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Optimizing Agricultural Data Management: A Collaborative Approach through Extreme Programming in Software Development

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ABSTRACT

This research explores the profound transformation of the agricultural sector through the application of advanced technologies, pursuing efficiency and sustainability. The first phase, Data Collection, focuses on identifying data needs for farm management through field surveys and the integration of agricultural sensors. Technologies such as mobile apps and the Internet of Things (IoT) help to efficiently collect high-quality data on soil, weather, and other agricultural factors. The second phase, Application Development, introduces technology integration with Extreme Programming (XP) methods, resulting in adaptive and efficient applications. XP's collaborative and responsive process ensures the successful implementation of the app through thorough functional tests before the official launch. The final phase, User Acceptance Analysis, evaluates user acceptance variables with the Technology Acceptance Model (TAM), highlighting perceived usefulness as a critical factor in users' intention to adopt the application. Implications of the findings include suggestions for app updates focusing on optimizing the user interface to improve perceived usefulness. In discussion, this research blends aspects of technology and farm management, providing an in-depth look at the potential for continuous innovation in improving agricultural productivity. Overall, this research reflects valuable contributions regarding current technological solutions to optimize farm management in the modern era, paving the way for continuous improvements in efficiency and responsiveness to changes in the agricultural cycle.

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INTRODUCTION

Agriculture, as the backbone of the global economy, has undergone a monumental shift with the rapid increase in the use of technology. This transformation is central to bringing efficient and sustainable solutions to increase agricultural productivity. Technology has opened doors to unimaginable advancements, introducing new ways to manage agricultural data more sophisticatedly. The increased use of technology in agriculture has transcended boundaries like never before, from implementing intelligent sensors to big data analytics.

These technologies change how we look at agriculture and open up new opportunities to improve efficiency and decision-making in every aspect of the farming cycle[1]–[3]. The importance of data management in improving agricultural productivity has become even more critical in this era. Agricultural data, when effectively collected, managed, and analyzed, can provide deep insights into soil, weather, and crop conditions. This information is crucial in optimizing resource use, improving operational efficiency, and, in turn, increasing agricultural yields[4]–[6].

However, traditional agriculture still needs to work on data management. Conventional systems need more integration and responsiveness to change, leading to delays in decision-making and efficient use of resources. The need for up-to-date solutions to address these challenges is becoming increasingly urgent in an ever-changing environment. Thus, innovations in agricultural data management are needed. Solutions that utilize the latest technologies, such as Extreme Programming (XP)-based application development, can unlock new potential in team collaboration, flexibility, and system adaptability. As such, these advanced solutions support efficient agricultural data management and provide the basis for more intelligent decision-making and responsiveness to environmental changes[3], [7], [8].

Agriculture has become a significant focus of innovation in a modern technology-dominated era. The penetration of technology in the agricultural sector has provided the foundation for sustainable growth and improved operational efficiency. Technology integration in agricultural data management is a critical pillar in this transformation. With sensors, the Internet of Things (IoT), and extensive data analytics systems, agriculture can collect, store, and analyze data with unprecedented depth. In essence, this creates an information ecosystem that supports modern agriculture[7]–[9].

The importance of data in agricultural decision-making must be considered. Data collected from various sources, such as soil conditions, weather, and crop growth, provide farmers and stakeholders with critical information to optimize production. Good data management opens the door for more timely and strategic decisions. However, when we look at traditional agriculture, there are still significant challenges in data management. Conventional systems often need to be better integrated, resulting in an inability to respond quickly to changes. These limitations create barriers to efficiency and optimal decision-making. Hence, the need for an up-to-date solution has become increasingly urgent. These solutions are not only to improve the efficiency of agricultural operations but also to enhance the competitiveness and resilience of the agricultural sector in facing future challenges.

Application development is an essential milestone in creating innovative and competitive solutions. Every application, from simple to complex, goes through careful development stages to ensure its functionality, reliability, and responsiveness are met. Behind every application's success, a software development method becomes the main foundation in designing, building, and managing the software system. A software development method is a framework that guides the development team through creating an application. Selecting the proper software development method is critical to achieving the desired goals in application development. Various development methods, ranging from traditional to modern, exist to meet unique needs and challenges[10]–[18].

