Nepalese Journal of Agricultural Sciences, January, 2025, Volume 28
eISSN 2091-0428; pISSN 2091-041X; esjindex ID = 6279

KRISHIDRISHTI: TRANSFORMING NEPALESE FARMING INTO PRECISION AGRICULTURE WITH SATELLITE AND DIGITAL TECHNOLOGY

[1,2*]**Shakriya PANDEY,** [3]**Bidur P. CHAULAGAIN,** [2]**Bikram THAPA,**[2,3]**Shrisha PANDEY**

[1]St.Xavier's College, Maitighar, Tribhuvan University Kathmandu, Nepal
[2]BOTS Industries Pvt Ltd, Kathmandu, Nepal
[3]Himalayan College of Agriculture Sciences and Technology, Nepal
[4]Saraswati Multiple Campus, Kathmandu, Nepal
[*]**Corresponding Author's email**: pandayshakriya@gmail.com

ABSTRACT

Satellite remote sensing has emerged as a transformative tool in modern agriculture, providing real-time, large-scale, and cost-effective solutions to enhance both productivity and sustainability. This paper reviews the current applications of satellite data in agriculture, with a particular focus on its potential in Nepal. By examining global use cases in crop health monitoring, soil moisture estimation, weather pattern analysis, and land use classification, the paper emphasizes the value of integrating satellite technology into Nepal's agricultural practices. It also explores the challenges of data accessibility, technical expertise, and policy integration, offering recommendations for overcoming these barriers to foster sustainable agricultural development. The paper introduces KrishiDrishti, a platform designed specifically for Nepal that uses satellite data to deliver actionable insights, empowering farmers and policymakers with tools for precision agriculture. By leveraging the potential of KrishiDrishti, this platform supports the transition to more efficient and climate-resilient farming practices, showcasing its transformative potential in Nepal's agricultural sector.

Keywords: Agricultural information technology, Data-driven agriculture, Precision agriculture, Satellite remote sensing

INTRODUCTION

Agriculture accounts for approximately 27% of Nepal's GDP and employs more than 65% of the population, making it a cornerstone of the country's socio-economic development (World Bank, 2023). Despite Nepal's rich agro-

biodiversity and diverse agro-climatic zones, the sector faces persistent challenges, including low productivity, reliance on traditional methods, and vulnerability to climate variability. Farming practices are predominantly traditional and subsistence-based, shaped by fragmented landholdings and reliance on rain-fed systems. Outdated methods, limited access to modern technologies, and inadequate infrastructure further constrain efficiency and sustainability. Additionally, insufficient market access and underinvestment in research and development exacerbate these challenges. As a result, Nepal's agricultural sector remains underdeveloped, underscoring the urgent need for innovative solutions such as precision agriculture and climate-resilient technologies to enhance productivity, ensure food security, and drive sustainable development.

As a prior success story of such kinds of endeavors, satellite technology has proven to be a game-changer in addressing agricultural challenges. For instance, India's Crop Cutting Experiment, which integrates satellite data to assess crop production, resulted in a 20% improvement in yield predictions and reduced the cost of field surveys by 30% (Srivastava et al., 2020). Similarly, the United States' use of NASA's Landsat imagery has helped optimize fertilizer application and detect pest outbreaks, saving an estimated $1 billion annually in agricultural losses (Mulla, 2013). In Brazil, the National Institute for Space Research employs Moderate Resolution Imaging Spectroradiometer (MODIS) data for soybean crop health monitoring, which has led to a 15% reduction in yield losses caused by undetected stress factors (Hansen et al., 2013). These global examples underscore the transformative potential of satellite data to enhance agricultural efficiency and sustainability.

Nepal's diverse geography and climate necessitate customized satellite data applications. While global methodologies offer valuable insights, their implementation in Nepal must address unique challenges, such as fragmented landholdings, varied agro-climatic zones, and limited infrastructure. Digital technologies integrated with satellite data can provide precise solutions for irrigation, weed management, plant health, soil nutrition, fertilizer applications, and disease diagnosis, enabling precision agriculture tailored to Nepal's needs (Pudasainee et al., 2020). KrishiDrishti, a pioneering platform developed specifically for Nepal, bridges this gap by delivering localized, actionable satellite data in a user-friendly format. Through features such as real-time crop monitoring, soil moisture analysis, weather forecasting, and land use mapping, KrishiDrishti empowers farmers and policymakers to adopt precision farming practices. These innovations promise not only to boost productivity and resilience but also to foster sustainable agricultural development in Nepal.

What is KrishiDrishti?

