Original Article
ISSN (Online): 2582-7472

ShodhKosh: Journal of Visual and Performing Arts
June 2024 5(6), 2779–2783

ADVANCED TECHNOLOGIES IN AGRICULTURE

Sarvapriya Singh [1]

[1] M. SC Geography VMOU Kota, India

DOI
10.29121/shodhkosh.v5.i6.2024.5937

Funding: This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

ABSTRACT

Modern agriculture increasingly relies on advanced technologies to improve productivity, resource management, and sustainability. Three key technologies transforming the agricultural landscape are Remote Sensing, Global Positioning System (GPS), and Geographic Information Systems (GIS). These tools form the backbone of precision agriculture, enabling data-driven decisions that optimize crop production and environmental stewardship.

Remote sensing, GPS, and GIS are vital technologies in modern agriculture, playing a crucial role in enhancing precision and efficiency. GPS (Global Positioning System) is widely used in precision farming, enabling accurate farm planning, field mapping, soil sampling, crop scouting, and yield monitoring. It allows farmers to operate efficiently even under low-visibility conditions such as rain, dust, fog, and darkness. Through GPS, essential agricultural data—such as field slope, soil nutrient levels, and crop yield—can be continuously tracked and recorded, contributing to the development of extensive agricultural databases.

GIS (Geographic Information System) complements GPS by storing, managing, and analyzing the spatial data collected, offering deeper insights into field variability and aiding in decision-making. Remote sensing further enhances this process by providing real-time and large-scale monitoring of crop health, moisture levels, and land use.

This paper explores how the integration of remote sensing, GPS, and GIS can significantly improve agricultural practices, promoting more sustainable, efficient, and data-driven farming methods.

Keywords: Agriculture, Remote Sensing, GIS (Geographic Information System), GPS (Global Positioning System), Precision Farming

1. INTRODUCTION

Crops' health and growth can be effectively monitored using remote sensing by analyzing spectral data obtained from satellites, airborne sensors, or ground-based instruments. This data helps farmers identify areas of their fields that may require additional attention, such as irrigation, fertilization, or pest management. Global Positioning Systems (GPS) are used to determine the precise location of agricultural features, while Geographic Information Systems (GIS) are employed to record, manage, and visualize this information on maps. Together, remote sensing and GIS provide powerful tools to collect, store, analyze, and interpret data from virtually any geographic location on Earth.

One of the critical applications of remote sensing in agriculture is soil moisture and irrigation management, enabling efficient use of water resources. In addition, remote sensing and GIS technologies are widely used for real-time weather analysis, flood forecasting, and monitoring crop areas affected by natural disasters such as heavy rainfall or flooding.

Over the past few decades, the use of Remote Sensing and GIS has expanded significantly across various sectors, particularly in agriculture. These technologies allow for the reliable observation of natural and man-made features and phenomena on the Earth's surface without direct physical contact. Today, farmers increasingly rely on these technological advancements to improve decision-making, increase productivity, and manage resources efficiently. In this paper, we will explore the diverse applications of remote sensing and GIS in agriculture and how they contribute to sustainable and data-driven farming practices.

Remote sensing plays a crucial role in predicting expected crop yield and estimating the quantity and quality of crops under various environmental and management conditions. It aids in assessing crop progress, detecting crop damage, and calculating the proportion of damaged versus healthy crops remaining in the field. This technology enables accurate monitoring of agricultural production, which is essential for food security and planning.

Remote sensing can also be used to study the planting systems of different crops, providing valuable insights into planting density, crop distribution, and spatial variations. In horticulture, remote sensing technologies are employed to monitor flower growth, enabling the analysis of growth patterns and prediction of flowering behavior under various conditions.

Additionally, remote sensing allows for the identification of unusual crop characteristics or anomalies that may indicate stress, disease, or nutrient deficiencies. The data collected through satellite or aerial imagery can be further analyzed in laboratories to study various aspects of crop physiology and cultivation practices.

One of the major advantages of remote sensing is its ability to estimate land area and field size without manual intervention, which is especially useful for large-scale agricultural planning. It can assess crop health conditions, detect plant stress, and evaluate overall vegetation vigor. These insights help in making timely decisions regarding irrigation, fertilization, and pest control.

