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APPLICATIONS AND CHALLENGES OF INTERNET OF THINGS(IoT) IN SMART AGRICULTURE ECOSYSTEM

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Abstract: Now a day's agriculture is the business or occupation which is having a great need for survival of human being. Prime need of human survival is food and it is fulfilled by agriculture. Similarly India belongs from agro based economy. But today also in Indian agriculture domestic or traditional methods are highly applied by Indian farmers. But in present if they are use new smart and advanced technologies in their farms or agro based industry then they could save extra money, time as well as energy. Today agricultural production decreasing day by day and on other side population of India as well as world is increasing. Obviously in future human being get problems to living his life on the things which developed by himself i.e. smart phones, computers, smart vehicles etc. so end of the day human being needs food to survive. And in present day food is producing only through the farming. Currently we are living in modern or smart era where all the things which are important for us for our daily life such as smart homes, smart vehicles, industries, health etc. Accordingly if the Internet of Things (IoT) would be used in agriculture then it may be become more profitable for world and its society.

Index Terms: Internet of Things(IoT), Smart Agriculture, Industrial Internet of Things(IIoT).

I. INTRODUCTION

Agriculture is the foundation of the Indian economy, the development of agricultural industry is good for the entire nation and this can help to improve economy steadily. Using IoT(Internet of Things) in the field of agriculture can boost the yield. The Indian farmers use traditional methods for farming. The use of IOT in farming will help increase the yield as well as beneficial for the farmers.

In this paper IOT will be taken as a measure to help in the increase of yield of the crops. Here, the development of intelligence based systems for the farming sector has to concentrate. The system monitors and alerts based on IOT with real time monitoring environmental parameters, which, is aimed at monitoring and managing the growth of crops in the farm. It includes mobile inspection device, data receiving devices, data acquisition units, data storage servers. So, the system can automatically collect environmental parameters such as air temperature, air humidity and soil moisture, etc from the environment. It automatically judges the parameters and presents a graphical reading for the users to understand the requirement of the parameters. This will also enable the farmers to control the different devices using the mobile application.

Green computing seeks to use IT resources in an energy-efficient, economically-efficient and environmentally friendly manner by greening computers and computer products (using, disposing, designing and manufacturing), which in turn affect the development of a wide range of regions in the country. India is an agricultural country and agriculture and its associated activities are the main livelihoods for 80% of rural India's population. Therefore, agriculture is the core of India's economy and agriculture is a prerequisite for our domestic prosperity. It is the main source of livelihood for about the majority of the

population of India, particularly in rural areas. According to IBEF reports, the Rs. 19.48 lakh crore (\$ 276.37 billion) for agriculture, forestry and fishing was accessed in FY20 (PE) [1]. GVA growth remained at 4% in FY20 in agriculture and its allied sectors. In order to stabilize and increase growth, this agro industry must be merged with the use of technology so that our country can develop smoothly. Even if the Government of India has focused and highlighted the need for progress in agri-business measures previously referred to, this is an indication of innovative technology and the implementation of this technology to increase crop productivity that would lead to overall system growth. With the implementation of the Internet of Things (IoT) in agriculture, crop production and other sustainable products are growing tremendously [2]. Various IoT Applications are used in farming which involves data collection on the humidity of the soil, temperature, climate, water levels, infertility of soils etc. This information is gathered from the sensors and actuators and can be further stored on the cloud and can be assessed for various analytics to obtain meaningful information. Furthermore, this information can be used to automate agriculture techniques and make better decisions to improve the production of crops in terms of quality and quantity. With the use of IoT in agriculture the life of Farmer can be relieved and which would result in better production and reduced risks. For instance, there is no need for farmers to check the soil temperature for irrigation and would now be able to screen soil temperature and dampness from a far distance, they will be getting the entire information on their phones through alarms.

II. LITERATURE SURVEY

Agriculture is the major source of income for the largest population in many countries and is major contributor to the country's economy. However technological involvement and its usability still have to be grown and cultivated for agro sector in India. Some initiatives have also been taken by the respective Governments by providing online and mobile messaging services to farmer related to agricultural queries, agro vendor information to farmers, it provides static data related to soil quality at each region. The system has not been implemented which can utilizes real time data of soil quality based on its current properties. Soil properties determine the quality of soil. Also health of soil can be maintained by applying only required amount of fertilizers with the help of real time monitoring. Soil moisture analysis helps to supply the water whenever necessary avoiding wastage of water.