KrishiDrishti is a cutting-edge platform developed by the team at BOTS Industries to address Nepal's unique agricultural challenges. This platform leverages satellite remote sensing technology with resolutions of up to 1x1 km, integrated with data from an in-house-built ground station. It is specifically designed for researchers, policymakers, and farmers, providing actionable insights through advanced data processing and visualization tools.

KrishiDrishti generates detailed graphs and maps to help users analyze critical agricultural parameters (Figure 1). The platform also offers a user-friendly website and plans to include a mobile application, providing customized suggestions tailored to farmers' specific needs. Additionally, the platform facilitates students and researchers conducting research works or case studies by simplifying the process of data extraction and analysis. Designed to bridge the gap between satellite data and on-ground application, KrishiDrishti aims to facilitate sustainable agricultural practices and data-driven decision-making. It is a versatile tool that supports academic research, policymaking, and daily farming activities, thus serving as a comprehensive resource for stakeholders across the agricultural value chain.

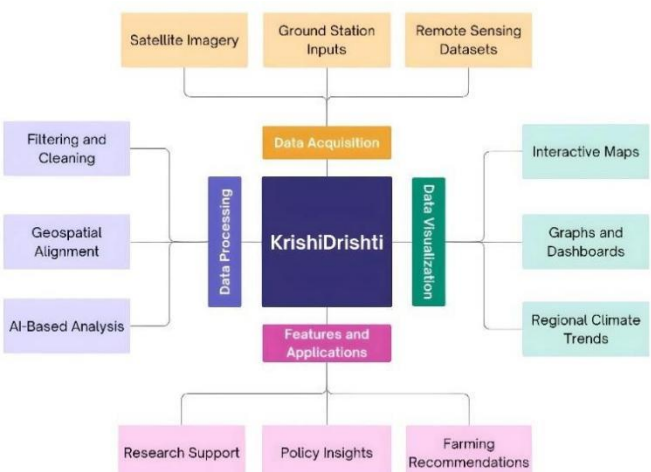

Figure 1. Visual Representation of the KrishiDrishti Platform

Technical Features of KrishiDrishti

KrishiDrishti integrates multiple technical features to provide comprehensive support for agricultural activities. The platform utilizes high-resolution satellite data alongside in-house ground station inputs to generate real-time, location-specific insights. The data integration capabilities allow for multi-layered analysis, including vegetation health indices, soil moisture levels, and weather patterns. These insights are visualized through interactive graphs and maps, enabling users to make informed decisions with ease.

One of the standout features of KrishiDrishti is its predictive analytics engine, which combines historical and real-time data to forecast crop yields, irrigation needs, and potential risks such as pest outbreaks. The platform's mobile-friendly design ensures accessibility, even for farmers in remote areas, while its modular structure supports customization based on specific regional or crop-related requirements. This adaptability makes KrishiDrishti an indispensable tool for promoting precision agriculture and ensuring sustainable farming practices in Nepal.

Leveraging Satellite Data for Agricultural Innovation with KrishiDrishti

Crop health monitoring

KrishiDrishti leverages satellite-derived vegetation indices such as the Normalized Difference Vegetation Index (NDVI) and Enhanced Vegetation Index (EVI) to deliver real-time insights into crop health. By identifying areas experiencing stress from pests, diseases, or nutrient deficiencies, the platform enables farmers to implement targeted interventions (Figure 2).

The platform also integrates historical and current satellite data to predict crop yields, helping farmers and policymakers prepare for market demands. By combining plant health data with environmental factors, KrishiDrishti offers a predictive framework that enhances decision-making for agricultural output. Furthermore, the platform provides customized alerts and recommendations based on satellite observations, ensuring that farmers apply fertilizers and irrigation optimally, reducing waste and improving sustainability.

Successful precedents highlight the potential of such applications. In India, the Indian Space Research Organization (ISRO) uses satellite data in its Crop Cutting Experiment to assess production and identify stressed areas, improving accuracy and resource efficiency (Srivastava et al., 2020). NASA's Landsat imagery in the United States has been instrumental in detecting pest outbreaks and optimizing fertilizer application, leading to cost savings and improved crop quality (Mulla,

2013). In Brazil, the National Institute for Space Research monitors soybean crop health using MODIS data, reducing yield losses by 15% (Hansen et al., 2013). These successful methodologies exemplify the capabilities KrishiDrishti can bring to Nepal's agriculture, enhancing food security and promoting economic stability.

