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SMART FIELDS: SUSTAINABLE FARMING THROUGH IoT

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ABSTRACT

Global increasing population is driving a change to more intelligent agricultural methods. Food security is a serious worry for most nations due to an increase in unpredictable weather patterns, dwindling natural resources, and a shortage of arable land. Consequently, the agricultural industry is using the Internet of Things (IoT) to boost production and operational efficiency. This article discusses the use of various IoT devices and the advantages they offer over conventional farming techniques. It also identifies the challenges and limitations of these devices in agriculture.

KEYWORDS: Agricultural drones, Farming techniques, Food security

INTRODUCTION

Sustainable agriculture makes it feasible to promote farming practices and strategies that maintain the sustainability of farmers and resources. Over time, India's total agronomic output has increased, while the country's share of farmers has declined, from 71.9% in 1951 to 42.3% in 2024. According to the 2018 Economic Survey, in 2050, the percentage of workers in agriculture will fall to 25.7% of the overall employment. Since the world is about to experience a digital revolution, now is the right moment to introduce and facilitate digital communication with farmers by using wireless technology to link the agricultural landform. IoT-based smart agriculture technology offers several benefits for all agricultural operations and procedures in real-time, such as plant protection, fertilization, irrigation, disease prediction, and improvement in product quality. Farmers may use the exact field view provided by today's sensor and communication technology to identify ongoing field operations without physically being there. Use of wireless sensors for different field operations provide higher resource use efficiencies, yields; accurate agricultural monitoring and early problem detection, thus protect from crop failures, save time and resources.

IoT IN AGRICULTURE

The Internet of Things (IoT) in agriculture refers to a network of physical objects embedded with electronics, software, sensors, and connectivity, which enables these objects to collect and exchange data. This concept builds on historical advancements, from 19th-century steam engines to 20th-century robotics and programmed machinery, evolving into the current era where big data, artificial intelligence, and IoT devices are revolutionizing farming practices. IoT leverages mobile devices, cloud-based intelligence, sensors, smart objects, and communication infrastructure to facilitate decision-making.

APPLICATIONS OF IOT IN AGRICULTURE

IoT technologies can be used for different purposes in agriculture such as for soil mapping and plant monitoring, irrigation management, weed management, crop protection, site-specific nutrient management, yield monitoring and forecasting etc.

A. Soil mapping and plant monitoring: Today, farmers can track the quality of their soil and take appropriate action to prevent soil degradation caused by erosion, alkalization, acidification, salinization, and pollution by using a variety of sensors and tools that monitor soil properties like water-holding capacity, texture, and absorption rate. Farmers can use sensors and mobile devices to monitor soil and ambient factors like leaf wetness, temperature, humidity, and crop quality from sowing to harvest, emphasizing the interplay between soil, plant, and environment for maximum agricultural output.

B. Smart irrigation management: - Predictions utilizing the irrigation index values may be employed for every field depending on slope or soil variability to increase water consumption efficiency. Information from sensors, satellite imagery, and climate data are coupled to the CWSI (crop water stress index) model for water need computation. Sensor based analysis of crop water requirements provide real time values that can be correlated with application amount.

C. Site-specific nutrient management: - Utilizing site-specific soil nutrient fertilization, smart agriculture reduces environmental effect while precisely estimating nutrient levels. Measurements are influenced by several factors such as crop type, soil type, yield objectives, and fertilizer type. Nutrient distribution patterns are estimated via IoT-based fertilizing strategies. This strategy makes use of satellite imagery as well as technology like GPS, geotagging, and driverless cars. Two efficient methods of management are chemigation and fertigation.

D. Agricultural Drones: - In smart farming using IoT, drones are being utilized to enhance a number of agricultural processes. Aerial-based and Surface-based are the two categories of agricultural drones. They

are used in tasks including crop health assessment, spraying, irrigation, crop monitoring, soil and field analysis

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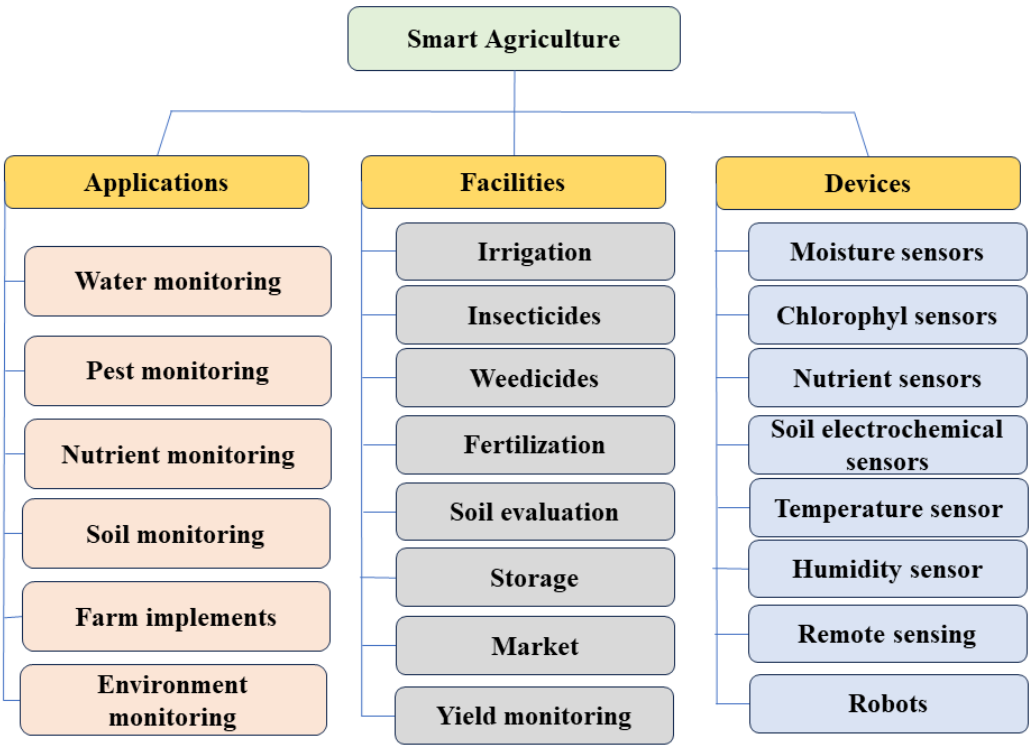