Also environmental conditions such as temperature and moisture also affect the crop production and crop diseases. In this respect we need a dynamic model which collects such real time data. To increase the production and ease the distribution of agricultural products all agriculture entities need to be connected to have decision making system from farmers to marketing agencies and from vendors to farmers. Such system will also be responsible for controlling other parameters like agro product rates.

With the increasing use of the Internet of Things (IoT), connected devices have used in each side of our life, from health and fitness, home automation, automotive and provision, to smart cities and industrial IoT. By mistreatment numerous good agriculture gadgets, farmers have gained higher management over the method of raising placental mammal and grooving crops, creating it a lot of certain and economical. Smart farming through the use of IoT technologies will help farmers to reduce generated wastes and enhance productivity. That can come from the quantity of fertilizer that has been utilized to the number of journeys the farm vehicles have made. So, smart farming is basically a hi-tech system of growing food that is clean and is sustainable for the masses. It is the induction as well as the application of modern ICT (Information and Communication Technologies) into agriculture. Internet of Things (IoT) has the potential to influence the globe we have a tendency to live in; connected vehicles, advanced industries, smart cities and towns are all the parts of the IoT. However applying technology like IoT to the agriculture field might have the best impact. Smart farming supported IoT technologies can alter growers and farmers to scale back waste and enhance productivity starting from the fertilizer utilised to the amount of journeys the farm vehicles have created. Smart farming could be a capital intensive and high tech system of growing food cleanly and property for the plenty. It's the appliance of contemporary Information and Communication Technology (ICT) into agriculture.

In IoT based sensible farming, a system is constructed for observation the crop field with the assistance of various sensors like humidity, temperature, light, soil wetness etc. and automation the water irrigation system. The farmers will monitor the field conditions from anywhere in the world. IoT based smart farming is extremely economical in comparison with the traditional approach. The applications of IoT based sensible farming not solely target typical, huge farming operations, however might even be new levers of uplift different growing or common trends in agriculture like organic farming, family farming and enhance extremely clear farming. In terms of environmental problems, IoT based smart farming will give nice edge

together with additional economical water usage or optimization of inputs and coverings. The main applications of IoT based smart farming that are revolutionising agriculture field are as follow.

With the remarkable development of the world's population, as the United Nations Food and Agriculture Organization indicated, in 2050, we need to increase the consumption of food by 70%, for horticultural land use and the exhaustion of natural resources, the need to increase the yield of ranches has become essential. To solve the above problems, IoT solutions offer better product solutions, mainly aimed at helping farmers to shut down the inventory request hole by guaranteeing outstanding returns, benefits and climate assurance. IoT provides various solutions that lay the foundation for helping farmers to improve productivity, profitability and environmental benefits. In agricultural technologies Agribusiness IoT plays an important role, which includes specialized equipment, wireless connectivity, software and IT services. The use of technology led to intelligent farming, because technological advances have provided farmers with a better controlled ecosystem. Devices/computers identify the requirements for control of farm animals and farm crops [3]. This technique makes efficient decisions on the use of plants and animals. Decisions can be taken on a square acre or smaller tract of land that is capable of individually processing crops or animals. The business intelligence survey reports that IoT devices are expected to reach 75 million in the agriculture industry in 2020, increasing by 20% every year. Simultaneously, the global smart agriculture market is expected to triple by 2025, to 15.3 billion dollars (as opposed to just over 5 billion dollars by 2016).

Smart IoT-dependent agriculture enables farmers and growers to reduce waste and improve profitability, from the quantity of manure and fertilizers used to the number of excursions made by vehicles, and to enable the effective use of assets such as water, energy and so on. IoT intelligent agriculture solutions are a framework, which is designed to control yields with the aid of sensors (light, mugginess, temperature, soil damping, crop well-being, etc) and to mechanize the framework of the water system [4]. Farmers can monitor the conditions in the field from any place, including their homes or elsewhere. You can also choose between manual and mechanized alternatives to make important moves that depend on this information. For example, if soil moisture deteriorates, farmers can send sensors to start the water system. This mechanism, in contrast, is exceptionally productive and the regular manual methodology involves a lot of work. There are many different ways IoT applications change the way agriculture works, i.e., the future of agriculture.