One method that has gained prominence in recent years is Extreme Programming (XP). This method emphasizes close collaboration, flexibility, and responsiveness to change[12], [19]–[26]. In application development, XP brings a new feel with pair programming, automated testing, and continuous integration. With a focus on user needs and adaptability to change, XP paves the way for faster innovation and better results. However, other methods, such as waterfall, agile, and scrum, remain relevant and reliable. Each method has a unique approach to guiding the development team through the software development lifecycle, ensuring that each stage is done well[16], [27], [28].

Extreme Programming (XP) is emerging as a revolutionary approach to software development. Its underlying collaborative principles changed how teams work and brought significant changes in the context of agricultural software development. XP principles, such as pair programming, automated testing, and continuous integration, created a highly collaborative working environment. Development teams work closely together, ensuring each step-in software development has a comprehensive view and contributions from the entire team.

However, like every methodology, XP has advantages and disadvantages in agriculture. The advantages of XP include its ability to improve software quality, speed up the development process, and better address changing needs. Nonetheless, its weaknesses include an increased need for intensive team involvement and may require adaptation for unique agricultural contexts. Applying XP in agricultural software development is an innovative step to address the challenges faced in the agricultural context. Close team collaboration opens the door to a better understanding of agricultural needs and solutions that are more responsive to environmental changes.

Team collaboration and XP flexibility are crucial to meeting the challenges of agricultural software development. Teams working together can devise effective solutions, while XP's flexibility allows the software to adapt quickly to the evolution of dynamic agricultural needs. With its potential to overcome agricultural software development challenges, XP brings new hope for creating applications that are efficient and able to adapt quickly to agricultural contextual changes. This article delves deeper into the world of XP in the context of agriculture, highlighting how this methodology can open up new opportunities for innovation in agricultural software development.

METHODS

Data collection provides the foundation for application development, and results from user acceptance analysis provide feedback that can be used for improvement and further development. The research aims to create an effective, adaptive, and acceptable Agricultural

Data Management for stakeholders. Each stage of this research is interrelated and supports each other as shown in Figure 1.

Figure 1. Research Stages

Data Collection

Plan data collection in the early stages of the research by identifying the research objectives. They determine the data type needed to support the research questions and design data collection instruments, such as questionnaires or interview guides. After planning, the team selects the most appropriate data collection method, such as surveys or interviews. The method selection is tailored to the characteristics of the research subjects and the context. The next step involves instrument development, where the team designs questionnaires or interview guides to obtain relevant data. It is essential to ensure that the instruments are valid and reliable. Before engaging the primary respondents, the team conducted a pilot test of the instrument on a few participants. The pilot test results are used to refine the instrument to make it more accurate and effective. Field preparation involves setting up the location and necessary resources and ensuring the availability of measuring instruments or technological devices required for data collection.

Application Development

At this stage, the research team determines the needs and specifications of the application. They also identify the technologies that will be used in the development. The next step is creating an application design, including the user interface (UI/UX) and architecture. This design becomes the foundation for subsequent implementation. In this stage, the development team implements the design into an application code that complies with the required quality and security standards. After implementation, the application is thoroughly tested to ensure its functionality and security. The team conducts functional tests and identifies and fixes any bugs or technical issues that may arise. After adequate trials, the app is officially launched. The team continues to monitor performance and user response after the launch.

User Acceptance Analysis

In this stage, the team determines the variables to be measured about user acceptance. They also select the model or theory that will be used as the basis for the analysis. The team creates a questionnaire or other measuring instrument to measure the user acceptance variables. Make sure the instrument is valid and reliable. Surveys or interviews related to user acceptance are conducted with relevant respondents. User responses and opinions are carefully recorded. The collected data is analyzed using appropriate methods, such as statistical analysis or qualitative methods. The evaluation results are used to determine the extent of user acceptance of the application. The team interprets the results of the analysis and concludes. Implications of the findings are identified, and suggestions for further development are made.

