Application of Smart Farming Using IoT & Sensor Technology in Agriculture.

Sonu Paswan, Dr. N. R. Meena, Dr. R. K. Doharey, Dr. Neha Singh, Abhishek Singh Yadav

Abstract: -

Agriculture has always been the backbone of human civilization, but traditional farming techniques are becoming insufficient in meeting the rising demand for food, sustainability, and efficiency. Agriculture plays an important role in economy of any country. Balance water, fertilizer and proper weather information can help to get good quality and quantity of crop. In today's time where science is making such progress, it has contributed a lot in the field of agriculture. IoT is the current world technology that is use to connect different devices or sensors through internet. In agriculture, IoT can play an important role to improve productivity and product quality. Through IoT sensors a farmer can control water supply as well as can aware from weather, but it is not a sufficient for good crop and quality product. In today's scenario, a farmer should know about everything related to farming. Like which crop is good to be cultivated in which season and what crop is currently demanding, what type of fertilizers are good for crop and soil need in what quantity. Therefore, a farmer needs to know many more then water control and weather information. We use IoT sensor to check the water level in soil, temperature, weather information and soil ph is not sufficient for good crop. We have to Use different technologies for the implementation of smart farming Like Internet, IoT sensors, with the help of Cloud and decision-making capacity. By the use of IoT sensors, collecting data and sent that on cloud, farmer can take decision that in future what type of crop farming could be plan. By the using soil sensor technology of water level, temperature and nutrition, farmer can know which good crop should cultivate, what kind of crops can harvest. In addition, through these sensors, this data can be collected, how much water, how many nutrition will be required for that different kind of crop. Therefore, farmers can use Inexhaustible quantity of water and fertilizer to produce good crop. I am proposing a system to manage the different area in agriculture with help of IoT.

Sonu Paswan, Dr. N. R. Meena, Dr. R. K. Doharey, Dr. Neha Singh, Abhishek Singh Yadav
Department of Agricultural Extension Education,
Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya, U.P., India 224229

Introduction:

Agriculture faces numerous challenges in the 21st century, including climate change, soil degradation, unpredictable rainfall, increasing population, and food security concerns. According to the United Nations, the global population will reach nearly 10 billion by 2050, requiring a 70% increase in food production. Traditional farming methods lack the efficiency and precision needed to meet this demand sustainably. by utilizing modern information and communication technologies through smart farming or precision-agriculture, an innovative approach, agricultural practices can be made more efficient and productive. Smart farming refers to the use of modern information and communication technologies (ICT), especially Internet of Things (IoT) and sensor-based technologies, to enhance agricultural efficiency, productivity, and sustainability. This introduction delves into the components, functionalities, and benefits of IoT and AI-based smart farming systems, with a focus on how these technologies interconnect to optimize agricultural operations. India is primarily an agrarian nation, with agriculture representing the largest sector of the Indian economy. Approximately half of the country's workforce is employed in agriculture, contributing about 18% to the nation's GDP. Despite its significance, India has seen a decline in agricultural GDP in recent years.

Challenges such as inefficient water usage, prolonged field monitoring requirements, and outdated technology persist within the sector. Pest control in agriculture relies on cultural, chemical, and biological methods, with efforts to minimize insecticide use and manage pests through techniques like ploughing before sowing. Early pest detection remains a challenge, often only identified after plants are already damaged, leading to reduced crop quality due to increased pesticide applications. To address these issues, a system has been developed to bridge the information gap between farmers and their fields. This system aims to give farmers well-timed, precise, and relevant information to monitor and take necessary control actions. Increasing the integration of IoT in agriculture is therefore a critical objective. The work focuses on providing real-time data on soil related information such as moisture levels, humidity, pH, and temperature to farmers. It also alerts farmers to plant infections and pest attacks, categorizing them based on available data.