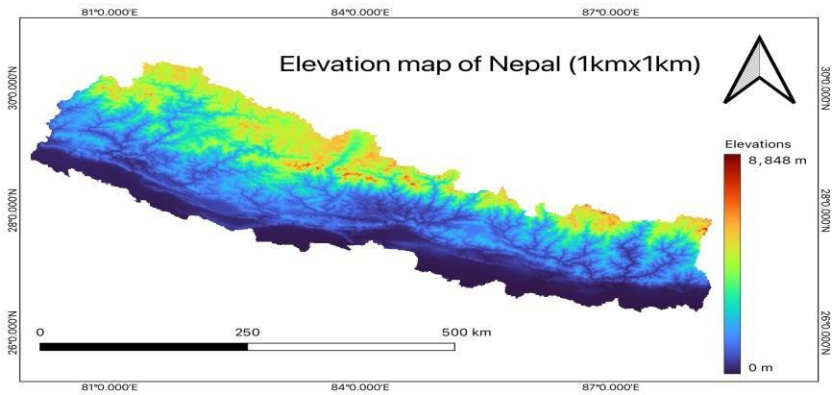

Figure 2. Elevation map of Nepal generated through KrishiDrishti. The figure helps to highlight diverse elevation zones of Nepal, aiding crop health monitoring through altitude-based vegetation indices and stress analysis

Soil Moisture Estimation

KrishiDrishti utilizes microwave remote sensing data to generate accurate soil moisture maps tailored to Nepal's agricultural context. By identifying regions with moisture deficits, the platform enables efficient irrigation planning, optimizing water use across the country. In drought-prone areas, KrishiDrishti facilitates the early detection of water stress, empowering farmers and policymakers to implement proactive mitigation strategies. These insights are particularly valuable for rainfed farming systems, where the platform assists in determining optimal planting schedules to maximize productivity.

Drawing on successful precedents, NASA's Soil Moisture Active Passive (SMAP) mission has mapped soil moisture deficits in Africa, supporting the implementation of effective drought mitigation strategies (Entekhabi et al., 2010). In Australia, SMAP data aids water resource management in arid regions, enhancing crop resilience (Walker et al., 2014). Similarly, the European Space Agency's (ESA) Sentinel-1 radar data plays a crucial role in irrigation planning and water conservation across Mediterranean agricultural systems (Janssen et al., 2021). By incorporating these successful applications, KrishiDrishti ensures

equitable water distribution for farming and promotes sustainable irrigation practices throughout Nepal (Figure 3).

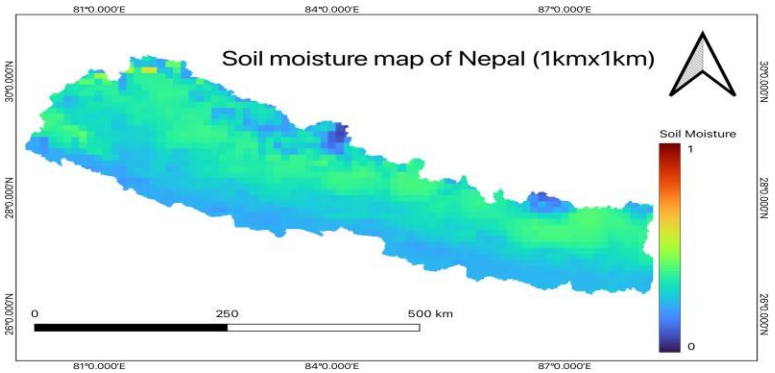

Figure 3. Volumetric soil water map of Nepal generated by KrishiDrishti. The map shows soil moisture distribution across Nepal, supporting irrigation planning and drought management.

Weather Pattern Analysis and Weather Forecasting

KrishiDrishti integrates advanced weather forecasting models with local satellite data to enhance Nepal's agricultural resilience. By providing accurate predictions on monsoon onset, duration, and intensity, the platform plays a crucial role in planning crop cycles. Real-time alerts about extreme weather events enable farmers to take proactive measures to protect their crops and livestock. Additionally, KrishiDrishti tracks long-term climate trends, facilitating the design of sustainable, climate-resilient farming strategies (Fig. 4).

Looking at similar applications globally, Fengyun satellites in China predict typhoon impacts and drought trends, offering critical protection to vulnerable agricultural regions (Zhang et al., 2017). In India, a collaborative effort between the India Meteorological Department (IMD) and satellite agencies has enabled precise monsoon tracking, benefiting millions of farmers (Srivastava et al., 2020). The United States' National Oceanic and Atmospheric Administration (NOAA) combines weather models and satellite data to improve early warning systems for hurricanes and frost, thereby safeguarding agricultural yields (Mulla, 2013). With comparable capabilities, KrishiDrishti seeks to empower Nepalese farmers, helping them adapt to changing weather patterns and protect their livelihoods.

