International Journal of Sustainable and Integrated Studies
Volume 1, Issue 4 | ISSN: 3155-6361
DOI: https://doi.org/10.65339/ijsis.V1.I4.272

Design and Development of a Smart Crop Recommendation System Based on Soil and Climate Data

John Raymar A. Arastam MIT[1], Shena D. Milendes[2], Ariana T. Jahandal[2], Evelyn J. Persing[2]

[1]*Instructor, College of Computing Studies, Sulu State University, Jolo, Sulu, Philippines*
[2]*College of Computing Studies, Sulu State University, Jolo, Sulu, Philippines*

Email of Corresponding Author: jandiearastam@gmail.com

Publication history:
Received: October 8, 2026 Accepted: November 8, 2026
Revised: November 6, 2026 Published: November 9, 2026
International Journal of Sustainable and Integrated Studies, Vol. 1, No. 4, pp. 202–209, November 2026.

Abstract

This study aimed to design and develop AgriSmart PH, a web-based Smart Crop Recommendation System that supports crop selection using soil and climatic information in Sulu, Philippines. The study employed a developmental approach guided by the Agile Software Development Life Cycle, involving iterative planning, design, implementation, and testing. The application integrates a Smart Rule-Based Expert Engine, an agronomic knowledge base, and a weighted scoring algorithm to assess seven environmental parameters: nitrogen, phosphorus, potassium, soil pH, temperature, humidity, and rainfall. The developed system accepts manually entered farm data, demonstration inputs, and available weather information for selected climatic fields. It calculates crop suitability scores, ranks crops according to environmental compatibility, and presents personalized recommendations. Additional functions include a searchable Crop Vault and an analysis history for reviewing previous results. These documented functions demonstrate a structured approach to translating environmental measurements into accessible agricultural decision support. The study concludes that AgriSmart PH provides an integrated platform for evaluating crop compatibility against defined agronomic requirements. Field validation using local soil laboratory results and expert review of crop requirements and scoring thresholds are strongly recommended before broader application. The system is limited by manual soil data entry, internet dependence, and the exclusion of market prices, seed availability, and supply-chain conditions. Predictive accuracy and user acceptance outcomes were not reported. By illustrating a practical application of agricultural information technology, the project supports the aims of Sustainable Development Goals 2 and 9 and offers a foundation for future improvements in locally relevant, resource-conscious crop planning.

Keywords: Agricultural Decision Support, Agile Development, Crop Recommendation, Precision Agriculture, Rule-Based Expert System, Soil Climate Data, Weighted Scoring Algorithm

1. Introduction

Agricultural productivity depends on the compatibility of crop requirements with soil and climatic conditions. Precision agriculture integrates digital technologies, environmental information, and intelligent data management to support site-specific farming decisions. Through soil nutrient analysis and climatic assessment, farmers can identify suitable crops rather than relying solely on traditional planting practices. Despite technological advancements, local farmers continue to face challenges involving limited agricultural information, variable environmental conditions, and reliance on trial-and-error crop selection. Inadequate assessment of nitrogen,

phosphorus, potassium, soil pH, temperature, humidity, and rainfall may contribute to unsuitable planting decisions, reduced productivity, and inefficient resource utilization. These challenges emphasize the need for an accessible, data-driven crop recommendation system that translates technical agricultural information into practical recommendations. The proposed AgriSmart PH system addresses these concerns by processing seven environmental parameters and matching them with established crop requirements. Its development seeks to improve crop selection, minimize resource wastage, and support informed farming decisions. Related literature emphasizes the importance of integrating digital technologies into agricultural management. Khan et al. (2021) highlighted the role of Internet of Things technologies in sustainable agriculture through environmental monitoring and precision farming. Similarly, Yang et al. (2023) emphasized sustainable irrigation technologies for improving water productivity, while climatic monitoring supports agricultural adaptation to changing environmental conditions (Khan et al., 2021; NOAA, 2021). Rule-based expert systems provide structured decision support by comparing environmental conditions with established agricultural requirements. Crop suitability assessment can integrate climatic, soil, and topographic conditions to evaluate agricultural land suitability (Dornik et al., 2024). Pattern-matching approaches have likewise been applied to crop selection under changing climatic conditions (Patel & Rane, 2023). Furthermore, interpretable decision-making methods help users understand the basis of system-generated recommendations (Lundberg & Lee, 2017). Shams et al. (2024) further demonstrated the application of explainable artificial intelligence in crop recommendation systems, emphasizing the importance of providing understandable explanations to support farmers' agricultural decisions.