Data collected by intelligent agricultural sensors, a key component of this agricultural management approach, includes sensors, control systems, robotics, self-supporting vehicles, automatic hardware, variable rate technology, movement detectors, button cameras and wearable devices. This information can be used to monitor general business conditions as well as the performance of employees and the efficiency of equipment. The ability to manage output allows for better product delivery planning. Agricultural landowners can use various wireless IoT applications to collect information about the location, well-being, and health of their cattle so that they can identify themselves sooner and remove them from the doctors' treatment group [5].

III. APPLICATIONS OF IoT IN SMART AGRICULTURE

Here are some real-world applications of IoT in smart farming that are revolutionizing the way farms operate by enabling farmers to optimize resource use, automate processes, and make data-driven decisions.

Use Cases of IoT in Agriculture

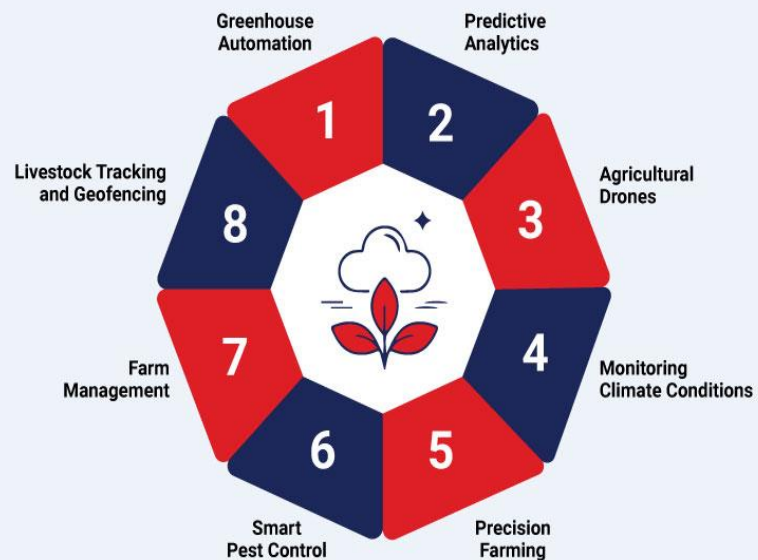
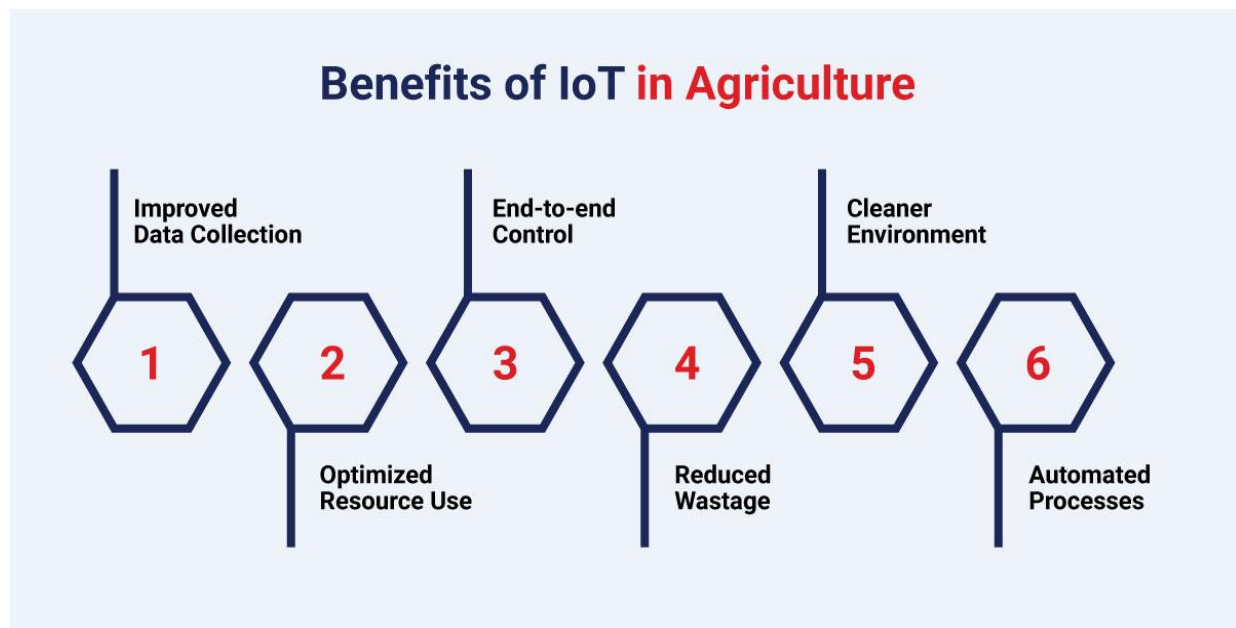


