GeoCROP: Geospatial Mapping of Agricultural Crops

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Abstract: This study presents GeoCROP, a GIS-Based Crop Recommendation and Agricultural Data Management System developed to improve agricultural planning, data accessibility, and decision-making among farmers and agricultural stakeholders. Traditional agricultural practices often rely on fragmented and manual data handling, resulting in inefficiencies in monitoring crop distribution and accessing timely information. To address these challenges, GeoCROP was designed and developed using the Agile methodology, enabling iterative development and continuous system refinement.

The system integrates Geographic Information System (GIS) technology to provide spatial visualization of farmer profiles, crop information, and agricultural locations. Core features include farmer profiling, crop management, GIS mapping, messaging, announcements, and report generation. The system was evaluated by IT experts and end-users using selected ISO/IEC 25010 quality criteria. Results indicate high technical quality, usability, and user acceptability, demonstrating that GeoCROP effectively supports agricultural data management and digital transformation initiatives.

Keywords: *GeoCROP, GIS-Based System, Crop Recommendation, Agile Methodology, ISO/IEC 25010.*

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I. INTRODUCTION

➢ *Background of the Study*

Agriculture continues to serve as the backbone of the Philippine economy, employing millions of Filipinos and ensuring the nation's food security. However, the agricultural sector faces recurring challenges such as inefficient data collection, fragmented crop monitoring, and limited access to timely, accurate information for decision-making. Farmers and local government agencies often depend on manual data recording and decentralized reporting systems, which lead to redundancy, delays, and inconsistencies in agricultural records. These gaps hinder the government's ability to plan crop distribution, monitor production, and assess land suitability effectively. The integration of Geographic Information Systems (GIS) into agriculture has emerged as a vital innovation to address these issues. GIS technology provides a means to visualize, analyze, and manage spatial agricultural data—enabling farmers, planners, and policymakers to understand the geographic distribution of crops, identify suitable planting zones, and evaluate land productivity more accurately. The adoption of GIS in agricultural systems aligns with global trends toward precision agriculture and data-driven farm management, emphasizing sustainability and resource optimization.

In response to these challenges, the study developed GeoCROP: A GIS-Based Crop Management and Recommendation System, a web-based platform that centralizes agricultural data using geospatial mapping and interactive analytics. Designed and tested in Nueva Ecija—known as the "Rice Granary of the Philippines"—the system integrates location-based data, farmer profiles, and crop details to create a dynamic visualization of agricultural conditions across barangays and municipalities. GeoCROP supports core functions such as crop registration, data visualization, announcement dissemination, and real-time communication between administrators and farmers. By incorporating GIS technology and an Agile development framework, the system ensures that agricultural data are not only accessible but also actionable, supporting evidence-based decisions for local government units, the Department of Agriculture, and independent farmers. Ultimately, this study demonstrates how digital innovation through geospatial systems can modernize agricultural management, enhance productivity, and promote sustainable rural development within the Philippine context.

➤ *Objectives of the Study*

This study aims to:

- Design, develop, and deploy GeoCROP based on the Agile Software Development Model.
- Evaluate its quality using ISO/IEC 25010 criteria, focusing on functionality, efficiency, reliability, and usability.
- Assess user perception of its usefulness and ease of use for agricultural data management.

➤ *Conceptual Framework or Theoretical Framework*

The study adopts the **Input–Process–Output–Outcome (IPOO) Model**, integrating Agile principles. Inputs include geospatial and agricultural datasets, user requirements, and institutional standards. The process involves iterative analysis, development, and testing. The output is the GeoCROP system—an interactive, GIS-based crop management platform. Outcomes include data-driven planning, policy formulation, and improved agricultural productivity.

