

Role of Precision Agriculture in Modern Rice Cultivation

**Chinmoy deori^{1*}, P.
Chowdhury², Purabi
Tamuli Phukan³, Joyshikh
Sonowal⁴, Rasen bey⁵**

¹SMS (Agronomy), KVK
Sribhumi, Assam

²Senior Scientist and Head,
KVK Sribhumi, Assam

³SMS Horticulture, KVK
Sribhumi, Assam

⁴SMS Animal Science, KVK
Sribhumi

⁵Farm Manager, KVK Farm
Manager



Open Access

*Corresponding Author

Chinmoy deori*

Article History

Received: 24.06.2025

Revised: 29.06.2025

Accepted: 03.07.2025

This article is published under the
terms of the [Creative Commons
Attribution License 4.0](https://creativecommons.org/licenses/by/4.0/).

INTRODUCTION

Rice cultivation is a resource-intensive process, traditionally dependent on large quantities of water, fertilizers, and manual labor. As agricultural systems face increasing pressures from population growth, climate change, and environmental degradation, there is a need to shift towards more sustainable and efficient methods. Precision agriculture, also known as site-specific crop management (SSCM), leverages technology such as sensors, GPS, drones, and data analytics to optimize crop inputs and maximize yields.

In modern rice farming, precision agriculture helps monitor and manage variability within fields, enabling farmers to apply the right amount of input at the right time and place. This technological shift marks a significant evolution from conventional practices, ensuring improved productivity, environmental conservation, and economic viability.

2. Key Technologies in Precision Rice Farming

2.1 Geographic Information Systems (GIS) and GPS

GIS and GPS allow farmers to map fields accurately and identify spatial variability in soil properties, water distribution, and crop performance. This georeferenced data supports variable rate application and site-specific interventions.



2.2 Soil and Moisture Sensors

These sensors monitor soil moisture levels, temperature, pH, and nutrient content. In flooded rice fields, accurate water level control is essential. Soil sensors enable real-time irrigation decisions that conserve water and avoid over-flooding.

2.3 Remote Sensing and Drones

Multispectral and hyperspectral cameras mounted on drones or satellites capture high-resolution imagery. These images detect stress in rice plants due to pests, diseases, or nutrient deficiencies and help monitor crop health across large areas efficiently.

2.4 Variable Rate Technology (VRT)

VRT enables the site-specific application of inputs such as seeds, fertilizers, and pesticides based on data analysis. This reduces input costs and minimizes environmental impact by avoiding unnecessary application.

2.5 Artificial Intelligence and Machine Learning

AI algorithms analyze large datasets to identify patterns and support decision-making. Predictive models help forecast yields, pest outbreaks, and optimal harvest times based on weather and sensor data.



3. Applications in Modern Rice Cultivation

3.1 Precision Water Management

Water is critical in rice farming, and precision agriculture allows for optimized water usage through automated irrigation systems and sensor-guided water application. Technologies such as alternate wetting and drying (AWD) supported by sensors reduce water consumption by up to 30% without compromising yield.

3.2 Nutrient Management

Through soil testing and remote sensing, deficiencies in nitrogen, phosphorus, or potassium can be precisely identified. Fertilizers are then applied in targeted amounts, improving nutrient uptake and reducing runoff into waterways.

3.3 Pest and Disease Control

Early detection of diseases like rice blast or bacterial blight is made possible with drone imagery and AI. This allows for localized pesticide application, reducing costs and mitigating resistance build-up.

3.4 Yield Monitoring and Forecasting

Onboard sensors in harvesters collect yield data, which is analyzed to understand performance trends and guide future planting decisions. AI-driven forecasting tools help plan harvest logistics and market timing.

3.5 Labor Optimization and Automation

Precision agriculture reduces dependence on manual labor through mechanized seeding, weeding, spraying, and harvesting. Automation improves consistency, reduces human error, and lowers labor costs.

4. Advantages of Precision Agriculture in Rice Production

4.1 Improved Productivity

Precision farming enhances productivity by targeting particular requirements of the fields, enhancing crop health and yields. It optimizes planting, application of inputs, and harvest schedules with better-quality production and maximum yield.