A primary application of remote sensing in agriculture is the assessment of vegetation dynamics using indices such as the Normalized Difference Vegetation Index (NDVI). NDVI is derived from satellite imagery by calculating the difference between near-infrared (which vegetation strongly reflects) and red light (which vegetation absorbs). It serves as a reliable indicator of green biomass, which correlates with crop health. By using NDVI, researchers and farmers can monitor crop phenology—the stages of plant growth—and understand how crops respond to weather and climatic changes throughout the growing season.

Remote sensing technology has become an essential tool in modern agriculture, enabling farmers to observe and analyze a wide range of factors such as soil types and weather patterns. This information is crucial for forecasting optimal planting and harvesting periods for different crops. By evaluating crop quality and land area, both farmers and agricultural experts can accurately predict expected yields.

One of the key benefits of remote sensing is its ability to detect pest infestations in agricultural fields. It provides timely and accurate data that can be used to implement targeted pest control strategies, thereby reducing crop damage and improving overall plant health.

Remote sensing is also highly effective in monitoring changes in farming systems and land management, which often lead to soil degradation and negatively impact both current and future agricultural productivity. Through micro-nutrient mapping, farmers can gain detailed insights into critical soil properties such as soil pH, organic matter content, texture, and nutrient availability. These indicators are often inferred by observing surface vegetation characteristics and growth patterns.

Furthermore, remote sensing enables the monitoring of soil moisture, a crucial factor in determining soil health and crop suitability. With accurate soil moisture data, farmers can estimate the moisture levels necessary for specific crops and assess whether irrigation is required. This helps in drought management, efficient water use, and crop selection based on soil-water compatibility.

Another important application is soil mapping. Remote sensing allows for large-scale, detailed mapping of soil types, helping farmers understand which soils are best suited for specific crops and which fields may need soil treatment or irrigation. This kind of data-driven decision-making enhances farm productivity and promotes sustainable land use.

Remote sensing technology plays a crucial role in monitoring weather patterns and drought conditions over agricultural land. By analyzing this data, experts can predict rainfall patterns and estimate the time intervals between current and future rainfall events, which is valuable for maintaining drought records and planning irrigation schedules effectively.

Remote sensing is also instrumental in assessing and designing land cover maps for specific regions. This capability allows experts to identify areas of land degradation and distinguish them from those still in good condition. Such information is critical in implementing effective land management practices and combating land degradation proactively.

In addition, remote sensing helps in identifying soil-related problems during the planting season to ensure optimum crop yields. One key application is the detection of nutrient deficiencies in crops. By analyzing spectral data, remote sensing can reveal the presence and extent of nutrient imbalances in plants. This enables timely interventions, such as targeted fertilization, to restore nutrient levels and enhance crop health and productivity.

A unique strength of remote sensing technology is its ability to extract data on the reflectance characteristics of crops. Reflectance values are closely linked to soil moisture content and the nutritional status of the crop, both of which significantly influence crop development and yield. This non-invasive and large-scale monitoring capability allows for more informed and precise agricultural decision-making.

Remote sensing technology enables precise determination of soil moisture content and the estimation of water content within crops. By integrating data on crop quality, soil moisture levels, and land cover, agricultural experts can accurately predict expected crop yield during the planting season. This holistic approach supports efficient farm planning and yield forecasting.

In addition to yield estimation, remote sensing allows for the mapping of flood-affected areas and identification of regions with poor drainage. Such data is invaluable for implementing preventive measures to reduce the risk of future flooding. Furthermore, historical and real-time weather data can be collected and stored, forming a robust foundation for climate prediction and informed agricultural decision-making.

An advanced application of remote sensing and GIS is natural catastrophe modeling, which uses probabilistic methods to estimate and forecast the risks of natural hazards. This involves risk mapping, hazard analysis, and simulation models that combine historical disaster data with modern information technologies. In the case of floods, flood risk maps are generated using hydrological and remote sensing data, estimating the depth of inundation. Areas with higher predicted flood depths are assigned higher hazard scores, aiding in disaster preparedness and risk mitigation.

Remote sensing also facilitates the collection of vital crop data, including crop rotation patterns, planting cycles, and crop diversity across different soil types. This information is critical for sustainable land use and optimizing crop productivity.

