

A. Robotics

Automated processes have only gotten more complicated and more productive since the Industrial Revolution of the 1800s. Farmers are becoming more interested in Agribots, or agriculture robots, due to escalating labour demands and global labour scarcity. The annual loss in agricultural output in the United States is estimated at 213 crores, or $3.1 billion. Agrobots have gained prominence as sensor and AI technology have improved. However, the agricultural robotics revolution is still in its infancy, with most commodities still in testing and R&D mode[9].

1) *Weeding Robots*

Digital image processing is used to scan through their database of crop photographs for any similarities and then remove or spray the offending weeds with their robotic arms. As a result, there has been a rising number of pesticide-resistant plants suitable for the environment and farmers because they save them money by reducing the number of herbicides they must use on their farms.

2) *Machine Navigation*

With remote control, you may operate heavy ploughing equipment from the comfort of your own home using GPS and a computer. These integrated automated gadgets will help you get it done more quickly and accurately if you're doing a lot of manual labour. Mobile phones allow you to keep tabs on their whereabouts and how well they're doing at work. These technology-powered motors are getting more intelligent and more self-sufficient thanks to breakthroughs in machine learning, such as identifying obstacles.

3) *Harvesting Robotics*

Using ag robots to harvest crops eliminates the need for human labour. An engineering marvel, round-the-clock fruit and vegetable harvesting machines are now a reality. These devices combine image processing with robotic arms to scan the field to select just the best-quality fruits. Ag robots are used to harvest orchard crops, like apples, early in the season because of their high operational expenses. These robots can also pick High-value fruits like tomatoes and strawberries in greenhouses. Crop harvesting robots like these could be helpful to in greenhouses.

4) *Material Handling*

Humans and robots can work together to complete physically demanding activities. To maximise floor space, plant quality, and production costs, they are capable of lifting big objects with ease and performing jobs like plant spacing with extreme precision.

B. *Drones*

Agricultural drones will play an essential role in the future. Agricultural farms are photographed, mapped, and surveyed using drones equipped with sensors and cameras. Ground-based drones and airborne drones are both possible. By using a wheeled robot, a ground drone can cover a big area with ease. Unmanned aerial vehicles (UAVs) is the technical term for flying robots such as aerial drones (UAVs). Drones' embedded systems, which use sensors and GPS to guide software-controlled flight plans, are self-flying machines. There are many applications for drone data, including the study of plant health, irrigation and spraying, planting and soil/field, and production forecasts. Drones can be recharged and repaired more conveniently if pre-scheduled or pre-purchased. Drones must be transported to adjacent labs for analysis when surveys are done.

C. *Remote Sensing*

Using sensors like weather stations and other IoT-based remote sensing devices, data is collected and sent to a computer for analysis. Sensors are tools for spotting anomalies in the real world. For example, farmers can use an analytical dashboard to keep tabs on their crops and take appropriate action due to their results.

1) Crop *Monitoring* - Sensors located throughout the farms keep tabs on factors such as light, humidity, temperature, shape, and growth of the crops. Sensors look for any unusual behaviour, and the farmer is notified if further action is required. Remote sensing is excellent for preventing disease and monitoring crop growth.

2) Weather conditions - Temperature, humidity, rainfall, and dew detection can all be used to anticipate the weather on a farm using sensors. Sensor data, such as humidity, temperature, precipitation, and dew detection, can be used to predict weather patterns on farms.

3) Soil *quality* - You may find out how much water is needed for irrigation; how much acidity is in the soil and what cultivating method is most successful by examining soil quality on a farm.

D. *Computer Imaging*

Computer imaging uses sensor cameras or drones outfitted with cameras to create photographs that are then digitally processed. Digital image processing is based on computer algorithms processing an input image. Infrared images are examined, compared over time, and irregularities are discovered, thereby analysing limiting variables and assisting in enhanced farm management through image processing[10], [11].

1) Quality control - By comparing images from a database with photographs of actual crops, image processing and machine learning can determine the latter's size, shape, colour, and growth.

2) Sorting and grading - Sorting and classifying products based on their size, colour, and form can be made easier with the help of computer imaging.

3) Irrigation Monitoring - The mapping of irrigated fields is aided by irrigation throughout time. Harvesting during the pre-harvest season is made more accessible with this information.

IV. Benefits Of Using IoT in Agriculture

We may achieve previously unimaginable levels of efficiency, resource and cost reduction, automation, and data-driven operations by using the Internet of Things in farming. However, these advantages are not upgrades but treatments for the overall firm, which is facing some severe issues in agriculture[12], [13].

Excelled efficiency: Agriculture nowadays is a race. Soil degradation, land depletion, and climate change have made it increasingly difficult for farmers to produce enough food to meet the needs of their communities. Internet of Things (IoT) technology allows farmers to maintain a watchful check on their crops and the surrounding environment. As a result, they are perceptive and fast to act, able to foresee potential issues and devise effective solutions. Using Internet of Things (IoT) technology, farmers may now use robots to do tasks such as watering, fertilising, and harvesting.