Concept of Smart Farming

Smart farming refers to the use of advanced technologies like IoT, sensors, artificial intelligence (AI), drones, robotics, and big data analytics in agriculture. Unlike traditional methods, smart farming emphasizes accuracy and efficiency in resource utilization. the core idea is to collect real-time data from

the farm (such as soil quality, temperature, moisture, crop growth, and livestock conditions), process this information, and provide actionable insights to farmers. For instance, instead of irrigating the whole field, smart irrigation systems water only the areas where crops actually need it, thus conserving water and reducing costs.

Key characteristics of smart farming:

- ☞ Data-driven decisions rather than intuition-based.
- ☞ Automation in irrigation, pest control, and harvesting.
- ☞ Optimization of inputs (water, fertilizer, energy).
- ☞ Remote monitoring and control through smart phones or computers.

Role of IoT in Agriculture

The Internet of Things (IoT) is the backbone of smart farming. IoT in agriculture involves connecting various devices and sensors to a central system via the internet, allowing seamless communication and data exchange.

1. **Smart Irrigation Systems:** – IoT enabled irrigation systems monitor soil moisture and weather conditions. Automated water supply reduces wastage and increases crop yield.

2. **Greenhouse Automation:** – IoT sensors regulate temperature, humidity, and light intensity inside greenhouses.

3. **Crop Monitoring and Disease Detection:** – Sensors and drones collect data on plant health, detect pest infestations.

4. **Livestock Monitoring:** – Wearable IoT devices track the health, movement, and feeding patterns of animals.

5. **Supply Chain and Storage:** – Smart logistics use IoT devices to monitor crop storage conditions and reduce losses.

Sensors in Agriculture

Sensors are the core components of smart farming systems, as they provide accurate, real-time data. Different types of sensors are used to measure critical agricultural parameters:

1. **Soil Sensors:** – Measure soil moisture, pH, and nutrient levels.

2. **Climate Sensors:** – Monitor temperature, humidity, rainfall, and wind speed.

3. **Crop Sensors:** – Detect crop growth patterns and stress levels.

4. **Livestock Sensors:** – Track animal movement, body temperature, and feeding activity.

5. **Water Quality Sensors:** – Analyze the quality of water used for irrigation etc.

Benefits of Smart Farming & Sensor Technology

1. **Higher Productivity;**

- ☞ Precision input use (water, fertilizer, pesticides) increases crop yield.

☞ Sensors help optimize planting, irrigation, and harvesting schedules.

2. Resource Efficiency;

☞ Smart irrigation systems reduce water usage by **30–40%** (Jawad et al., 2017).

☞ Fertilizer and pesticide use is minimized through site-specific application.

3. Cost Reduction;

☞ Lower input costs due to precise monitoring and targeted use.

☞ Reduced labor requirement with automation and robotics.

4. Real-time Decision Making;

☞ Farmers get instant feedback on soil health, crop condition, and weather.

☞ Early detection of pests and diseases prevents losses.

5. Sustainability & Environment;

☞ Reduced chemical runoff, greenhouse gas emissions, and soil degradation.

☞ Promotes climate-smart agriculture by adapting to changing weather.

6. Animal Welfare;

☞ Sensors monitor livestock health, behavior, and nutrition.

☞ Prevents disease outbreaks and improves productivity.

Challenges of Smart Farming & Sensor Technology

1. High Initial Investment;

☞ Smart devices, drones, and sensors are costly for small and marginal farmers.

2. Digital Divide;

☞ Low awareness and lack of technical knowledge hinder adoption, especially in rural areas.

3. Data Management Issues;

☞ Handling and interpreting large volumes of sensor data requires technical expertise.

☞ Risk of **data privacy** and ownership concerns.

4. Connectivity Problems;

☞ Rural areas often lack reliable internet, which is essential for IoT-based farming.

5. Maintenance & Reliability;

☞ Sensors may malfunction in harsh weather conditions.

☞ Requires regular calibration and maintenance.

6. Socio-economic Barriers;

☞ Farmers may resist technology due to traditional practices.