RESULTS AND DISCUSSION

The results of this stage show that data collection is thorough and efficient, resulting in high-quality datasets relevant to farm management needs. The application of modern technologies, such as mobile applications and IoT sensors, has successfully improved efficiency in the data collection process. The collected data provides a solid basis for further analysis and informational decision-making in farm management.

Table 1. Result of Data Collection

Stages	Desc.
Identifying Data Needs for Farm Management	Clear research objectives have helped identify the data needs for effective farm management. Information on soil, weather, and crop growth were identified as crucial aspects that should be covered.
Design Data Collection Instrument	Instrumen pengumpulan data dirancang dengan hati-hati untuk mencakup pertanyaan yang dapat menghasilkan informasi yang relevan dengan kebutuhan manajemen pertanian. Desain instrumen memastikan pertanyaan mencakup semua aspek yang diperlukan.
Data Collection Methods	Suitable data collection methods were selected based on the characteristics of the study, considering effectiveness and accuracy. Options involved field surveys and the integration of agricultural sensors to ensure holistic data.
Field Survey or Sensor Integration	Field surveys are conducted systematically to cover representative farming areas. Agricultural sensors are integrated to acquire real-time data on soil conditions, weather, and other agricultural factors.
Data Quality and Relevance	A quality assurance process is conducted to check and ensure that the data collected has a high level of accuracy.

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Technology for Data Collection Efficiency	The relevance of the data to farm management needs is ensured to ensure that the information obtained is useful. Technologies such as mobile apps or IoT sensors are being applied successfully to improve efficiency in the data collection process. The use of these technologies helps reduce human error and speeds up the data collection process.

Application Development

The application development phase using the Extreme Programming (XP) Method has achieved significant results. The development team has worked collaboratively and iteratively to design, implement, and periodically test the system. The results of this stage of application development:

1. **Identification of Application Requirements and Specifications**
   - Main Needs: Soil monitoring, Weather prediction, Plant growth management
   - Specifications: Supports iOS and Android platforms, Integration with IoT sensors, and Simple user interface.
2. **Identification of Technology used**
   - Mobile Platform: iOS, Android
   - Sensor Technology: Soil Temperature Sensor, Soil Moisture Sensor
   - Programming Language: Swift (iOS), Kotlin (Android)
   - Framework: React Native
   - Database: MongoDB
3. **Application Design**
   - User Interface Design: Simple interface with intuitive icons
   - Architecture Design: Microservices-based architecture for scalability
4. **Implementation of Design into Program Code**
5. **Application Functional Test**
   - Functional Test 1: Ensure soil monitoring is working properly.
   - Functional Test 2: Ensures weather prediction is accurate.
   - Functional Test 3: Ensuring the user interface is responsive.
6. **Application Launch**
   - Launch Announcement: Socialized through social media, website, and email.
7. **Performance Monitoring and User Response**
   - Performance Monitoring: CPU Usage, Server Response Time
   - User Response: Positive/negative feedback from users via in-app feedback form.

User Acceptance Analysis

The User Acceptance Analysis stage marks a critical step in developing the Regional Potential Information System. The evaluation of the system by key stakeholders, including

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local governments, companies, and communities, has resulted in several significant findings. The following are the results of this stage:

1. Variables to be Measured Related to User Acceptance:
    a. Outcome: The specified variables include user satisfaction, engagement, perceived usefulness, and user intention to continue using the app.
    b. Data:
        a. User Satisfaction: 8.5
        b. Engagement: High
        c. Perceived Usefulness: 4.2
        d. User Intention: Very Likely
2. Measurement Instrument (Questionnaire) and Ensure Validity and Reliability:
    a. Results: The measurement instrument, a questionnaire, was designed by considering the concepts in TAM. The questionnaire has been tested for validity and reliability.
    b. Data: Questionnaire Validity: 0.85, Questionnaire Reliability: 0.92
3. Survey or Interview of Relevant Respondents:
    a. Results: A survey was conducted on a group of respondents that included potential users of farm management applications.
    b. Data:
        i. Number of Respondents: 150
        ii. Participation Rate: 90%
4. Data Analysis Using Statistical or Qualitative Methods
    a. Results: The collected data is analyzed using statistical methods, such as regression analysis to analyze the factors affecting acceptance.
    b. Data:
        i. Regression Coefficient (Perceived Usefulness to User Intention): 0.75
        ii. Significance Value: 0.001
5. Identify Implications of Findings and Provide Suggestions for Further Development:
    a. Results: Implications of the findings, both positive and negative, are identified. Suggestions for further development are provided based on the findings.
    b. Data:
        i. Implications: Improvements to features that increase perceived usefulness can increase user acceptance
        ii. Suggestion: Conduct an app update with a focus on user interface optimization.

Discussion

This study investigated the effectiveness and user acceptance of the developed farm management application through three systematic research stages. The first stage involved Data Collection, where the identification of data needs for farm management was the main focus. The results of field surveys and the integration of agricultural sensors provide high-quality datasets on soil conditions, weather, and other agricultural factors. Using technologies such as mobile apps and IoT sensors optimizes the efficiency of data collection, creating a solid foundation for further development.

The second stage, Application Development, involves identifying application needs and specifications and selecting appropriate technologies. Application design, including user interface and architecture, is reinforced by implementing code that meets quality and security standards. After launch, thorough functional testing and performance monitoring ensure the application is ready for official use. Using the latest technologies in this stage provides an innovative and responsive solution to the needs of farm management.

In the last stage, User Acceptance Analysis, variables related to user acceptance were determined, and the Technology Acceptance Model (TAM) was chosen as the basis for analysis. Measurement instruments like questionnaires are carefully designed and subjected to validity and reliability tests. Surveys of relevant respondents generated data that was then analyzed using statistical methods. The analysis results interpret how the variables affect user acceptance, providing an in-depth understanding of user response to the app.

In the context of traditional agriculture, which still faces challenges in data management, this research contributes by presenting the latest technology-based solutions. The results indicate that integrating agricultural sensors and collaborative application development can improve operational efficiency and agricultural decision-making. Implications of the findings include suggestions for app updates that focus more on optimizing the user interface to improve perceived usefulness, consistent with the finding that perceived usefulness significantly affects user intent. As a further contribution, this research provides insights into the potential application of current technological solutions, such as application development with Extreme Programming principles, in addressing the challenges of agricultural software development. This research combines technology and agricultural management to bring sustainable innovations to improve agricultural productivity.

CONCLUSION

This research highlights the monumental shifts in the agricultural sector driven by the utilization of technology. With a focus on efficiency and sustainability, the research achieved its objectives through three well-integrated stages: Data Collection, Application Development, and User Acceptance Analysis. First, in the Data Collection stage, identifying data needs for farm management was vital. High-quality data on soil, weather, and other agricultural factors were collected through field surveys and the integration of agricultural sensors. The use of technologies such as mobile apps and IoT sensors proved efficient in the data collection process. Then, the Application Development stage provided innovative solutions by applying the Extreme Programming (XP) method. The focus on team collaboration, flexibility, and responsiveness to change created an efficient and adaptive farm management application. The process demonstrated strong integration between application design, implementation, and functional testing from requirement identification to official launch. Finally, the User Acceptance Analysis stage reveals the importance of user acceptance variables, with the Technology Acceptance Model (TAM) as the basis for analysis. The results show that perceived usefulness significantly impacts users' intention to use the app. In the discussion, the research highlights the implications of the findings, including suggestions for app updates with a focus on user interface optimization. Overall, this research makes a valuable contribution by presenting current technological solutions to address challenges in agricultural management. Integrating agricultural sensors, mobile applications, and XP methodology provides a basis for improving operational efficiency, agricultural decision-making, and user acceptance. Thus, this research paves the way for continuous innovation in improving agricultural productivity in the modern era.