Moreover, remote sensing plays a key role in mapping water resources in agricultural regions. Through satellite imagery and spectral analysis, farmers can gain detailed insights into the availability, distribution, and adequacy of water resources in their fields, enabling better irrigation planning and water conservation.

Remote sensing technology plays a crucial role in advancing precision agriculture, allowing for the cultivation of healthier crops and enabling farmers to harvest at the optimal time. This technology supports improved decision-making across the agricultural cycle—from planting to harvesting—by providing timely and accurate data.

One of its key applications is in monitoring climate change and maintaining a comprehensive record of climatic conditions over time. This information is instrumental in determining suitable crop types for specific regions based on climate trends and variability.

Remote sensing also assists in record-keeping and compliance monitoring, ensuring that farmers adhere to standardized agricultural practices. It provides transparency and accuracy in planting schedules and harvesting timelines, contributing to increased efficiency and accountability in farming operations.

In terms of soil management, remote sensing enables the collection and analysis of soil data from agricultural fields. This supports the evaluation of soil properties, helping to guide soil treatment and fertilization practices for better crop performance.

Furthermore, remote sensing can estimate air moisture levels, providing insight into the humidity of specific areas. Understanding humidity is crucial for determining the most suitable crops for cultivation under particular environmental conditions.

Another significant application is the analysis of crop health. Remote sensing detects variations in vegetation indices, which can be used to assess crop vigor and stress levels, ultimately allowing for the estimation of crop yield.

Finally, remote sensing supports the mapping of agricultural land for multiple purposes, including landscape planning, crop zoning, and soil suitability analysis. These capabilities make remote sensing an indispensable tool in precision agriculture, enabling more efficient land use and improved agricultural outcomes.

2. CONCLUSION

After examining the various technologies applied in agriculture—namely Remote Sensing, GIS (Geographic Information Systems), and GPS (Global Positioning System)—it is evident that they play a transformative role in improving land and crop assessment. These tools allow for more accurate determination of erosion control, long-term cropping strategies, tillage system assessments, and salinity management, all through the use of high-resolution spatial and spectral data.

Modern farmers are increasingly adopting these advanced technologies, working alongside agricultural professionals and leveraging GPS and computing tools to enhance productivity. As such, GIS, GPS, and remote sensing are not just support tools—they are becoming foundational elements of precision agriculture.

Remotely sensed data enables early identification of a wide range of plant-related issues, including weed infestations, irregular plant populations, wind or hail damage, water stress, nutrient deficiencies, insect attacks, and herbicide injuries. In variable rate applications of pesticides and fertilizers, the spatial information collected via remote sensing is used to create base maps, guiding targeted interventions. This approach ensures that only affected areas are treated, reducing costs and environmental impact.

Furthermore, ranchers can use remote sensing to monitor weed invasions, identify overgrazed lands, and locate optimal grazing zones. These technologies not only increase operational efficiency but also support sustainable land management.

In conclusion, the integration of remote sensing, GIS, and GPS has proven to be highly beneficial in modern agricultural practices, offering data-driven solutions to traditional farming challenges. Their continued use and development will be essential for addressing the demands of global food production and sustainable resource management.

CONFLICT OF INTERESTS

None.

ACKNOWLEDGMENTS

None.

REFERENCES

Abha Chhabra, Manjunath, K. R., & Panigrahy, S. (2010). Non-point source pollution in Indian agriculture: Estimation of nitrogen losses from rice crop using remote sensing and GIS.

Acharya, S. M., Pawar, S. S., & Wable, N. B. (2018). Application of Remote Sensing & GIS in Agriculture. International Journal of Advanced Engineering Research and Science (IJAERS), 5(4).

Akshay, M., & Masdekar, M. (2018). Precision agriculture – A modern approach to smart farming. International Journal of Scientific & Engineering Research, 9(2). ISSN 2229-5518.

Bambang, R., Windiastuti, R., & Rudiastuti, A. W. (2018). Spatial modeling for selection of agricultural potential site. International Journal of Advanced Engineering Research and Science (IJAERS), 5(9).