Figure 1: Overview of Smart Agriculture: Applications, Facilities, and Devices

E. Crop yield prediction and price forecast: Crop forecasting helps farmers with future planning and decision-making by predicting output before harvest. By observing characteristics like as fruit size and color, maturity establishes the ideal time for harvesting. Accurately determining when to harvest is essential to maximize crop yield and quality. A harvester's yield monitor that is linked to a smartphone app provides real-time harvest statistics and sends information to a web platform. Satellite pictures are used to assess fruit conditions and market potential, as well as to estimate and monitor agricultural productivity, especially for fruit crops.

F. Crop surveillance: Use of remote sensing, In-field sensors, IoT devices, data analytics and GIS (Geographic information systems) for monitoring insect pest infestation, disease diagnosis, nutrient deficiencies and other factors that can affect crop productivity. IoT enables surveillance of the crops by the farmers without physical presence.

G. Livestock monitoring and management: Use of location sensors by tying them to the neck or feet of the animal. These devices, with the help of satellites, continuously provide location data to the owner on

the mobile phone. Automated cleaning, feeding, and milking systems for cattle are made possible by IoT devices. Estrus, body temperature, rumen pH, and temperature are all detectable via sensors.

BENEFITS OF IoT IN AGRICULTURE

- Increased productivity and efficiency: IoT devices provide real-time data related to several parameters such as soil moisture, air and crop temperature, nutrient deficiency, pest and disease infestation on crop etc., thus on time management strategies can be applied which ultimately improve overall efficiency of the resources and productivity of the crops.
- *Resource optimization:* Reliable data produced by the sensors can be used for calculation of actual quantity of resources required by the crop. Wastage of water, fertilizers, pesticides and others can be minimized with real-time estimation.
- *Enhanced decision-making:* Farmers become able to make decisions related to crop management practices based on climate, soil and crop data generated by the sensor embedded devices.
- *Reduced environmental impact:* Better management of the inputs (Right time, method, quantity, place and source) reduces the burden of chemicals on environment.
- *Improved crop quality and yield:* Early detection of the pests, diseases and nutrient deficiencies helps in timely adoption of control measures, yield data can be generated by mounting sensors on harvesters. Based on this data resources can be supplied accordingly with the help of GIS, remote sensing and GPS (Global positioning system) technologies.

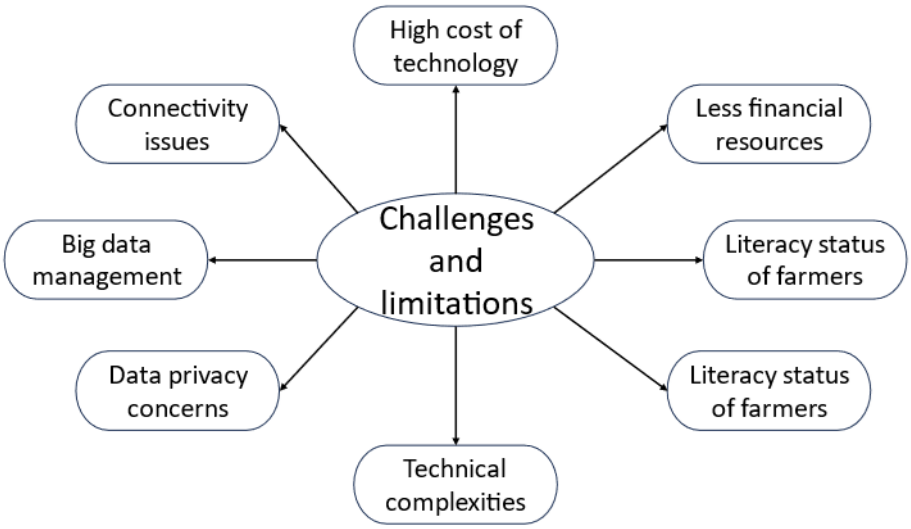

Figure 2: Key Challenges and Limitations in Smart Agriculture

CONCLUSION

World hunger is a pressing issue, and agriculture faces challenges like climate change and population growth. Innovative solutions like artificial intelligence (AI), IoT, and big data can revolutionize farming and increase production in poor countries. Technical breakthroughs and financial backing from organizations like governments, cooperatives, and FPOs can transform the agricultural industry, despite potential drawbacks like high prices and data management issues.

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