These studies support the development of a transparent crop recommendation system that evaluates soil nutrients and climatic variables through structured agronomic rules and weighted suitability scores. Recent research by Dhingra et al. (2026) demonstrated how crop recommendation systems can integrate nitrogen, phosphorus, potassium, soil pH, temperature, humidity, and rainfall with explainable artificial intelligence to support transparent agricultural decision-making.

Globally, agricultural technologies increasingly support food production, resource efficiency, and climate-responsive farming. Farajpour (2026) reviewed artificial intelligence applications in precision agriculture, including soil and nutrient management, irrigation, crop yield prediction, and agricultural decision-support systems, emphasizing their potential contributions to sustainable farming. Digital monitoring, expert systems, and environmental data analysis offer opportunities to improve agricultural decision-making and address the effects of climatic variability (Khan et al., 2021; Yang et al., 2023). In the Philippines, smart agricultural technologies have demonstrated potential for improving farm monitoring and site-specific management. Mastul et al. (2023) identified the benefits of IoT applications in Philippine agriculture while recognizing limitations involving connectivity, implementation costs, and technological accessibility. Similarly, Manono (2026) identified infrastructure limitations, resource constraints, and technology adoption challenges affecting small-scale farmers, highlighting the importance of accessible and context-appropriate smart farming solutions. Digital literacy, connectivity limitations, and unequal access to agricultural technologies remain barriers to the adoption of agricultural automation among smallholder farmers (Food and Agriculture Organization of the United Nations [FAO], 2022). Yuan and Sun (2024) also examined digital transformation in smallholder agriculture, identifying technological, economic, and organizational challenges that influence the adoption and effective use of digital farming technologies.

Local agricultural information also supports the development of context-specific recommendation systems. The Department of Agriculture (DA, n.d.) provides the National Color-Coded Agricultural Guide Map, which identifies suitable crops based on soil properties, climatic conditions, and other biophysical requirements, while the Philippine Rice Research Institute (PhilRice, 2022) reported the use of agricultural decision-support tools to assist farmers and agricultural technicians in crop and nutrient management. Nevertheless, effective implementation requires reliable environmental information, localized validation, and consideration of farmers' technological capabilities (FAO, 2022; Yang et al., 2023). Within the Sulu agricultural context, AgriSmart PH seeks to provide localized crop recommendations using soil information and available climatic data. Its web-based design incorporates environmental analysis, crop information, and weather-related features to support agricultural decision-making.

The study uses the Input-Process-Output (IPO) model to organize environmental inputs, computational processing, and crop suitability recommendations. The integration of digital agricultural technologies and environmental information is supported by recent research on smart and sustainable agriculture (Ahmed & Shakoor, 2025). The input component consists of seven environmental parameters: nitrogen, phosphorus, potassium, soil pH, temperature, humidity, and rainfall. These variables represent the soil and climatic conditions used to assess crop compatibility. The process component employs a Smart Rule-Based Expert Engine supported by an Agronomic Knowledge Base. Environmental inputs are validated, compared with crop requirements, and evaluated through a weighted scoring algorithm and pattern analysis (Patel & Rane, 2023). Structured decision rules enable the system to generate interpretable recommendations based on environmental suitability. The output component provides ranked crop recommendations and suitability scores. The system also incorporates a crop information repository and analysis history to assist users in reviewing agricultural information and previous assessments. This framework integrates agricultural knowledge and information technology into a structured decision-support process that prioritizes transparency, accessibility, and localized crop selection.