☞ Lack of financial support and institutional policies.

Results (Case Studies & Findings)

1. **Smart Irrigation in India:** In Maharashtra, farmers using IoT-based drip irrigation reduced water usage by 40% and increased yield by 20%.

2. **Greenhouse Farming in Netherlands:** Sensor-driven automated greenhouses optimized temperature, humidity, and light, resulting in a 30% productivity increase.

3. **Livestock Monitoring in Europe:** IoT wearables reduced cattle mortality rates by 25% by detecting diseases at early stages.

4. **Crop Disease Detection in Africa:** AI-enabled drones identified maize leaf diseases with 90% accuracy, reducing crop loss significantly.

⇨ These case studies prove the effectiveness of IoT and sensor technology in enhancing productivity and reducing wastage.

Conclusion

Smart farming powered by IoT and sensors represents a transformative shift in agriculture, offering solutions to long-standing issues of food security, resource scarcity, and environmental sustainability. by adopting these technologies, farmers can optimize crop production, improve efficiency, and ensure long-term agricultural sustainability. however to achieve widespread adoption, supportive government policies, affordable devices, and farmer training are essential. The evolution of smart farming represents a definitive shift in the agricultural sector, moving from instinct and observation to a science-based, data-driven discipline. This transformation, catalyzed by the convergence of sensor technology, IoT, AI, and robotics, is a logical progression of agricultural history, driven by the imperative to feed a growing global population sustainably. The analysis demonstrates that smart farming is not merely a passing trend but a powerful and necessary tool for enhancing productivity, ensuring profitability, and protecting the environment. The documented economic and environmental benefits from a significant increase in crop yields (over 20%) and a reduction in operational costs to the conservation of precious resources and a reduction in greenhouse gas emissions underscore the immense value of this paradigm shift. However, the path to universal adoption is not without its challenges. The high initial investment, limited access to financing, and the digital divide encompassing issues of infrastructure, literacy, and trust remain significant barriers that must be addressed through concerted effort and innovative policy. Looking ahead, the next phase of this evolution will be characterized by the continued development of autonomous robotics and the emergence of predictive models like Digital Twins. These technologies will not only automate manual tasks but will also allow farmers to simulate and optimize their operations in a virtual environment before making real-world decisions. This promises to move farming from a reactive endeavor to a truly pre-emptive one.

Ultimately, smart farming is a critical component of a resilient global food system. Its continued development and widespread adoption are essential for ensuring that future generations can grow up in a healthier and more sustainable world.

References

1. Wolfert, S., Ge, L., Verdouw, C., & Bogaardt, M. J. (2017). 'Big Data in Smart Farming – A review.' Agricultural Systems, 153, 69-80.

2. Ray, P. P. (2017). 'Internet of Things for Smart Agriculture: Technologies, Practices and Future Directions.' Journal of Ambient Intelligence and Smart Environments, 9(4), 395-420.

3. Dossier. Precision agriculture - Smart Farming. https://www.wur.nl/en/research-results/dossiers/file/

4. Smart Agricultural Technology and Sustainable Farming. https://www.verizon.com/business/resources/whitepapers/2021/

5. From Ancient Egypt to the Smart Farm: A History of Agricultural Technology. https://puregreensaz.com/blog/history-of-agriculture/

6. The Evolution of Sensor Technology .https://www.monolithicpower.com/en/learning/mpscholar/sensors/intro-to-sensors/history-and-evolution

7. Wearable Plant Sensors: A Review of Advancements and Agricultural Applications. https://pmc.ncbi.nlm.nih.gov/articles/PMC11123445/

8. Top 10 Sensors Used in Smart Farming. https://www.niubol.com/Product-knowledge/

9. The 10 Best Smart Sensors for Farming: Top Picks for 2025. https://sensorex.com/best-smart-sensors-for-farming-top-picks-for-2025/