Fig 2: Use Cases of IoT in Agriculture

- **Greenhouse Automation:** IoT sensors and actuators are vital in greenhouse automation. They monitor and control crucial environmental factors such as temperature, humidity, and lighting. By maintaining optimal conditions, IoT enables careful cultivation, accelerates plant growth, and boosts overall greenhouse productivity.
- **Predictive Analytics for Smart Farming:** By collecting and analyzing data from various sources, including weather patterns, soil moisture levels, and crop health sensors, IoT empowers farmers with predictive analytics. This input enables making informed decisions regarding irrigation, crop rotation, disease prevention, and resource allocation.
- **Agricultural Drones:** IoT sensors and cameras support gathering data on crop health, plant density, and irrigation needs. It enables the farmers to analyze & identify problem areas, take proactive measures, and optimize their farming practices. It leads to increased yield and a reduction in resource wastage.
- **Monitoring Climate Conditions:** The installation of IoT weather stations across farms helps collect accurate data on temperature, humidity, wind speed, and rainfall. This input can be used in real-time to make precise irrigation schedules, pest control, and crop management decisions.
- **Precision Farming:** It is made possible by combining data from different sources, such as soil sensors, satellite imagery, and machine vision. And this data-driven approach enables farmers to optimize pesticide & water usage for higher crop yields.
- **Smart Pest Control:** IoT devices can precisely detect pests using sensors and image recognition technology. Early detection enables farmers to implement targeted pest control measures, thereby minimizing crop damage and reducing the need for excessive pesticide usage.
- **Farm Management:** These systems enable farmers to consolidate and manage all their data in a suitable location. From crop yields and livestock records to financial information and inventory levels, the system is a centralized hub for planning schedules and optimizing resource use.
- **Livestock Tracking and Geofencing:** With IoT-enabled tracking devices, farmers can monitor the location and behavior of their livestock in real time. Geofencing allows them to set virtual boundaries and receive alerts if animals stray beyond designated areas. This technology ensures better management of grazing patterns and enhances animal welfare.

IV. ADVANTAGES OF IoT IN SMART AGRICULTURE

From improving efficiency and reducing wastage to enabling precision farming and enhancing product quality, IoT empowers farmers to meet the challenges of feeding a growing population while ensuring a more sustainable future for agriculture. Let's look at the key benefits of IoT in agriculture:



- **Improved Data Collection for Enhanced Farming Efficiency:** Farmers strive to produce more on shrinking land amidst fluctuating weather patterns and degrading soil conditions. Fortunately, IoT-enabled agricultural solutions have come to their rescue, empowering them to monitor their crops and environmental conditions in real time. Farmers gain valuable insights and can predict potential issues by swiftly collecting crucial data on weather, land conditions, livestock, and crop health. This information enables them to make informed decisions & proactively address challenges, increasing their farming efficiency.
- **Optimized Resource Use for Sustainable Agriculture:** IoT precision farming allows farmers to gather real-time data from sensors deployed across farms. With this input at their fingertips, farmers can make accurate decisions regarding resource allocation, ensuring that their crops receive the right amount of water, fertilizers, and other essential inputs.
- **End-to-end Control of the Production Process:** Farmers can respond swiftly to weather conditions, air quality, and humidity changes using prediction and real-time monitoring systems. This level of control helps them prevent potential damages while ensuring a more successful crop production cycle.
- **Reduced Wastage and Efficient Cost Management:** IoT solutions in farming play a crucial role in mitigating risks and reducing wastage by detecting anomalies and inconsistencies in crop production. Farmers can take immediate action to minimize waste and manage costs effectively.
- **A Cleaner Environment with a Greener Approach:** Farmers can minimize fertilizers & pesticides through precision farming techniques. It would lead to more organic crop production. And, this eco-friendly approach enables reducing the overall carbon footprint for agriculture initiatives while ensuring high-quality yields.
- **Enhanced Efficiency with Process Automation:** The introduction of IoT solutions has also automated various farming processes, such as demand-based fertilizing, irrigation, and robot harvesting. Farmers can optimize their operations, save time, and improve overall productivity by streamlining these tasks.