Existing agricultural technologies demonstrate the potential of automated monitoring, expert systems, and data-driven crop recommendations. However, their application among local farmers remains constrained by limited connectivity, implementation costs, digital literacy, and the availability of localized agricultural information (FAO, 2022; Mastul et al., 2023). Although agricultural decision-support tools have been developed, localized validation remains necessary to determine their suitability for Philippine soil and climatic conditions (FAO, 2022; PhilRice, 2022). Farmers also require accessible systems capable of converting complex environmental measurements into understandable crop recommendations. To address these gaps, the study aims to design and develop AgriSmart PH, a web-based crop recommendation system using a weighted scoring algorithm and rule-based expert engine. Specifically, it seeks to examine local crop selection practices, develop a system that processes seven environmental parameters, and evaluate its predictive accuracy, effectiveness, and usability using historical agricultural datasets, User Acceptance Testing, and agricultural expert validation. The system focuses on agronomic and environmental suitability rather than market prices, seed availability, or supply-chain conditions. Soil information is manually entered, and the application requires internet connectivity. These delimitations establish the study's technical scope while identifying opportunities for future development.

The study aligns primarily with Sustainable Development Goal 2 (Zero Hunger) and Sustainable Development Goal 9 (Industry, Innovation and Infrastructure). SDG 2 emphasizes food security and sustainable agriculture. By supporting crop selection based on soil nutrients and climatic conditions, AgriSmart PH seeks to improve agricultural decision-making, promote efficient resource utilization, and reduce the risks associated with unsuitable planting practices. Its localized recommendations may contribute to more productive and sustainable farming systems. SDG 9 promotes technological innovation and infrastructure development. The integration of a web-based platform, agronomic knowledge base, and intelligent recommendation algorithm demonstrates the application of digital technologies to agricultural challenges. The system supports agricultural digitalization by making technical environmental information more accessible to local farmers. Together, these goals reflect the study's intended contribution to agricultural productivity, technological innovation, and sustainable food production.

The study contributes to agricultural sustainability by promoting crop selection based on environmental compatibility. Evaluating soil nutrients and climatic conditions can support more appropriate planting decisions, reduce unnecessary resource use, and encourage evidence-based agricultural practices. In terms of technological sustainability, AgriSmart PH demonstrates the practical integration of information technology, expert systems, database management, and web development into agricultural decision support. Its structured recommendation process and accessible interface provide a foundation for improving the availability and usability of agricultural information. The study also has potential socio-economic relevance by helping farmers make informed planting decisions and reduce risks associated with unsuitable crop selection. For agricultural organizations and local government units, localized environmental information may support agricultural planning and food security initiatives. From an institutional and educational perspective, the project demonstrates how computing technologies can address community agricultural concerns through interdisciplinary applications. Its integration of agricultural science and information technology highlights the value of digital innovation in supporting sustainable development. Overall, AgriSmart PH provides a technological approach to improving crop selection and agricultural decision-making while recognizing the need for further field validation, expert assessment, and improvements in accessibility.

