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Short communication

Applications of machine learning in agrometeorological forecasting and modeling: A short review from the *Journal of Agrometeorology*

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Agrometeorology, the science of applying meteorological data to enhance agricultural productivity, stands at the critical intersection of climate science, agriculture, and global food security. In an era of increasing climate variability, the ability to accurately forecast weather patterns and model their impact on agricultural systems is more crucial than ever. Recently, the field has witnessed a transformative shift with the integration of machine learning (ML), a powerful set of computational tools capable of identifying complex patterns and making predictions from vast datasets. This influx of ML applications promises to deliver more precise, timely, and actionable insights for farmers, policymakers, and researchers. The purpose of this literature review is to synthesize and analyze recent research on the application of machine learning in agrometeorology. Drawing exclusively from studies published in the *Journal of Agrometeorology* during 2025, this short review identifies the core domains where ML is being applied, evaluates the diversity of modeling techniques being deployed, and highlights emerging methodological trends.

This document is structured to provide a clear and comprehensive overview of the current landscape. I will begin by examining core applications in on-farm crop production and management, including yield forecasting and pest forewarning. The review will then explore the use of ML for modeling fundamental environmental parameters such as precipitation and evaporation. Following this, we will discuss advanced applications in hazard prediction before synthesizing the key methodological trends observed across the literature. Finally, we will conclude with a summary of findings and propose potential directions for future research. This exploration begins with the most direct application of ML in agriculture: improving on-farm decision-making for crop management.

Core Applications in Crop Production and Management

Predictive analytics are of paramount strategic importance for modern on-farm decision-making, enabling producers to move from reactive responses to proactive planning. Machine learning models that provide accurate forecasts for crop yield and timely warnings for pest outbreaks directly impact agricultural productivity by optimizing resource allocation, reducing input costs, and mitigating potential losses. Recent research highlights a significant focus on deploying ML to solve these fundamental agricultural challenges.

Crop Yield Forecasting and Prediction: A primary objective in applied agrometeorology is the accurate forecasting of crop yields. Several recent studies demonstrate the application of machine learning to predict yields for a variety of staple crops. Research by Jhajharia (2025) focuses on wheat, while studies by Patel & Bunkar (2025) and Singh *et al.,* (2025) address soybean and sorghum, respectively. Similarly, Chand & Ranjan (2025) have applied these techniques to sugarcane, and Rao & Krishnan (2025) have focused on rice. The common goal across these efforts is to leverage computational models to anticipate production outcomes, providing valuable information for regional food security assessments and market planning.

A significant aspect of this research is the reliance on diverse data sources to train the predictive models. The work by Jhajharia (2025) explicitly notes the use of both climatic and satellite data as inputs, underscoring the power of integrating multiple data streams for robust forecasting. Furthermore, there is a clear trend toward methodological sophistication. While some studies refer generally to "machine learning techniques," others, such as those by Patel & Bunkar (2025) and Rao & Krishnan (2025),

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specify the use of "advanced ensemble machine learning models" and "ensemble machine learning" respectively, suggesting a move towards more powerful and accurate algorithms that combine the strengths of multiple models. This is a critical development, as ensemble methods can improve model robustness, reduce the risk of overfitting to specific climatic conditions in a single year's data, and provide more stable predictions across different geographical regions.

Pest Forewarning Systems: Beyond yield prediction, machine learning is being applied to more proactive crop protection strategies. The research by Naranammal *et al.,* (2025) on forewarning sucking pests in cotton crops represents a significant evolution in this domain. Their study details the application of an "Enhanced hybrid CEEMDAN-GMDH regression model" specifically designed for pest forewarning.

The significance of this approach lies in its shift from estimating an outcome (yield) to predicting a threat (pest infestation). By providing advance warning of pest pressure, such models empower farmers to implement targeted pest management strategies precisely when and where they are needed. This proactive capability enhances integrated pest management (IPM) frameworks by enabling precision interventions, thereby protecting yield potential while minimizing the prophylactic use of pesticides and mitigating the risk of resistance development. This targeted application of ML for crop protection complements the broader modeling of environmental conditions that influence all aspects of agriculture.