4.2 Enhanced Resource Efficiency

Precision agriculture reduces wastage of water, fertilizers, and pesticides by using them only where and when required. This effective utilization of resources reduces the cost of production and substantially lowers environmental pollution, saving the surrounding ecosystems from excess usage and contamination.

4.3 Environmental Sustainability

Minimized chemical use and rational water management help sustain ecosystem balance. Methods such as Alternate Wetting and Drying (AWD) lower methane emission from flooded rice, serving to stem climate change and ensure sustainable agriculture.

4.4 Cost Saving

Although initial investments in precision agriculture technology may be high, farmers save money in the long run. These occur through rational input use, lower labor needs, and loss reduction in crops so that farming is more economically viable in the long run.

4.5 Evidence-Based Decision Making

Precision agriculture equips farmers with precise, real-time information, facilitating intelligent and strategic decision making. This move from reactive to proactive management enhances planning, boosts responsiveness to field conditions, and maximizes overall farm performance.

5. Challenges and Limitations of Precision Agriculture in Rice Cultivation

Whereas precision farming provides a paradigm-changing advantage for rice farming, various drawbacks prevent it from gaining widespread acceptance, especially from small and medium-scale farmers. Among the major challenges is the immense capital required to buy high-tech devices like drones, GPS-equipped devices, and sensor networks. Although these technologies prove to be inexpensive in the long term, they are economically out of reach without government incentives or cooperative funding.

- A major concern is also the insufficient technical skills and training. Proper application of precision tools requires an elementary grasp of digital technologies, the interpretation of data, and handling of equipment. Most farmers in developing countries do not have access to such training, thus hindering effective application.

- Connectivity limitations also pose a great obstacle. Real-time data tracking and cloud-based analysis necessitate stable internet connectivity, which in most rural rice-producing regions is not available or at best unstable.
- Additionally, technical services and routine maintenance of sensors and devices are needed for calibration and maintenance purposes, leading to higher operational expense and complexity.
- Finally, data ownership and privacy are big issues. With more farm data being housed and interpreted on outside platforms, questions of who owns this sensitive data have risen. Having secure and open use of data is required to foster trust and inspire wider uptake.

6. Future Prospects

Rice cultivation's future is scalable, low-cost precision agriculture systems that are made available for all farmers. A number of advancements are likely to lead to the next wave of adoption:

- Low-cost sensor sets and mobile platforms will bring technology within the reach of small farmers.
- Advisory systems enabled by AI will make real-time advice accessible via smartphones.
- Blockchain integration can enhance traceability and transparency in the rice supply chain.
- Government incentives and public-private partnerships can reduce barriers to adoption and encourage technology dissemination.

With escalating climate change and increasing global food demands, the contribution of precision agriculture in rice farming will be progressively important. Prioritizing training, infrastructure, and policy support will be important to facilitate far-reaching and equitable adoption.

7. CONCLUSION

Precision agriculture is transforming the future of rice production by changing how farmers use resources, react to environmental conditions, and optimize productivity. With data and technology, rice farmers can transition toward more sustainable, efficient, and profitable agricultural systems. As challenges remain, steady innovation and enabling policy environments provide promising answers. Steady development and implementation of precision agriculture will be

key to securing food and environmental sustainability in the 21st century.

REFERENCES

- Amin, M., Rowshon, M., & Aimrun, W. (2011). Paddy water management for precision farming of rice. *Current Issues of Water Management. InTech*, 107-142.
- Iida, S. (2023). Precision Agriculture in Rice Farming. In *Precision Agriculture: Modelling* (pp. 239-250). Cham: Springer International Publishing.
- Kassam, A., & Brammer, H. (2016). Environmental implications of three modern agricultural practices: Conservation agriculture, the system of rice intensification and precision agriculture. *International Journal of Environmental Studies*, 73(5), 702-718.
- Radočaj, D., Jurišić, M., & Gašparović, M. (2022). The role of remote sensing data and methods in a modern approach to fertilization in precision agriculture. *Remote Sensing*, 14(3), 778.
- Raj, E. F. I., Appadurai, M., & Athiappan, K. (2022). Precision farming in modern agriculture. In *Smart agriculture automation using advanced technologies: Data analytics and machine learning, cloud architecture, automation and IoT* (pp. 61-87). Singapore: Springer Singapore.