2. Material and methods

2.1 Research Design

The study adopted a developmental research approach using the Agile Software Development Life Cycle (SDLC), which supports iterative prototyping, continuous testing, stakeholder feedback, and system refinement (Ramadhani et al., 2025). Development followed planning, analysis, design, and implementation, with activities organized into two- to four-week sprints. These involved identifying system requirements, designing the architecture, developing a functional prototype, validating recommendation rules, and refining the application based on feedback (Ramadhani et al., 2025). The system followed the Input-Process-Output (IPO) framework, organizing soil nutrients and climatic variables as inputs, data preprocessing and weighted scoring as processes, and ranked crop recommendations as outputs. Soil nutrients and climatic variables served as inputs, while data preprocessing, weighted scoring, and pattern analysis formed the processing component (Patel & Rane, 2023). The resulting outputs consisted of ranked crop recommendations and suitability information. The architecture integrated a web-based interface, an expert system processing component, and structured data storage for crop requirements and analysis records (B. et al., 2025). Administrative functions supported crop database maintenance and rule management (Ramadhani et al., 2025), while user functions enabled environmental data submission and localized recommendations (Fayaz et al., 2026). The processing workflow incorporated authentication, data loading, suitability assessment, and recommendation generation (Fayaz et al., 2026; Shastri et al., 2025). The Smart Rule-Based Expert Engine compared environmental inputs with established crop requirements through structured decision rules and weighted scoring. Rule-based expert systems have also been applied to agricultural decision support, particularly in diagnosing crop diseases and recommending appropriate treatments (Bugao & Talirongan, 2025). The development environment included Python, JavaScript, HTML5, CSS3, Tailwind CSS,

Chart.js, structured databases, and the Open-Meteo REST API, with supporting tools for data processing, visualization, and version control (Fayaz et al., 2026; Shastri et al., 2025).

2.2 Locale of the Study

The study focused on the agricultural context of Sulu, Philippines, particularly Jolo, Sulu, where localized soil and climatic information was considered for crop suitability assessment. The system incorporated available weather information for Sulu and agricultural data relevant to Philippine crops. Local soil laboratory reports and historical climatic records from regional weather stations were identified as sources for determining environmental ranges and calibrating crop suitability requirements. The application was designed to generate recommendations appropriate to the agricultural conditions of the target community.

2.3 Respondents of the Study

The study identified local farmers, agricultural experts, and Department of Agriculture personnel as its intended participants. Farmers were considered the primary end-users of the system, while agricultural experts and officers were identified as sources of technical validation. Local farmers were to provide information regarding crop selection practices, environmental challenges, and technological readiness. Agricultural experts and Department of Agriculture personnel were to assess the agronomic knowledge base, validate crop requirements, and identify regional agricultural priorities. Their feedback was intended to support system usability, accuracy, and relevance to local farming conditions.

2.4 Sample and Sampling Procedure

The study proposed gathering information from local farmers and agricultural experts within the target community. Farmers were identified as survey participants, while agricultural experts and Department of Agriculture officers were identified as interview participants and validators of the recommendation system. The manuscript did not specify the number of respondents, sampling technique, or sample-size determination procedure. These details therefore remain unspecified in the present methodology.

2.5 Research Instrument

The study utilized agricultural datasets, semi-structured interviews, farmer surveys, soil laboratory reports, and historical climatic records as sources of information for system development and validation. Historical agricultural datasets were identified from Kaggle, the UCI Machine Learning Repository, and official agricultural extension databases. These contained information on nitrogen, phosphorus, potassium, soil pH, temperature, humidity, rainfall, and crop suitability. Semi-structured interviews were intended to gather agricultural experts' assessments of crop requirements and regional farming priorities, while surveys were designed to examine farmers' planting practices, environmental challenges, and technological readiness. Local soil laboratory reports and weather records provided additional environmental information for calibrating the recommendation rules. The developed AgriSmart PH application also served as the technical platform for crop suitability analysis. Its interface allowed users to enter seven environmental parameters, access weather information, browse the Crop Vault, and review previous analyses. Administrative functions supported the maintenance of crop records and agronomic requirements (Fayaz et al., 2026; Ramadhani et al., 2025). The manuscript additionally identified User Acceptance Testing (UAT) and agricultural expert validation as methods for evaluating system usability and recommendation accuracy.