Modeling and Estimation of Key Environmental Parameters

The reliability of any agrometeorological advisory system or high-level agricultural model is fundamentally dependent on the accurate estimation and forecasting of core environmental parameters. Parameters such as precipitation, air temperature, and evaporative demand serve as foundational inputs for virtually all biophysical and empirical models in agrometeorology. Consequently, a substantial body of research is dedicated to applying machine learning techniques to improve the prediction of these fundamental variables, forming a critical prerequisite for more complex agricultural applications.

Precipitation and Temperature Forecasting: Accurate forecasting of rainfall and temperature is essential for agricultural planning, from determining optimal sowing dates to managing irrigation schedules. Recent studies highlight the use of a range of time-series and artificial intelligence models for this purpose. Research by Kothiyal *et al.,* (2025) employs the SARIMA (Seasonal AutoRegressive Integrated Moving Average) model for analyzing rainfall and temperature trends. Building on this, Naidu & Chandniha (2025) propose a more complex hybrid SARIMA–Bi-LSTM (Bidirectional Long Short-Term Memory) model for monthly rainfall forecasting, integrating a classical statistical model with a deep learning architecture. In a similar vein, Bhattacharjee *et al.,* (2025) explore the application of "artificial intelligence and statistical recurrent models" for predicting rainfall. The shared objective across these studies is to enhance the predictability of these core weather variables, thereby providing a more reliable foundation for agricultural advisories.

Evaporation and Evapotranspiration Prediction: Evaporation and reference evapotranspiration (ET0) are critical parameters for water resource management and irrigation planning. Researchers are increasingly deploying machine learning to model these complex processes. The methodologies employed show a notable diversity, reflecting a field actively exploring novel computational solutions.

1. *General Machine Learning Techniques*: Several studies, including those by Naik *et al.,* (2025) for pan evaporation and Caguiat *et al.,* (2025) for reference evapotranspiration, utilize general "machine learning techniques" to build predictive models.

2. *Localized Large Language Models (LLMs)*: A particularly novel approach is presented by Ray & Pradhan (2025), who developed an "AgroMetLLM" system. This system uses localized LLMs for evapotranspiration estimation and the generation of agro-advisories, demonstrating the potential of cutting-edge AI architectures in resource-constrained environments.

3. *Adaptive Neuro-Fuzzy Inference System (ANFIS):* Research by Mahadeva & Sriram (2025) focuses on ANFIS-based models for the estimation of ET0, combining the learning capabilities of neural networks with the reasoning structure of fuzzy logic.

The deployment of sophisticated architectures like LLMs represents a potential paradigm shift in how model outputs are translated into practice. The AgroMetLLM system demonstrates that these models can bridge the gap between quantitative prediction (e.g., an ET0 value) and qualitative, actionable advice (e.g., a natural language advisory for a farmer). This has the potential to democratize access to complex model outputs, empowering end-users to make informed decisions without needing to interpret raw numerical data.

Specialized Climatological Parameter Estimation: Machine learning applications also extend to more specialized environmental variables that enable more nuanced agrometeorological analysis. Research by Bakr *et al.,* (2025) demonstrates the use of Artificial Neural Network (ANN) and WEKA models for the general estimation of climatological parameters. In a more targeted application, Kureshi *et al.,* (2025) utilize machine learning approaches for the retrieval of clear-sky Land Surface Albedo (LSA) from satellite data. The accurate estimation of such variables is crucial, highlighting how ML facilitates the derivation of high-resolution, physically meaningful parameters like albedo, which are essential for calibrating surface energy balance models and improving the accuracy of regional climate simulations. These foundational modeling efforts provide the necessary inputs for predicting specific agricultural hazards.

Advanced Modeling for Agrometeorological Hazard Prediction

A critical frontier in agrometeorology is the shift from reactive damage assessment to proactive risk management. Managing agricultural risks, particularly those posed by extreme weather and climate events, requires robust early warning systems. Machine learning models are proving to be pivotal tools in this effort, offering the capability to forecast hazards like drought with greater accuracy and longer lead times, thereby enabling preemptive action.

The research conducted by Prasad *et al.,* (2025) on the "Applicability of machine learning models for drought prediction using SPI in Kalahandi, Odisha" provides a clear example of this application. This study focuses specifically on using ML models to predict drought conditions, a hazard that poses a severe threat to agricultural production and regional water security. The strategic value of such an application is immense. Early and reliable drought warnings allow water resource managers, government agencies, and farmers to make critical, timely decisions. These can include implementing water conservation measures, adjusting irrigation allocations, or shifting to more drought-tolerant crop varieties. By leveraging machine learning for hazard prediction, stakeholders can better anticipate and mitigate the impacts of extreme climatic events, enhancing the resilience of agricultural systems. The variety of models used for this and other applications reveals important trends in the field.