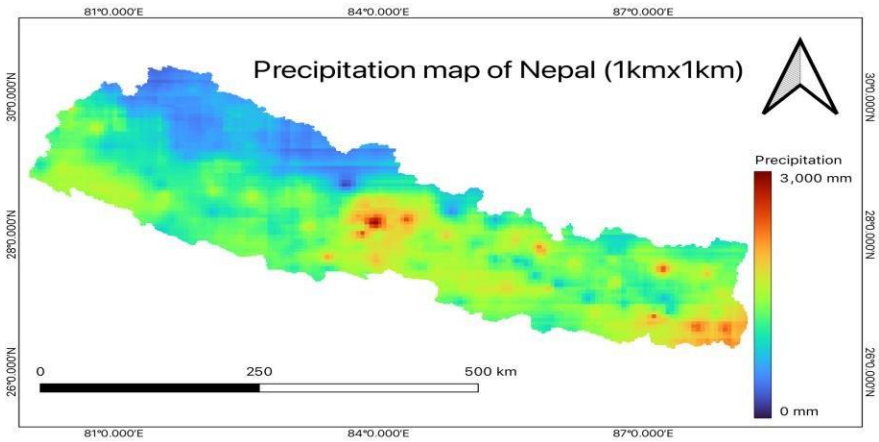

Figure: Precipitation Map of Nepal Generated by KrishiDrishti

Visualizes precipitation patterns across Nepal, aiding weather analysis and agricultural planning by identifying rainfall variability.

Figure 4. Precipitation map of Nepal generated by KrishiDrishti. This map visualizes precipitation patterns across Nepal, aiding weather analysis and agricultural planning by identifying rainfall variability.

Land Use Mapping

KrishiDrishti provides dynamic and detailed land use maps tailored to Nepal's unique needs. It can identify suitable areas for agricultural expansion while preserving ecological balance, ensuring sustainable growth. The platform is designed to monitor urban encroachment, preventing unauthorized land use changes that threaten agricultural lands. Additionally, KrishiDrishti equips policymakers with accurate data for sustainable land management and conservation strategies (Fig.5).

In global scenarios, Brazil's deforestation monitoring using MODIS and Landsat has helped control land encroachment and promote sustainable agricultural practices (Hansen et al., 2013). India extensively uses satellite imagery for balanced policy formulation, supporting industrial and agricultural growth (Roy et al., 2015). In Europe, the Copernicus Land Monitoring Service offers high-resolution data for efficient land use planning across the EU (Janssen et al., 2021). Through similar applications, KrishiDrishti supports sustainable development in Nepal's agriculture sector.

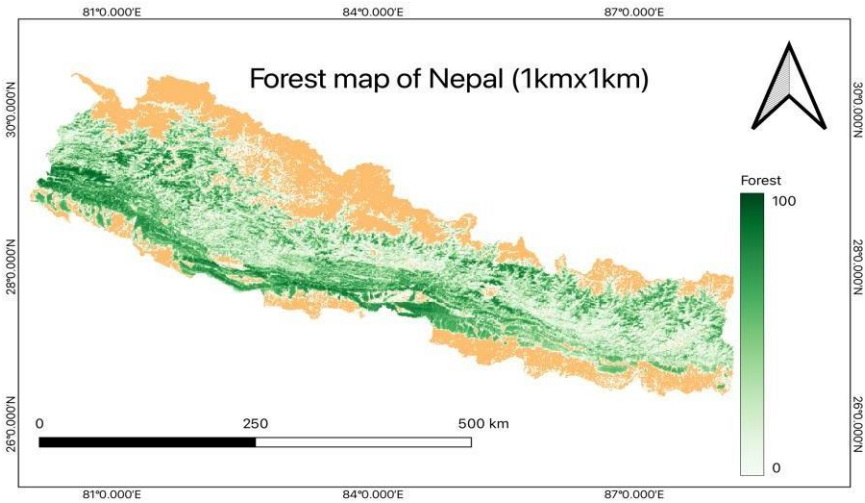

Figure 5. Forest coverage map of Nepal generated by KrishiDrishti. The map depicts vegetation distribution across Nepal, aiding in land use planning and conservation efforts

CHALLENGES

Adopting satellite data in Nepal's agricultural sector presents several significant challenges. Limited internet access and inadequate infrastructure in rural areas impede the accessibility of real-time satellite insights, which are crucial for timely decision-making. Moreover, a lack of technical expertise among farmers and policymakers hinders effective interpretation and utilization of this data. To overcome this, targeted training programs and capacity-building initiatives are essential. Additionally, the absence of a clear policy framework for integrating satellite-based solutions into Nepal's agricultural systems poses a substantial barrier. Without comprehensive policies, scaling and operationalizing these insights for widespread use becomes difficult. Addressing these challenges is pivotal to unlocking the full potential of platforms like KrishiDrishti in transforming Nepal's agricultural landscape.