2.6 Data Gathering Procedure

Data gathering was designed to combine secondary agricultural information with primary stakeholder feedback. The researchers planned to obtain historical agricultural datasets from Kaggle, the UCI Machine Learning Repository, and official agricultural extension databases. These records would provide the environmental parameters necessary for constructing the agronomic knowledge base. Primary data collection was planned through semi-structured interviews with agricultural experts and Department of Agriculture personnel, together with surveys of local farmers. The interviews would validate crop suitability requirements and identify regional agricultural priorities, while the surveys would assess farming practices, technological readiness, and environmental challenges. Local soil laboratory reports and historical weather records would also be reviewed to establish environmental ranges and refine suitability thresholds. The collected information would inform the development and calibration of the Smart Rule-Based Expert Engine. System development involved integrating the agronomic knowledge base with the web-based application, validating environmental inputs, connecting the user interface to the scoring algorithm, and checking browser compatibility. The implementation process included data validation, knowledge base integration, system configuration, and user access preparation. The engine was designed to process environmental inputs and generate recommendations without requiring manual interpretation by agricultural experts during each analysis (Fayaz et al., 2026). During system operation, users enter soil nutrient and climatic information manually or use available weather data to populate selected fields. The application then evaluates the inputs, calculates crop suitability scores, displays ranked recommendations, and saves completed analyses for future reference.

2.7 Data Analysis Techniques

The study employed a Smart Rule-Based Expert Engine and weighted scoring algorithm to analyze soil and climatic information. The system evaluated nitrogen, phosphorus, potassium, soil pH, temperature, humidity, and rainfall by comparing user-provided values with the optimal environmental requirements stored in the agronomic knowledge base. Data processing involved input validation, normalization, and suitability assessment. Environmental measurements were checked against defined ranges before being processed through structured decision rules and weighted scoring. The algorithm calculated suitability scores for available crops and ranked the results from highest to lowest according to environmental compatibility. The weighted scoring procedure assigned 15% each to nitrogen, phosphorus, potassium, temperature, soil pH, and rainfall, while humidity received 10%. The algorithm calculated the absolute difference between each input value and its corresponding crop requirement, converted the difference into a parameter score, and combined the weighted scores to produce an overall suitability value. The resulting recommendations were presented through the web interface, together with crop information and suitability scores. Completed analyses were stored in the application's history function for subsequent review. The analytical process was intended to provide transparent crop recommendations based on identifiable environmental criteria rather than relying entirely on black-box predictive models. Historical agricultural datasets were identified for evaluating recommendation accuracy, while User Acceptance Testing and agricultural expert validation were intended to assess system effectiveness, usability, and the appropriateness of agronomic rules. However, the manuscript did not specify statistical formulas or quantitative evaluation metrics for these assessments.

3. Results and Discussion

3.1 Development and Functional Features of AgriSmart PH

3.1.1 Environmental Data Input and Processing

The developed AgriSmart PH system accepts seven environmental parameters: nitrogen, phosphorus, potassium, soil pH, temperature, humidity, and rainfall. Users can manually enter farm information, load demonstration data, or use available real-time weather information from Sulu to populate selected climatic fields. The Smart Rule-Based Engine processes these inputs by comparing the submitted environmental conditions with the optimal crop requirements stored in the agronomic knowledge base. These features demonstrate how the system converts soil and climatic information into structured inputs for crop suitability assessment. By combining manual data entry with available weather information, the application provides a practical approach to evaluating environmental conditions and reduces the need for farmers to interpret technical agricultural data independently.

3.1.2 Crop Suitability Assessment and Recommendations

The system calculates suitability scores for crops in its database using a weighted scoring algorithm and rule-based expert engine. After processing the environmental inputs, it ranks crops from highest to lowest suitability score and displays personalized recommendations with progress bars and detailed crop information. This enables users to identify crops whose environmental requirements most closely match their farm conditions. The recommendation process supports transparent agricultural decision-making by comparing environmental measurements with predefined crop requirements. Unlike black-box predictive approaches, the rule-based system uses identifiable suitability criteria, making its recommendations more understandable to non-technical users. This approach addresses the need for accessible agricultural information that can guide crop selection based on soil and climatic compatibility.