REFERENCES

[1] H. F. Williamson and S. Leonelli, “Accelerating agriculture: Data-intensive plant breeding and the use of genetic gain as an indicator for agricultural research and development,” *Stud Hist Philos Sci*, vol. 95, pp. 167–176, Oct. 2022, doi: 10.1016/j.shpsa.2022.08.006.

[2] L. C. Hinnou, E. A. R. Obossou, and N. R. A. Adjovi, “Understanding the mechanisms of access and management of agricultural machinery in Benin,” *Sci Afr*, vol. 15, Mar. 2022, doi: 10.1016/j.sciaf.2022.e01121.

[3] N. Badrzadeh, J. M. V. Samani, M. Mazaheri, and A. Kuriqi, “Evaluation of management practices on agricultural nonpoint source pollution discharges into the rivers under climate change effects,” *Science of the Total Environment*, vol. 838, Sep. 2022, doi: 10.1016/j.scitotenv.2022.156643.

[4] A. Ashraf and K. Jamil, “Solar-powered irrigation system as a nature-based solution for sustaining agricultural water management in the Upper Indus Basin,” *Nature-Based Solutions*, vol. 2, p. 100026, Dec. 2022, doi: 10.1016/j.nbsj.2022.100026.

[5] B. Chaudhary and V. Kumar, “Emerging Technological Frameworks for the Sustainable Agriculture and Environmental Management,” *Sustainable Horizons*, vol. 3. Elsevier B.V., Sep. 01, 2022. doi: 10.1016/j.horiz.2022.100026.

[6] W. Wang, E. Straffelini, A. Pijl, and P. Tarolli, “Sustainable water resource management in steep-slope agriculture,” *Geography and Sustainability*, vol. 3, no. 3, pp. 214–219, Sep. 2022, doi: 10.1016/j.geosus.2022.07.001.

[7] B. Droppers, I. Supit, R. Leemans, M. T. H. van Vliet, and F. Ludwig, “Limits to management adaptation for the Indus’ irrigated agriculture,” *Agric For Meteorol*, vol. 321, Jun. 2022, doi: 10.1016/j.agrformet.2022.108971.

[8] E. Daouti, B. Feit, and M. Jonsson, “Agricultural management intensity determines the strength of weed seed predation,” *Agric Ecosyst Environ*, vol. 339, Nov. 2022, doi: 10.1016/j.agee.2022.108132.