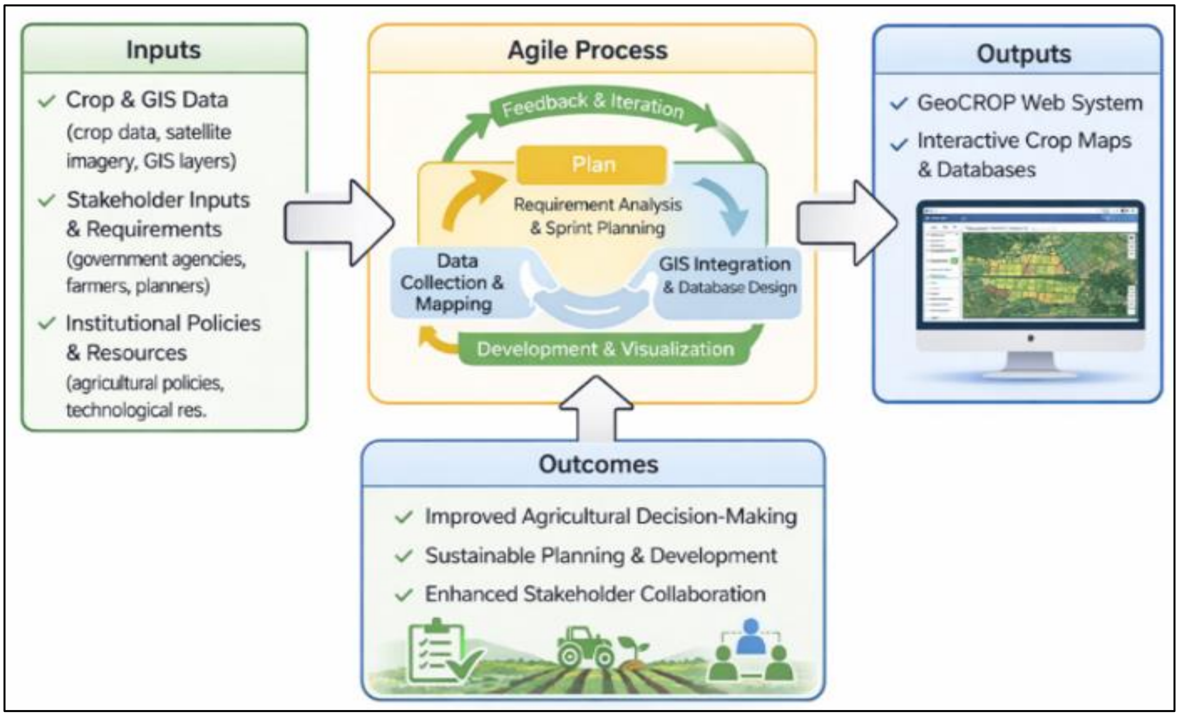

Fig 1 (IPOO) Model

II. METHODS

➤ *Research Design and Model Used*

A **mixed-method** design combining developmental and descriptive approaches was used. The Agile methodology guided the system's iterative development phases: requirements gathering, design, development, testing, and deployment. Quantitative data were collected through structured surveys, while qualitative insights were derived from interviews and observations.

➤ *System Development Methodology*

The Agile model structured system development across six phases:

- Planning: Defined objectives and technical scope.
- Design: Created database schemas, workflows, and GIS integrations.
- Development: Implemented PHP- and MySQL-based components with Leaflet.js for map visualization.
- Testing: Conducted by IT experts and end-users.
- Deployment: Implemented pilot testing in Nueva Ecija.
- Feedback: Continuous refinements based on user inputs.

➤ *Participants and Setting*

The study was conducted in Nueva Ecija, Philippines. A total of 50 respondents were purposively selected: 20 farmers (40%), 15 LGU/DA staff (30%), 10 researchers/educators (20%), and 5 IT experts (10%).

➤ *Research Instrument*

Two tools were used:

- Online Survey Questionnaire – measured system quality based on ISO 25010.
- Structured Interview Guide – collected qualitative feedback from key stakeholders.