Taloor, A. K., Meraj, G., Kanga, S., Singh, S. K., Đurin, B., & Anand, S. (2021). Climate vulnerability and economic determinants: Linkages and risk reduction in Sagar Island, India – A geospatial approach. Quaternary Science Advances.

Bhatt, C. M., et al. (2017). Satellite-based assessment of the catastrophic Jhelum floods of September 2014, Jammu & Kashmir, India. Geomatics, Natural Hazards and Risk, 8(2), 309–327.

Gupta, D., Kushwaha, A., Sikander, M., & Trivedi, S. (2014). Precision agriculture for drip irrigation using microcontroller and GSM technology. International Journal of Engineering Research and Applications, 4(6, Version 5), 229–233.

Shivanand, H. K., Puneeth, P., & MeghaShree, K. A. (2020). Analysis on application of GIS and GPS in sugarcane agriculture. International Journal of Scientific Research in Science and Technology, 7(6), 354–357.

Goswami, S. B., Matin, S., Saxena, A., & Bairagi, G. D. (2012). A review: The application of remote sensing, GIS and GPS in precision agriculture. International Journal of Advanced Technology & Engineering Research (IJATER), 2(1).

J., Kanga, S., Singh, S. K., & Sudhanshu, S. (2021). Cadastral-level soil and water conservation priority zonation using geospatial technology. International Journal of Agriculture System, 9(1), 10–26.

Joy, J., Kanga, S., & Singh, S. K. (2019). Kerala flood 2018: Flood mapping by participatory GIS approach, Meloor Panchayat.

Kanga, S., Rather, M. A., Farooq, M., & Singh, S. K. (2021). GIS-based forest fire vulnerability assessment and its validation using field and MODIS data: A case study of Bhaderwah Forest Division, Jammu and Kashmir (India). Indian Forester, 147(2), 120–136.

Kanga, S., Sheikh, A. J., & Godara, U. (2020). GIscience for groundwater prospect zonation. Journal of Critical Reviews, 7(18), 697–709.

Kanga, S., Kumar, S., & Singh, S. K. (n.d.). Climate-induced variation in forest fire using remote sensing and GIS in Bilaspur District of Himachal Pradesh. International Journal of Engineering and Computer Science.

Liaghat, S., & Balasundram, S. K. (2010). A review: The role of remote sensing in precision agriculture. American Journal of Agricultural and Biological Sciences, 5(1), 50–55.

(2010). Impacts of climate change on agriculture sector using GIS technology. ISO 9001:2008 Certified Journal.

Chauhan. (n.d.). Land suitability and capability by integrating remote sensing and GIS for agriculture in Chamarajanagar district, Karnataka, India.

Nathawat, M. S., et al. (2010). Monitoring and analysis of wastelands and its dynamics using multi-resolution and temporal satellite data in part of Indian state of Bihar. International Journal of Geomatics and Geosciences, 1(3), 297–307.

Pandey, A. C., Singh, S. K., & Nathawat, M. S. (2010). Waterlogging and flood hazards vulnerability and risk assessment in Indo-Gangetic Plain. Natural Hazards, 55(2), 273–289.

Pandey, A. C., Singh, S. K., Nathawat, M. S., & Saha, D. (2013). Assessment of surface and subsurface waterlogging, water level fluctuations, and lithological variations for evaluating groundwater resources in Ganga Plains. International Journal of Digital Earth, 6(3), 276–296.

Salam, M. A., & Saha, S. K. (1998). Crop inventory using remote sensing and Geographical Information System (GIS) techniques. Journal of Remote Sensing and Environment, 2.

Shanmugapriya, S., Rathika, S., Ramesh, T., & Janaki, P. (2019). Applications of remote sensing in agriculture – A review. International Journal of Current Microbiology and Applied Sciences, 8(1), 2270–2283.

Singh, S. K., & Pandey, A. C. (2014). Geomorphology and the controls of geohydrology on waterlogging in Gangetic Plains, North Bihar, India. Environmental Earth Sciences, 71(4), 1561–1579.

Singh, S. K., Mishra, S. K., & Kanga, S. (2017). Delineation of groundwater potential zone using geospatial techniques for Shimla city, Himachal Pradesh (India). International Journal for Scientific Research and Development, 5(4), 225–234.