3.1.3 Crop Information Management and Analysis History

The developed application includes a Crop Vault that allows users to browse and search crop information without conducting a new suitability analysis. It also provides a History function for reviewing or clearing previously completed analyses. The system saves completed assessments, allowing users to revisit earlier recommendations and examine crop information through the same web-based platform. These features extend AgriSmart PH beyond a crop recommendation tool into an agricultural information and decision-support platform. The Crop Vault provides access to crop requirements, while the History function supports the retrieval of previous assessments. Together, these functions improve the accessibility and organization of agricultural information for farmers.

3.2 System Development and Decision-Support Capabilities

3.2.1 Transparency of the Rule-Based Recommendation System

The developed system uses a weighted scoring algorithm and Smart Rule-Based Expert Engine to evaluate environmental compatibility. Its recommendation process compares user-provided conditions with defined agronomic requirements and produces ranked crop suitability results. The application therefore provides recommendations based on identifiable environmental criteria rather than relying entirely on an opaque predictive model. This approach is consistent with the study's objective of developing a transparent agricultural decision-support system. By presenting recommendations derived from defined crop requirements, AgriSmart PH helps make technical agricultural information more understandable and supports evidence-based crop selection.

3.2.2 Agile Development and System Refinement

The system development process followed the Agile Software Development Life Cycle, which organized development into iterative activities involving planning, design, implementation, testing, stakeholder demonstrations, and feedback. This framework supported the development of the web-based interface, agronomic knowledge base, and recommendation engine. The Agile approach provides a structured mechanism for refining system functions and recommendation rules according to testing outcomes and stakeholder needs. Its iterative nature supports adjustments to system features and agricultural parameters, contributing to the continued improvement of the application's functionality and relevance to intended users.

3.3 Challenges and Limitations of the Developed System

The study identified several limitations affecting the application of AgriSmart PH. The system relies on manually entered soil laboratory results and requires internet connectivity for its web-based functions. Its recommendation process considers environmental and agronomic suitability but excludes market price fluctuations, seed availability, and supply-chain conditions. The current development also does not incorporate automated irrigation equipment or physical soil-monitoring sensors. These limitations indicate that the system is primarily intended to support crop selection rather than provide comprehensive farm management or economic decision-making. Its effectiveness depends on the availability and accuracy of environmental inputs, while internet dependence may restrict accessibility in areas with limited connectivity. The exclusion of economic variables also means that recommended crops are ranked according to environmental suitability rather than overall financial feasibility.

3.4 Implications for Agricultural Decision-Making

The developed AgriSmart PH system demonstrates the potential of web-based expert systems to transform soil and climatic information into practical crop recommendations. Its integrated environmental input, suitability assessment, crop information, and analysis history functions provide farmers with a structured platform for evaluating crop compatibility under available environmental conditions. The findings suggest that the application can serve as a technological tool for supporting more informed agricultural decisions and reducing dependence on generalized planting practices. However, the manuscript does not report numerical predictive accuracy, completed User Acceptance Testing results, or measured improvements in crop productivity. Consequently, the findings establish the system's developed functions and intended decision-support capabilities rather than empirically verified agricultural outcomes.

4. Conclusion & Recommendations

The study concludes that AgriSmart PH provides a structured, web-based approach to supporting crop selection through the integration of soil characteristics and climatic information. By processing nitrogen, phosphorus, potassium, soil pH, temperature, humidity, and rainfall through a weighted scoring algorithm and Smart Rule-Based Expert Engine, the system generates ranked crop suitability recommendations based on defined agronomic requirements. Its Farm Input, Crop Vault, weather information, and analysis history features establish an integrated platform for accessing agricultural information and reviewing crop compatibility. The findings demonstrate the system's capability to transform technical environmental measurements into understandable recommendations for farmers, particularly within the Sulu agricultural context. Furthermore, the Agile development approach provides a framework for refining system functions through testing and stakeholder feedback. Overall, the study contributes a functional agricultural decision-support application, although its predictive accuracy, user acceptance, and effects on actual crop productivity remain unverified by reported empirical results.