➢ *Data Collection Procedure and Analysis*

The data collection procedure for this study was conducted in two major phases: **system development** and **system evaluation**. During the development phase, relevant agricultural and geospatial data were gathered from official sources such as the Department of Agriculture (DA) and local government units (LGUs) in selected pilot areas within Nueva Ecija. These data served as inputs for the GeoCROP database, particularly for mapping crop distribution and validating geographic boundaries. Preliminary interviews and consultations with LGU personnel and farmers were also carried out to align the system's features with actual agricultural workflows and information management practices.

The **evaluation phase** followed after the system's deployment, focusing on assessing its functionality, usability, and reliability. Data were collected through **structured surveys** based on ISO/IEC 25010 software quality characteristics, **focus group discussions (FGDs)** with farmers, LGU staff, and researchers, and **system testing** sessions with IT experts. The quantitative data from the surveys were analyzed using descriptive statistics such as frequency and weighted mean to determine performance levels, while qualitative feedback from interviews and FGDs was thematically analyzed to identify recurring issues and user insights. All participants were informed about the purpose of the study, their participation was voluntary, and all responses were treated with confidentiality. This mixed-method data collection ensured a comprehensive evaluation of the GeoCROP system's technical performance and its real-world applicability in agricultural data management.

III. RESULTS

The results of this study present the findings from the evaluation of the *GeoCROP* system in terms of its functionality, usability, and overall performance based on ISO/IEC 25010 software quality standards. This section highlights both the quantitative and qualitative outcomes gathered from IT experts, farmers, and local government personnel during system testing and validation. The results reflect the system's effectiveness in integrating geospatial data for crop management and its usability in supporting agricultural operations and decision-making. Furthermore, the assessment illustrates the system's perceived usefulness, ease of use, and behavioral intention to use (BI), which serve as indicators of user acceptance and system efficiency. These findings establish the foundation for the system's potential scalability and implementation across other agricultural regions in the Philippines.

➢ *Perceived Usefulness (PU)*

The evaluation of perceived usefulness (PU) examined how effectively the *GeoCROP* system supports users in managing agricultural data and decision-making. Respondents, including farmers, LGU staff, and researchers, found the system highly beneficial in improving accessibility, accuracy, and efficiency of crop information. Key features such as geospatial mapping, data visualization, and automated reporting were identified as valuable tools that enhanced agricultural planning and monitoring. Overall, the results indicate that *GeoCROP* is perceived as a practical and reliable system that promotes data-driven management in local agricultural operations.

Table 1. Summary of the IT Experts' Evaluation of GeoCROP: Geospatial Mapping of Agricultural Crops

GeoCROP: Geospatial Mapping of Agricultural Crops	Overall Mean	Verbal Description
Functional Suitability	3.87	Highly Functional
Performance Efficiency	3.93	Highly Efficient
Compatibility	3.70	Highly Compatible
Usability	3.90	Highly Usable
Reliability	3.65	Highly Reliable
Security	3.44	Highly Secured
Maintainability	3.85	Highly Maintainable
Portability	3.93	Highly Portable
Grand Mean	3.78	Excellent System Quality

The results indicate that GeoCROP achieved a Highly Usable rating across all usability indicators, demonstrating that the system is easy to use, intuitive, and accessible to its intended users. Among the evaluated indicators, user interface aesthetics obtained the highest mean score of 3.91, which was interpreted as Highly Usable. This result suggests that end-users found the visual design of the system clear, pleasing, and well-organized. A well-designed interface is important in reducing cognitive load and enhancing user engagement. The high rating reflects the effectiveness of the system's layout, color scheme, and visual elements in supporting user interaction.

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Table 2. Summary of the End-Users' Evaluation of GeoCROP: Geospatial Mapping of Agricultural Crops

Criteria	Overall Mean	Verbal Description
Functional Suitability	3.73	Highly Functional
Performance Efficiency	3.71	Highly Efficient
Usability	3.81	Highly Usable
Grand Mean	3.75	Excellent System Quality

The results show that the system was rated Highly Functional (M = 3.73), Highly Efficient (M = 3.71), and Highly Usable (M = 3.81), indicating positive user experiences in completing agricultural-related tasks. These findings suggest that the system effectively supports user needs while maintaining responsive performance and an intuitive interface. The grand mean of 3.75, interpreted as Excellent System Quality, confirms that GeoCROP is well accepted by end-users and suitable for practical agricultural applications.