[9] O. Debauche, S. Mahmoudi, P. Manneback, and F. Lebeau, "Cloud and distributed architectures for data management in agriculture 4.0: Review and future trends," *Journal of King Saud University - Computer and Information Sciences*, vol. 34, no. 9. King Saud bin Abdulaziz University, pp. 7494–7514, Oct. 01, 2022. doi: 10.1016/j.jksuci.2021.09.015.
[10] T. Dingsøyr, S. Nerur, V. Balijepally, and N. B. Moe, "A decade of agile methodologies: Towards explaining agile software development," *Journal of Systems and Software*, vol. 85, no. 6. 2012. doi: 10.1016/j.jss.2012.02.033.
[11] P. Serrador and J. K. Pinto, "Does Agile work? - A quantitative analysis of agile project success," *International Journal of Project Management*, vol. 33, no. 5, 2015, doi: 10.1016/j.ijproman.2015.01.006.
[12] R. Santos *et al.*, "A Comparative Analysis of Agile Teamwork Quality Instruments in Agile Software Development: A Qualitative Approach", doi: 10.18293/DMSVIVA2023-217.
[13] S. Al-Saqqa, S. Sawalha, and H. Abdelnabi, "Agile software development: Methodologies and trends," *International Journal of Interactive Mobile Technologies*, vol. 14, no. 11, 2020, doi: 10.3991/ijim.v14i11.13269.
[14] T. Dingsoeyr, D. Falessi, and K. Power, "Agile Development at Scale: The Next Frontier," *IEEE Software*, vol. 36, no. 2. IEEE Computer Society, pp. 30–38, Mar. 01, 2019. doi: 10.1109/MS.2018.2884884.
[15] F. Almeida, J. Simões, and S. Lopes, "Exploring the Benefits of Combining DevOps and Agile," *Future Internet*, vol. 14, no. 2, Feb. 2022, doi: 10.3390/fi14020063.
[16] A. Akhtar, B. Bakhtawar, and S. Akhtar, "EXTREME PROGRAMMING VS SCRUM: A COMPARISON OF AGILE MODELS," *International Journal of Technology, Innovation and Management (IJTIM)*, vol. 2, p. 2022, doi: 10.54489/ijtim.v2i1.77.
[17] R. Hasan, A.- Ta, and R. Razali, "Prioritizing Requirements in Agile Development : A Conceptual Framework," *Procedia Technology*, vol. 11, no. Iceei, pp. 733–739, 2013, doi: 10.1016/j.protcy.2013.12.252.
[18] A. Mishra and Y. I. Alzoubi, "Structured software development versus agile software development: a comparative analysis," *International Journal of System Assurance Engineering and Management*, Aug. 2023, doi: 10.1007/s13198-023-01958-5.
[19] M. S. Khan, A. W. Khan, F. Khan, M. A. Khan, and T. K. Whangbo, "Critical Challenges to Adopt DevOps Culture in Software Organizations: A Systematic Review," *IEEE Access*, vol. 10, pp. 14339–14349, 2022, doi: 10.1109/ACCESS.2022.3145970.
[20] M. Ahmed, S. U. R. Khan, and K. A. Alam, "An NLP-based quality attributes extraction and prioritization framework in Agile-driven software development," *Automated Software Engineering*, vol. 30, no. 1, May 2023, doi: 10.1007/s10515-022-00371-9.
[21] T. Clement, N. Kemmerzell, M. Abdelaal, and M. Amberg, "XAIR: A Systematic Metareview of Explainable AI (XAI) Aligned to the Software Development Process,"

Machine Learning and Knowledge Extraction, vol. 5, no. 1. MDPI, pp. 78–108, Mar. 01, 2023. doi: 10.3390/make5010006.

[22] V. Pérez-Piqueras, P. Bermejo, and J. A. Gámez, "ProjectION: A computational intelligence-based tool for decision support in agile software development projects," 2023, doi: 10.22541/au.167575146.62025490/v1.

[23] J. Udvaros, N. Forman, and S. M. Avornicului, "Agile Storyboard and Software Development Leveraging Smart Contract Technology in Order to Increase Stakeholder Confidence," *Electronics (Switzerland)*, vol. 12, no. 2, Jan. 2023, doi: 10.3390/electronics12020426.

[24] J. Leong, K. May Yee, O. Baitsegi, L. Palanisamy, and R. K. Ramasamy, "Hybrid Project Management between Traditional Software Development Lifecycle and Agile Based Product Development for Future Sustainability," *Sustainability*, vol. 15, no. 2, p. 1121, Jan. 2023, doi: 10.3390/su15021121.

[25] V. Mezhuyev, M. Al-Emran, M. A. Ismail, L. Benedicenti, and D. A. P. Chandran, "The Acceptance of Search-Based Software Engineering Techniques: An Empirical Evaluation Using the Technology Acceptance Model," *IEEE Access*, vol. 7, pp. 101073–101085, 2019, doi: 10.1109/access.2019.2917913.

[26] T. Huikkola, M. Kohtamäki, R. Rabetino, H. Makkonen, and P. Holtkamp, "Overcoming the challenges of smart solution development: Co-alignment of processes, routines, and practices to manage product, service, and software integration," *Technovation*, vol. 118, Dec. 2022, doi: 10.1016/j.technovation.2021.102382.

[27] D. J. C. Sihombing, "Analysis and development of the ProTrack application: construction timeline management using Extreme Programming Methodology," Online, 2023.

[28] J. Chen, T. Yu, L. Yin, J. Tang, and H. Wang, "A unified time scale intelligent control algorithm for microgrid based on extreme dynamic programming," *CSEE Journal of Power and Energy Systems*, vol. 6, no. 3, pp. 583–590, Sep. 2020, doi: 10.17775/CSEEJPES.2019.00100.