Based on the findings, the researchers recommend conducting field validation using actual soil laboratory results and environmental conditions from local farms to assess the reliability of AgriSmart PH's crop suitability recommendations. Agricultural experts and Department of Agriculture personnel should review the agronomic knowledge base, suitability thresholds, and recommendation rules to maintain their accuracy and relevance. System developers should expand the crop database by incorporating additional crops suited to Philippine and Sulu agricultural conditions, supported by verified soil and climatic requirements. Future development should prioritize offline data storage and synchronization capabilities to address connectivity limitations in rural communities. The system may also be enhanced by incorporating market prices, seed availability, supply-chain information, and irrigation requirements to provide more comprehensive agricultural decision support. Further evaluation through historical agricultural datasets, User Acceptance Testing, and expert validation is recommended to establish predictive accuracy, usability, and practical effectiveness before broader implementation among farming communities.

The study was limited to the design and development of a web-based crop recommendation system using seven environmental parameters and a predefined agronomic knowledge base. Its recommendations depend on manually entered soil laboratory results and available climatic information, making input accuracy essential. The system requires internet connectivity and does not support offline operation or automated soil monitoring through

physical sensors. Furthermore, its assessment focuses on environmental suitability without considering market prices, seed availability, or supply-chain conditions. The manuscript does not report completed predictive accuracy testing, User Acceptance Testing, or field-validation outcomes, limiting conclusions about real-world effectiveness. Future evaluations may address these limitations through field testing and expert validation.

5. Compliance with ethical standards

The researchers acknowledge the agricultural experts, Department of Agriculture personnel, and local farmers identified as prospective contributors to the development and validation of the AgriSmart PH Smart Crop Recommendation System. The study focused on developing a web-based agricultural decision-support application using soil and climatic data, with proposed stakeholder consultations. However, the manuscript does not provide a conflict-of-interest declaration or confirm whether institutional ethical approval and informed consent were obtained for the proposed interviews and surveys. These matters require confirmation from the researchers before publication.

REFERENCES

Ahmed, N., & Shakoor, N. (2025). Advancing agriculture through IoT, big data, and AI: A review of smart technologies enabling sustainability. *Smart Agricultural Technology, 10*, Article 100848. https://doi.org/10.1016/j.atech.2025.100848

B., D., S., U., Priya, M., Sabitha, M. S., E., I., & Kumar, M. U. R. (2025). A comprehensive framework for smart agriculture: Integrating IoT, edge computing, and AI for scalable, transparent, and adaptive crop management. In *Proceedings of the 1st International Conference on Research and Development in Information, Communication, and Computing Technologies* (Vol. 1, pp. 350–356). SciTePress. https://doi.org/10.5220/0013865600004919

Bugao, D. A., & Talirongan, H. (2025). AI rule-based expert system: Diagnosis and treatment of bean diseases. *International Journal on Science and Technology, 16*(3). https://doi.org/10.71097/IJSAT.v16.i3.7933

Department of Agriculture. (n.d.). *National color-coded agricultural guide (NCCAG) map*. https://amia.da.gov.ph/national-color-coded-agricultural-guide-nccag-map/

Dhingra, B., Agarwal, S., & Gupta, R. (2026). KRISHI.AI: An explainable machine learning framework for data-driven crop recommendation. *Scientific Reports*. Advance online publication. https://doi.org/10.1038/s41598-026-68815-w