➢ *Perceived Ease of Use (PEU)*

End-users rated GeoCROP as easy to navigate, visually clear, and highly intuitive, demonstrating that the system's interface effectively supports smooth user interaction. The learnability and accessibility indicators both received an average rating of 4.00 ("Highly Usable"), indicating that even individuals with limited technical experience can efficiently operate the system. Respondents noted that the organized layout, responsive mapping features, and straightforward data entry processes minimized confusion and reduced the learning curve. These results suggest that GeoCROP successfully meets usability standards, making it suitable for div

➢ *Behavioral Intention to Use (BI)*

The evaluation of behavioral intention to use (BI) aimed to determine the likelihood of users continuing to adopt and utilize the GeoCROP system after initial exposure. Findings revealed a strong positive response from participants, indicating a high intention to integrate the system into their regular agricultural operations. Farmers expressed interest in using GeoCROP for monitoring crop locations and identifying suitable planting zones, while LGU and DA personnel emphasized its potential for supporting planning, data consolidation, and reporting tasks. Respondents also appreciated the system's capability to centralize agricultural data and generate visual insights that assist in evidence-based decision-making. These results suggest that users not only found GeoCROP useful and easy to use but also saw long-term value in sustaining its implementation to improve efficiency and transparency in agricultural management.

Table 3. Cost–Benefit Analysis of Geocrop: Geospatial Mapping of Agricultural Crops

Category	Item / Component	Expected Benefits	Cost (₱)
Hardware Costs	Laptop/Development PC, Server/Hosting Unit, Network Router & Peripherals	Supports system development, testing, deployment, and reliable local network infrastructure	450,000
Software & Tools	Domain Registration (1 year), Web Hosting/VPS Subscription (1 year), GIS API/Software Tools, Office Productivity Tools, Operating System, HCI Platform, Antivirus	Enables system accessibility, GIS mapping integration, and cloud deployment	75,000
Human Resources / Labor	System Developer/Programmer, GIS Specialist/Consultant, Research Assistant/Encoder, Project Adviser/Consultant	Ensures proper system development, GIS integration, data handling, and technical oversight	120,000
Data Gathering & Field Validation	Transportation, Printing of Survey/Forms, Communication Allowance	Supports accurate field data collection, coordination, and validation	100,000
Evaluation & Documentation	Printing and Binding of Report, Presentation Materials, Miscellaneous / Contingency	Facilitates report submission, stakeholder presentation, and accounts for unforeseen expenses	60,000
Total Estimated Cost			**805,000**

Table 3 presents the estimated cost for implementing the GeoCROP system, with a total budget of ₱805,000. The expenses are divided into hardware, software and tools, human resources, data gathering, and evaluation/documentation. Hardware costs ensure reliable system development and deployment, while software and tools provide the necessary platforms and GIS integration at minimal expense. Labor costs cover the personnel involved in programming, mapping, data encoding, and technical oversight, ensuring efficient and accurate system development. Fieldwork costs support data collection and validation, and evaluation/documentation costs account for report preparation, presentations, and minor contingencies. Overall, the table reflects a cost-effective and sustainable plan that balances essential development, deployment, and operational needs while maximizing resource efficiency.

IV. CONCLUSION AND RECOMMENDATIONS

➢ *Conclusion*

GeoCROP successfully integrated GIS and web technologies to support agricultural data management in Nueva Ecija. The system met ISO/IEC 25010 standards for software quality, receiving high evaluations in functionality, usability, and portability. It proved effective for visualizing crop data and facilitating communication between farmers, researchers, and policymakers.

➢ *Recommendations*

- Integrate real-time weather data and climate forecasting for improved crop recommendations.
- Develop a mobile version to enhance accessibility in rural areas.
- Expand testing to other regions for broader validation.
- Strengthen data security through multi-factor authentication and regular audits.

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