Synthesis of Methodological Trends

The adoption of machine learning within agrometeorology is characterized by a dynamic and expanding range of computational techniques. An analysis of recent literature reveals a clear trajectory from the application of established algorithms to the development of more complex, integrated, and novel model architectures. This section deconstructs the specific models being deployed and highlights the significant trend toward customized and hybrid systems designed to tackle specific agrometeorological challenges. A comprehensive review of the selected studies reveals the breadth of ML applications and the diversity of the models employed.

Emergence of Hybrid and Novel Architectures: Beyond the application of singular models, a key trend is the development of more sophisticated systems. Studies by Naidu & Chandniha (2025) (Hybrid SARIMA–Bi-LSTM) and Naranammal *et al.,* (2025) (Enhanced hybrid CEEMDAN-GMDH regression model) explicitly utilize hybrid models. These approaches combine the strengths of different algorithms—such as traditional statistical time-series models and deep learning networks—to achieve superior predictive performance.

Furthermore, the introduction of novel architectures, most notably the use of localized Large Language Models (LLMs) by Ray & Pradhan (2025) for their "AgroMetLLM" system, marks a significant advancement. The development and application of these highly customized and state-of-the-art models signal a maturation of the field. This trend is driven by a recognition that agrometeorological systems are inherently complex and non-linear, and that "off-the-shelf" models often fail to capture the interactions between variables such as soil properties, microclimates, and crop phenology. Therefore, the development of hybrid and novel models is not just an incremental improvement but a necessary evolution to tackle these intertwined variables effectively.

Conclusion and Future Directions

This review of recent literature from the *Journal of Agrometeorology* confirms that machine learning has become an integral and dynamic tool in agrometeorological research. The surveyed articles demonstrate a clear focus on applying these computational techniques to solve pressing agricultural challenges. Dominant applications include the prediction of crop yields for a wide range of staple foods, the forecasting of fundamental climatological parameters like rainfall and temperature, and the estimation of key hydrological variables such as evapotranspiration.

The methodological landscape is diverse and evolving, with techniques ranging from established time-series models like SARIMA to advanced deep learning and ensemble systems. A notable trend is the move toward creating sophisticated hybrid models and deploying novel architectures like LLMs to build customized solutions. This indicates a growing maturity in the field, where researchers are tailoring advanced computational tools to fit the specific needs of complex agrometeorological systems.

The key takeaways from this review are:

- *Broad Application:* ML is being applied across a spectrum of critical agrometeorological tasks, from on-farm yield prediction and pest forewarning to regional drought prediction.
- *Methodological Diversity:* Researchers are utilizing a wide array of models, including time-series analysis, ANNs, ensemble methods, and neuro-fuzzy systems.
- *Increasing Sophistication:* There is a clear trend toward the development of hybrid and novel model architectures designed to improve predictive accuracy and address specific, complex problems.
- *Data Integration:* Effective ML models often rely on the integration of multiple data sources, including ground-based climatic data and satellite-derived information.

Based on the trends identified in these papers, several future research directions can be proposed. The success of hybrid models in rainfall forecasting and pest forewarning suggests their potential could be explored for other applications, such as crop yield prediction or drought modeling. Similarly, the innovative use of Large Language Models for evapotranspiration estimation and agro-advisory services opens a promising new frontier. Future work could investigate the applicability of LLMs to a broader range of agro-advisory tasks, including pest and disease forewarning or nutrient management recommendations, potentially transforming how predictive intelligence is delivered to agricultural stakeholders.