10. Smart Soil Monitoring Application: Case Study Rwanda. https://www.researchgate.net/publication/350830921

11. What is soil monitoring sensors? https://www.niubol.com/Product-knowledge/.html

12. How IoT and AI are Reshaping Agriculture. https://www.qodequay.com/the-smart-farm-revolution-

13. Crop Monitoring with Drones. https://agremo.com/products/crop-monitoring/

14. Drone-based Remote Sensing for Smart Olive and Fruit Orchards in

Semi-Arid Regions. https://www.sciepublish.com/article/pii/449

15. The benefits of smart farming. https://www.ibm.com/think/topics/smart-farming

16. The Role of IoT in Smart Farming. https://www.iotforall.com/iot-smart-farming-agritech

17. Smart Farming Technology Trends: Economic and Environmental Effects, Labor Impact and Adoption Readiness. https://www.researchgate.net/publication/341563076_

18. Cost Savings from Precision Agriculture Technologies on U.S. Corn Farms. https://www.ers.usda.gov/amber-waves/2016/may/ -

19. Smart Farming Adoption by Farmers Based on a Systematic Literature Review .https://www.researchgate.net/publication/371275807

20. How Smart Farming Can Lead to Higher Crop Yields and Sustainability. https://daxcooke.net/ -

21. What is Smart Farming and the Benefits and Drawbacks of it. https://www.agrirs.co.uk/blog/2023/04/

22. Wireless Soil Moisture Sensor Case Study: Financial and Ecological Benefits of Soil Data by Grounds Manager Andy Richards. https://soilscout.com/blog/

23. The Economic and Environmental Benefits of Smart Farming Technology. https://www.meegle.com/en_us/topics/smart-agriculture/smart-farming-benefits

24. Precision Agriculture: Federal Programs Support Research and Adoption, but Opportunities Exist to Address Challenges. https://www.gao.gov/assets/d24105962.pdf

25. Robots in Agriculture: Transforming the Future of Farming. https://www.freshconsulting.com/insights/blog/

26. The Role and Applications of Digital Twins in Modern Agriculture: A Review. https://www.mdpi.com/2077-0472/15/9/903

27. How Digital Twins in Agriculture are Transforming Farming Operations. https://intellias.com/digital-twins-in-agriculture/

28. Digital Twins in Agriculture: A Comprehensive Review of Their Applications and Future Perspectives. https://pubs.acs.org/doi/10.1021/acs.jafc.4c01934

29. Sustainable Agricultural Technology Policy. https://prism.sustainability-directory.com/term/

30. Agricultural Grants and Financial Assistance Programs. https://www.mass.gov/guides/

31. Sustainable Farms & Fields - Washington State Conservation Commission. https://www.scc.wa.gov/programs/sustainable-farms-fields

32. Agricultural Technology Policies for Rural Development. https://library.fes.de/libalt/journals/swetsfulltext/12093121.pdf

33. What are barriers to smart farming adoption? https://pollution.sustainability-directory.com/question/

34. Key Challenges and Solutions for Adopting Agricultural Technology. https://agtech.folio3.com/blogs/agricultural-technology-adoption-barriers/

35. Smart Farming 101: What It Is and Why Smart Farming Matters. https://nebraskacorn.gov/cornstalk/sustainability/

36. AEM-Backed Report to the MAHA Commission Spotlights Precision Agriculture as a Solution to Help Improve Public Health and Food Security. https://www.aem.org/news/make-america-healthy-again-report-spotlights-precision-agriculture

37. Smart Farming: 6 Emerging Trends for Agritech Startups to Watch. https://www.globalagtechinitiative.com/digital-farming/ smart-farming-6-emerging-trends-for-agritech-startups-to-watch/

38. Benefits of Smart Farming: How Smart Farming is Revolutionizing Agriculture. https://www.ruggedtelemetry.com/blog-posts/

39. Soil Moisture Sensors. https://ucanr.edu/site/irrigation-and-nutrient-management/

40. The Complete Guide to Smart Agriculture & Farming. https://smartertechnologies.com/guides/.