Expansion: 70% of the world's population will reside in urban areas by the time the global population hits 9 billion. Greenhouses facilitated by hydroponics and the Internet of Things (IoT) may contribute to global food security. Produce may now be produced in grocery stores, on rooftops, in shipping containers, and even in people's own homes, all thanks to closed-cycle agricultural technologies.

1) Reduced resources: Many IoT solutions for agriculture take into account resources like water, electricity, and land. Farmers can precisely supply each plant with the proper amount of nutrients thanks to sensors in the field.

2) Cleaner process: With the support of IoT-based precision agriculture technologies, farmers can conserve water and energy while also reducing pesticide and fertiliser usage. In addition, compared to normal agricultural practices, this method delivers a more natural and purer product.

3) Agility: Faster operations are one advantage of using IoT in farming. Farmers can respond swiftly to significant changes in the weather due to the use of real-time monitoring and forecasting tools. In the face of substantial weather shifts, new capabilities help agricultural experts save their crops.

4) Improved product quality: Farmers can produce more and higher-quality goods with the aid of data-driven agriculture. Through the use of soil and crop sensors, overhead drone surveillance, and farm mapping, farmers can better comprehend the connection between weather and crop quality. When linked systems are used, they are able to replicate the ideal circumstances and improve the nutritional value of the products.

V. Wheat Cultivation in India

Growth by the year Wheat is high in protein, vitamins, and carbs, and it offers a well-balanced diet. India is the world's fourth biggest wheat producer, making about 8.7 percent of global wheat production behind Russia, the United States, and China[12], [14].In the middle latitudes, wheat is mostly a grassland crop that requires low temperatures and moderate rainfall to thrive. Temperatures between 10° and 15° Celsius in the winter and 21° to 26° Celsius in the summer are ideal for growing wheat. However, higher temperatures are required as harvesting nears to ensure the best possible ripening of crops.However, a fast increase in temperature during maturation is hazardous. Wheat grows well in locations with an average annual rainfall of 75 cm. Wheat farming has a maximum annual rainfall of 100 cm. The isohyet of 100 cm delineates the boundary between wheat producing regions and rice growing areas. Irrigation is required for healthy development in locations with less than 50 cm of yearly rainfall. Wheat may, in fact, be cultivated in locations with as little as 20-25 cm of annual rainfall if sufficient irrigation facilities are available. Depending on the quantity of rainfall, irrigated regions require 5 to 7 waterings. While prolonged dryness, particularly in rainfed locations, is detrimental during maturity, small drizzles and cloudiness during ripening aid in increasing output. Frost during blooming and hail storms during ripening may both cause significant harm to the wheat crop. Although wheat may be cultivated on a variety of soils, the optimum soils for wheat cultivation are well-drained rich, friable loams and clay loams. It grows nicely in the dark soil of the Deccan plateau as well.

Wheat cultivation is a large sort of farming that is highly automated and requires very little labour. It is mostly cultivated in north India's flat alluvial plains.

So, to sum up, wheat requires a variety of factors, including a cold climate with moderate rainfall, flat and well-drained plain lands, fertile, friable loam, and significant inputs, such as irrigation, HYV seeds and fertilisers, automation, and other agricultural input technologies.

Because the use of different techniques and tools even before the term of IoT in agriculture was given, they have been helping in the growth of production, as the data shown in fig 1.

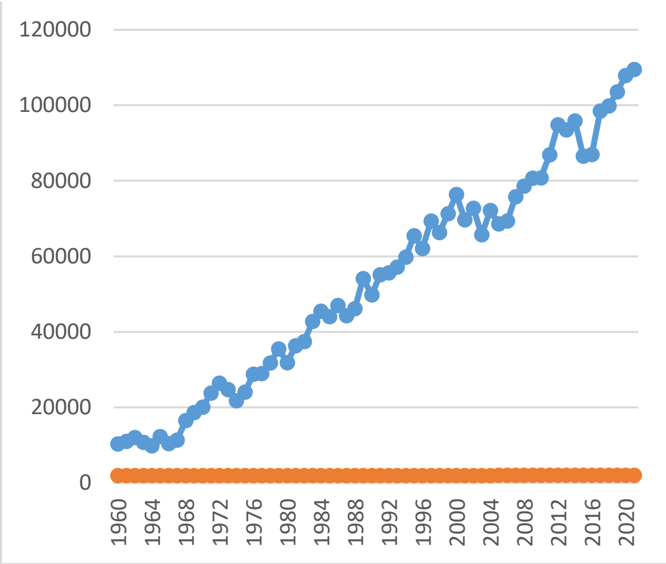

Fig. 1. Wheat Incremental Growth by year

VI. Conclusion

All things connected to the internet are included in the Internet of Things (IoT). IoWT (Internet of Wearable Things) products, such as smartwatches and home automation systems like Google Home, have increased client demand. Thirty billion devices are estimated to be part of the IoT by 2020. As demand for food rises and production losses decrease, IoT applications are being used to support traditional farming methods. Farmers may, for instance, monitor their crops more effectively than ever before by combining the use of drones, remote sensors, and computer imagery with ever-improving machine learning and analytical tools.

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