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REFERENCES

Bakr, D. I., Al-Khalidi, J., & Abed, H. N. (2025). Estimation of climatological parameters using ANN and WEKA models in Diyala Governorate, Iraq. *Journal of Agrometeorology*, *27*(2), 210–215. https://doi.org/10.54386/jam.v27i2.2877

Bhattacharjee, S., Biwalkar, N., Koyel Sur, Kaur, S., & Singh, S. P. (2025). Application of artificial intelligence and statistical recurrent models in predicting rainfall: A case study of Ludhiana, Punjab. *Journal of Agrometeorology*, *27*(3), 395–398. https://doi.org/10.54386/jam.v27i3.3038

Caguiat, L. S., Saludes, R. B., Castro, M. L. Y., & Lampayan, R. M. L. (2025). Machine learning modeling of reference evapotranspiration in Central Luzon, Philippines. *Journal of Agrometeorology*, *27*(4), 464–469. https://doi.org/10.54386/jam.v27i4.2909

Chand, N., & Ranjan, R. (2025). Sugarcane yield forecasting using machine learning techniques in Udham Singh Nagar district of Uttarakhand. *Journal of Agrometeorology*, *27*(2), 233–235. https://doi.org/10.54386/jam.v27i2.2888

Jhajharia, K. (2025). Wheat yield prediction of Rajasthan using climatic and satellite data and machine learning techniques. *Journal of Agrometeorology*, *27*(1), 63–66. https://doi.org/10.54386/jam.v27i1.2807

Kothiyal, S., Goel, S., Singh, R. K., Chilwal, A., & Ranjan, R. (2025). SARIMA-based time series analysis of rainfall and temperature for the Tarai region of Uttarakhand. *Journal of Agrometeorology*, *27*(1), 73–76. https://doi.org/10.54386/jam.v27i1.2838

Kureshi, A. M., Pathak, V. N., Kardani, D. B., Dave, J. A., Shah, D. B., Turakhia, T. P., Gujrati, A., Pandya, M. R., & Trivedi, H. J. (2025). Machine learning approaches for clear-sky Land Surface Albedo (LSA) retrieval using OCM-3 data over diverse Indian landscapes. *Journal of Agrometeorology*, *27*(4), 454–463. https://doi.org/10.54386/jam.v27i4.3174

Mahadeva, M., & Sriram A. V. (2025). Adaptive Neuro-Fuzzy inference system (ANFIS) based models for estimation of reference evapotranspiration (ET0). *Journal of Agrometeorology*, *27*(3), 381–384. https://doi.org/10.54386/jam.v27i3.3008

Naidu, D., & Chandniha, S. K. (2025). Hybrid SARIMA–Bi-LSTM model for monthly rainfall forecasting in the agroclimatic zones of Chhattisgarh. *Journal of Agrometeorology*, *27*(3), 332–337. https://doi.org/10.54386/jam.v27i3.3010

Naik, R., Majhi, B., & Naidu, D. (2025). Prediction of pan evaporation in Chhattisgarh using machine learning techniques. *Journal of Agrometeorology*, *27*(1), 86–91. https://doi.org/10.54386/jam.v27i1.2731

Naranammal, N., S. R. Krishna Priya, & K. Naveena (2025). Enhanced hybrid CEEMDAN-GMDH regression model for forewarning sucking pests in cotton crops of Coimbatore, Tamil Nadu. *Journal of Agrometeorology*, *27*(4), 447–453. https://doi.org/10.54386/jam.v27i4.3099

Patel, R. M., & Bunkar, K. (2025). Soybean yield prediction leveraging advanced ensemble machine learning models. *Journal of Agrometeorology*, *27*(2), 227–229. https://doi.org/10.54386/jam.v27i2.2971

Prasad, A., Singh, R., K V Ramana Rao, & C. K. Saxena. (2025). Applicability of machine learning models for drought prediction using SPI in Kalahandi, Odisha. *Journal of Agrometeorology*, *27*(2), 216–220. https://doi.org/10.54386/jam.v27i2.2906

Rao, A. S., & Krishnan, A. (2025). Rice yield prediction in Dakshina Kannada district using ensemble machine learning. *Journal of Agrometeorology*, *27*(4), 518–521. https://doi.org/10.54386/jam.v27i4.3148

Ray, P. P., & Pradhan, M. P. (2025). AgroMetLLM: An evapotranspiration and agro-advisory system using localized large language models in resource-constrained edge. *Journal of Agrometeorology*, *27*(3), 320–326. https://doi.org/10.54386/jam.v27i3.3081

Singh, R., Annu, Chandra, U., Maheshwari, H., Verma, A. P., & Shukla, G. (2025). Comparative analysis of weather-driven models for sorghum yield prediction in Bundelkhand. *Journal of Agrometeorology*, *27*(4), 511–513. https://doi.org/10.54386/jam.v27i4.3151