Dornik, A., Cheţan, M. A., Crişan, T. E., Heciko, R., Gora, A., Drăguţ, L., & Panagos, P. (2024). Geospatial evaluation of the agricultural suitability and land use compatibility in Europe's temperate continental climate region. *International Soil and Water Conservation Research, 12*(4), 908–919. https://doi.org/10.1016/j.iswcr.2024.01.002

Farajpour, M. (2026). Current applications of artificial intelligence for advancing agriculture, sustainability and climate mitigation. *Discover Artificial Intelligence, 6*, Article 1525. https://doi.org/10.1007/s44163-026-02540-1

Fayaz, A., Gilani, S. M. M., Fayyaz, S., & Ghaffar, H. (2026). AI-based Agricure Pro App: A machine learning solution for crop health monitoring. *Data Plus, 4*(1), 43–47. https://doi.org/10.62887/dataplus.004.01.0087

Food and Agriculture Organization of the United Nations. (2022). *The state of food and agriculture 2022: Leveraging automation in agriculture for transforming agrifood systems*. https://doi.org/10.4060/cb9479en

Khan, N., Ray, R. L., Sargani, G. R., Ihtisham, M., Khayyam, M., & Ismail, S. (2021). Current progress and future prospects of agriculture technology: Gateway to sustainable agriculture. *Sustainability, 13*(9), 4883. https://doi.org/10.3390/su13094883

Lundberg, S. M., & Lee, S. I. (2017). A unified approach to interpreting model predictions. *Advances in Neural Information Processing Systems*.

Manono, B. O. (2026). Smart farming for small farms: Technologies, challenges, and opportunities for small-scale producers. *Green, 1*(1), Article 3. https://doi.org/10.3390/green1010003

Mastul, A. H., Awae, A., Bara, Z. J., & Yaro, Y. (2023). The use of IoT on smart agriculture in the Philippines: A narrative review. *Bincang Sains dan Teknologi, 2*, 98–107. https://doi.org/10.56741/bst.v2i03.416

NOAA. (2021). *Global drought assessment and physical drivers*. National Oceanic and Atmospheric Administration.

Patel, M., & Rane, A. (2023). *Crop recommendation system using machine learning*. Open Engineering Inc. https://doi.org/10.31224/2959

Philippine Rice Research Institute. (2022, April 12). *Farmers, technicians learn agri decision support tools*. https://www.philrice.gov.ph/farmers-technicians-learn-agri-decision-support-tools/

Ramadhani, D. S., Aulia, N., Putri, A. S., Nugroho, M. T., Sakti, A. S. A., & Satriyono, R. D. A. P. (2025). Implementation of agile software development in the design of management information systems inventory and finance at P2MKP Alang-Alang Tumbuh Subur. *The 8th Mechanical Engineering, Science and Technology International Conference*, 62. https://doi.org/10.3390/engproc2025084062

Shams, M. Y., Gamel, S. A., & Talaat, F. M. (2024). Enhancing crop recommendation systems with explainable artificial intelligence: A study on agricultural decision-making. *Neural Computing and Applications, 36*, 5695–5714. https://doi.org/10.1007/s00521-023-09391-2

Shastri, S., Kumar, S., Mansotra, V., & Salgotra, R. (2025). Advancing crop recommendation system with supervised machine learning and explainable artificial intelligence. *Scientific Reports, 15*, Article 25498. https://doi.org/10.1038/s41598-025-07003-8

Yang, Y., Jin, Z., Mueller, N. D., Driscoll, A. W., Hernandez, R. R., Grodsky, S. M., Sloat, L. L., Chester, M. V., Zhu, Y.-G., & Lobell, D. B. (2023). Sustainable irrigation and climate feedbacks. *Nature Food, 4*, 654–663. https://doi.org/10.1038/s43016-023-00821-x

Yuan, Y., & Sun, Y. (2024). Practices, challenges, and future of digital transformation in smallholder agriculture: Insights from a literature review. *Agriculture, 14*(12), Article 2193. https://doi.org/10.3390/agriculture14122193