CONCLUSION

Integrating platforms like KrishiDrishti with satellite data presents a transformative opportunity for Nepal's agricultural sector, addressing challenges such as diverse agro-ecological zones, fragmented farmlands, and small-scale farming practices. By leveraging real-time data, predictive analytics, and climate-smart technologies, KrishiDrishti can enable precision agriculture tailored to Nepal's unique needs. Its features support better climate and weather prediction, stress management, and

land-use planning, fostering enhanced productivity and resilience. However, the successful implementation of such initiatives hinges on sustained investments, comprehensive stakeholder training, and strong partnerships with universities, agricultural agencies, local governments, and farmers. By embedding these technologies into agricultural practices and policies, Nepal can drive sustainable agriculture, bolster food security, and improve farmers' livelihoods, ensuring a more resilient and prosperous agricultural future.

RECOMMENDATIONS FOR FURTHER WORKS

To effectively integrate satellite-based solutions into Nepal's agricultural framework, it is crucial to establish dedicated training centers focused on satellite data interpretation, practical use of platforms like KrishiDrishti, and advanced technologies such as artificial intelligence (AI). AI has the potential to automate anomaly detection, crop yield forecasting, and resource optimization, generating predictive insights that can significantly improve decision-making for both farmers and policymakers. Strong collaboration with international agencies, such as NASA, ESA, and ISRO, alongside local institutions like agricultural universities, cooperative societies, and government bodies, is essential for tailoring Krishi Drishti's functionalities to meet regional needs while ensuring wide accessibility. Expanding the platform's features to include user-friendly, AI-driven analytical tools and ensuring that its data and insights are readily applicable in research, academic theses, and policy-making processes will enhance its effectiveness. Moreover, aligning KrishiDrishti with national agricultural strategies, supported by robust policy frameworks and regulations for AI-driven platforms, will foster innovation and accelerate adoption. These actions will enable stakeholders to harness the transformative potential of satellite data and AI, promoting sustainable agricultural development in Nepal.

REFERENCES

Entekhabi, Dara, Njoku, Eni G. & O'Neill, Peggy E. (2010) The Soil Moisture Active Passive (SMAP) Mission. *Proceedings of the IEEE*, 98(5): 704-716.

Farr, T. G., et al. (2007) The Shuttle Radar Topography Mission. *Reviews of Geophysics*, 45(2). DOI:10.1029/2005RG000183.

Funk, C., et al. (2015) The Climate Hazards Infrared Precipitation with Stations—A New Environmental Record for Monitoring Extremes. *Scientific Data*, 2(1). DOI:10.1038/sdata.2015.66.

Hansen, M. C., Potapov, Peter V. & Moore, Rebecca (2013) High-Resolution Global Maps of 21st-Century Forest Cover Change. *Science*, 342(6160): 850–853. DOI:10.1126/science.1244693.

Hersbach, H., et al. (2020) The ERA5 global reanalysis. *Quarterly Journal of the Royal Meteorological Society*, 146(730): 1999–2049. DOI:10.1002/qj.3803.

Janssen, Peter, Schneider, Markus & Christiaansen, Lars (2021) Advances in climate-smart agriculture using Copernicus data. *Climate Services*.

Mulla, David J. (2013) Twenty-five years of remote sensing in precision agriculture. *Precision Agriculture*, 14(6): 517-520.

Pudasainee, A., Pudasaini, U. & Chaulagain, B. P. (2020) Prospects of ICT based agricultural technology in the context of Nepal. *Nepalese Journal of Agricultural Sciences*, 19, 211-227.

Roy, P. S., Behera, M. D. & Murthy, M. S. R. (2015) Land use land cover data for policy formulation in India. *Remote Sensing of Environment*.

Srivastava, Shyam, Kumar, Ramesh & Gupta, Neha (2020) Remote sensing for agricultural monitoring in India. *Journal of Remote Sensing Applications*.

Walker, Jeffrey P., Western, Andrew W. & Grayson, Rodger B. (2014) Australian applications of SMAP soil moisture data. *Water Resources Research*.

World Bank (2023) Nepal Agricultural Sector Overview. *World Bank Data*.

Zhang, Wei, Huang, Jianping & Wang, Zheng (2017) Satellite-based drought monitoring in China. *Journal of Meteorological Applications*.