V. IMPACT OF INDUSTRIAL INTERNET OF THINGS(IIoT) ON AGRICULTURE

Industrial IoT (IIoT) has significantly impacted the agriculture industry. Today, it is revolutionizing traditional farming practices and enabling a new era of smart agriculture. Listed below are some of the critical impacts of IIoT in agriculture:

- Enhanced efficiency and productivity with remote monitoring of soil conditions, weather patterns, crop health, and equipment performance.
- Improved resource management with intelligent irrigation systems to adjust watering schedules based on real-time data, ensuring that crops receive the right amount of water at the right time.

- Enhanced crop monitoring and disease detection enable continuous monitoring of crops, allowing farmers to detect early signs of illness, nutrient deficiencies, or pest infestations.
- Livestock monitoring and management for livestock health, behavior, and environmental conditions to track parameters like body temperature, heart rate, feeding patterns, and location in real time.
- Data-driven decision-making helps farmers to leverage insights to optimize production processes, fine-tune resource allocation, and mitigate risks.
- Supply chain optimization with end-to-end visibility and traceability throughout the agricultural supply chain – from field to fork, data collected along the value chain can be tracked and analyzed, ensuring transparency, quality control, and food safety.

VI. CHALLENGES OF IoT IN SMART AGRICULTURE

If you're considering investing in an IoT-based smart agriculture system, then here are some challenges you should consider before taking the plunge:

- **Farm-specific Needs:** It is vital to understand your farm's specific needs & challenges. As a first step, it is essential to identify the areas where technology can bring the most significant improvements. It would include irrigation management, crop monitoring, livestock tracking, or supply chain optimization.
- **Data Management and Privacy:** Smart agriculture solutions generate vast data. Consider how the data will be collected, stored, analyzed, and managed. Address data privacy and security concerns to protect sensitive information about your farm operations and ensure compliance with relevant regulations.
- **Scalability and Flexibility:** Consider the ability of the solution that can adapt to the changing needs of your farm – as it grows or diversifies its operations. Ensuring that the solution can accommodate future expansions, additional sensors or devices, and evolving technologies is vital.
- **Interoperability and Integration:** As part of the process, it is essential to assess the compatibility of the proposed solution with existing farm equipment, machinery, and systems. The created solution must be able to integrate with other technologies or platforms you are already using. Importantly, seamless integration & interoperability will enable efficient data exchange and streamline farm management processes.
- **Regulatory and Environmental Factors:** Consider potential regulatory requirements or environmental considerations that might impact the implementation of innovative agriculture solutions. It is vital to ensure compliance with local laws, permits, and environmental regulations related to data collection, water usage, and pesticide application.
- **Vendor Selection:** In this case, the final step would be to choose a reliable & experienced vendor or technology provider. Before taking me on board – assess their track record, reputation, customer support services, and the availability of ongoing technical assistance. Evaluating their ability to provide long-term support, system updates, and troubleshooting is vital.

VII. CONCLUSION

The integration of IoT in agriculture holds immense potential. It revolutionizes cultivating crops, raising livestock, and managing our farms. And modern-day farmers are struggling to strike a balance between shrinking agricultural lands & depleting finite natural resources. Farmers can optimize resource utilization, enhance productivity, and make data-driven decisions to ensure sustainable and efficient farming practices by leveraging the power of connected devices, sensors, and data analytics with the help of an IoT consulting services provider.

With the world population increasing exponentially, the goal is to bridge the supply-demand gap. And here's where precision farming steps in as the ultimate problem solver. Smart farming goes way beyond the conventional approach, driving remarkable results. It slashes operational costs, boosts crop yields, and optimizes resource utilization – all in one go! And it doesn't stop there! IoT-powered smart solutions ensure farmers' profitability and prioritize environmental protection.

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